# 1 THE REAL NUMBER SYSTEM

1.1 SOME SETS OF NUMBERS

1. 15 is a natural number, whole number, integer, rational number, and a real number.

2. $-\frac{2}{3}$ is a rational number and a real number.

3. $\frac{-\sqrt{7}}{8}$ is an irrational number and a real number.

4. 0 is a whole number, integer, rational, and real number.

5. 1800

6. 2460

7. -3800

8. 54,000

9. 328,000

10. 432,800

11. 433,000

12. 430,000

13. 24.37

14. 0.1

15. 13.74

16. -4.2

17. $23''$

18. 30

19. $|15| = 15$

20. $\left|\dfrac{-\sqrt{7}}{8}\right| = \dfrac{\sqrt{7}}{8}$

21. $|0| = 0$

22. $|4 - 7| = |-3| = 3$

23.
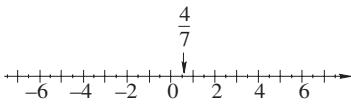
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24.
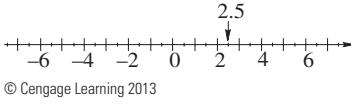
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25.
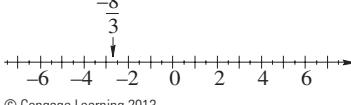
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26.
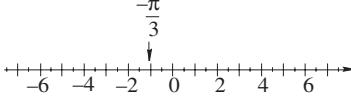
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27. $2 < 3; 2 - 3 = -1$ negative

28. $5 > 3; 5 - 3 = 2$ positive

29. $-4 < 7; -4 - 7 = -11$ negative

30. $9 > -7; 9 - (-7) = 16$ positive

31. $-3 > -8; -3 - (-8) = 5$ positive

32. $-15 < -7; -15 - (-7) = -8$ negative

33. $-\frac{2}{3} < -\frac{1}{2}; -\frac{2}{3} - \left(-\frac{1}{2}\right) = -\frac{4}{6} - \left(-\frac{3}{6}\right) = -\frac{1}{6}$ negative

34. $-\frac{7}{2} < -\frac{8}{3}$ because $-\frac{7}{2} - \left(-\frac{8}{3}\right) = -\frac{5}{6}$, which is negative

35. $0.7 > 0.5; 0.7 - 0.5 = 0.2$ positive

36. $-2.1 < -2.0$ because $-2.1 - (-2.0) = -0.1$, which is negative

37. $|2.3| < |-4.1|$ because $|2.3| - |-4.1| = 2.3 - 4.1 = -1.8$, which is negative

38. $|-5.1| < |3.7|$ because $|-5.1| - |3.7| = 5.1 - 3.7 = 1.4$, which is positive

39. Commutative law for addition (CA)

40. Associative law for multiplication (AM)

41. Commutative law for multiplication (CM)

42. Distributive law (DL)

43. Associative law for addition (AA)

44. Distributive law

45. Identity element for multiplication

46. Multiplicative inverses

47. Additive inverses

48. Commutative law for addition

49. Associative law for multiplication

50. Identity element for addition

51. Additive inverse of 91 is -91.

52. 8

53. $-\sqrt{2}$

54. $-\frac{1}{3}$

55. Multiplicative inverse of $\frac{1}{2}$ is 2.

56. $-\frac{1}{5}$

57. $\frac{2}{\sqrt{2}} = \frac{2}{\sqrt{2}} \frac{\sqrt{2}}{\sqrt{2}} = \frac{2\sqrt{2}}{2} = \sqrt{2}$

58. $-\frac{7}{3}$

59. The reciprocal of -5 is $\frac{1}{-5} = -\frac{1}{5}$.

60. The reciprocal of $\frac{1}{2}$ is $\frac{1}{1/2} = 1 \times \frac{2}{1} = 2$.

61. The reciprocal of $\frac{17}{3}$ is $\frac{1}{17/3} = 1 \times \frac{3}{17} = \frac{3}{17}$.

62. The reciprocal of $\frac{-2}{\pi}$ is $\frac{1}{-2/\pi} = 1 \times \left(-\frac{\pi}{2}\right) = -\frac{\pi}{2}$.

63. $16 - 8 \div 4 = 16 - 2 = 14$

64. $16 \div 8 + 2 = 2 + 2 = 4$

65. $24 + 3 - 10 \div 5 \times 8 + 2 = 24 + 3 - 2 \times 8 + 2 = 24 + 3 - 16 + 2 = 27 - 16 + 2 = 11 + 2 = 13$

66. $13 \times 7 - 26 \div 5 + 5 = 91 - 5.2 + 5 = 85.8 + 5 = 90.8$

67. $(7 - 2) - (3 + 8 - 7) = 5 - (11 - 7) = 5 - 4 = 1$

68. $7 - 2 - 3 + 8 - 7 = 5 - 3 + 8 - 7 = 2 + 8 - 7 = 10 - 7 = 3$

69. $7 \times 3 + 5 \times 2 = 21 + 10 = 31$

70. $6 \times 4 - 3 \times 5 = 24 - 15 = 9$

71. $\{-[5 - (8 - 4) + (3 - 7)] - (4 - 2)\} = -[5 - 4 + (-4)] - 2 = -[1 + (-4)] - 2 = -[-3] - 2 = 3 - 2 = 1$

72. $(14 + 3(8 - 6) + 4(9 - 5)) = 14 + 3 \times 2 + 4 \times 4 = 14 + 6 + 16 = 20 + 16 = 36$

73. Press $\boxed{(-)}$ 39 $\boxed{-}$ 72. The result is -111.

74. Press $\boxed{(-)}$ 56 $\boxed{-}$ $\boxed{(-)}$ 344. The result is 288.

75. **(a)** Press 243 $\boxed{+}$ $\boxed{(}$ $\boxed{(-)}$ 691 $\boxed{+}$ 89 $\boxed{)}$. The result is -359.

   (b) Press $\boxed{(}$ 243 $\boxed{+}$ $\boxed{(-)}$ 691 $\boxed{)}$ $\boxed{+}$ 89. The result is -359.

76. **(a)** Press $\boxed{(-)}$ 41 $\boxed{(}$ 63 $\boxed{+}$ $\boxed{(-)}$ 177 $\boxed{)}$. The result is 4674.

   (b) Press $\boxed{(-)}$ 41 $\boxed{\times}$ 63 $\boxed{+}$ $\boxed{(-)}$ 41 $\boxed{\times}$ $\boxed{(-)}$ 177. The result is 4674.

77. **(a)** Press $\boxed{(}$ $\boxed{(-)}$ 342 $\boxed{+}$ $\boxed{(-)}$ 18 $\boxed{)}$ $\boxed{\times}$ 91. The result is -32760.

   (b) Press $\boxed{(-)}$ 342 $\boxed{\times}$ 91 $\boxed{+}$ $\boxed{(-)}$ 18 $\boxed{\times}$ 91. The result is -32760.

78. **(a)** Press 3 $\boxed{\div}$ 7 $\boxed{\times}$ 7 $\boxed{\div}$ 3. The result is 1.

   (b) Press $\boxed{(-)}$ 3 $\boxed{\div}$ 11 $\boxed{+}$ 3 $\boxed{\div}$ 11. The result is 0.

79. 25.3

80. 25.3

81. -15.48

82. 467.4

83. 386.2

84. 301.8

85. $-5, -|4|, -\frac{2}{3}, \frac{-1}{3}, \frac{16}{3}, |-8|$

86. $-\sqrt{7}, -|\frac{7}{4}|, -\sqrt{2}, \sqrt{7} - \sqrt{2}, \frac{7}{5}, \pi, \frac{22}{7}$

87. **(a)** $\frac{1}{32}$ in.,   **(b)** $\frac{1}{8}$ in.,   **(c)** $\frac{1}{16} = 0.0625$ in.

88. $\frac{3}{4}$ h $= 0.75$ h, $1\frac{1}{2}$ h $= 1.5$ h, $2\frac{1}{4}$ h $= 2.25$ h

89. $|-19.4 - (-16.8)| = |-2.6| = 2.6$ so 2.6 V

90. $|-6.5 - 14.7| = |-21.2| = 21.2$ V

91. $\frac{5}{7}$ (Sheila), $\frac{2}{3}$ (Hazel), $\frac{3}{5}$ (José), $\frac{9}{16}$ (Robert), and $\frac{4}{9}$ (Lamar)

92. $|23.7 - (-5.2)| = |23.7 + 5.2| = |28.9| = 28.9$ V

93. Helen began at mile marker 157. If the mile markers were increasing, then after 1 h she was at mile marker $157 + 64 = 221$. If the mile markers were decreasing, then after 1 h she was at mile marker $157 - 64 = 93$.

94. $|14 - 19| = |-5| = 5 \, \Omega$

95. $13' \times 14'$

96. 4.85 m $\times 5.36$ m

97. **(a)** distributive property

   (b) $8(12 + 3) = 8 \times 12 + 8 \times 3$

98. **(a)** commutative property of multiplication

   (b) $21 \times 3.7 = 37 \times 2.1$

99. **(a)** commutative property for addition

   (b) $257 + 92 = 92 + 257$

100. **(a)** Both the associative and commutative property of addition

   (b) $123 + 73 + 49 = 49 + 73 + 135$

101. **(a)** Machine 1: $56,782 - 17,855 = 38,927$

   Machine 2: $42,538 - 13,947 = 28,591$

   Machine 3: $34,641 - 8,132 = 26,509$

   Machine 4: $87,462 - 46,937 = 40,425$

   Machine 5: $32,561 - 773 = 31,788$

   (b) $38,927 + 28,591 + 26,509 + 40,425 + 31,788 = 166,240$

102. From the original 5000 m, four lengths were removed, leaving $5000 - 325 - 580 - 260 - 98 = 3737$ m in stock. But, 127 m were returned to stock,

so at the end of the job there are $3737 + 127 = 3864$ m in stock.

103. It was estimated that $25 \times 6{,}500 = 162{,}500$ gal would be sold. Since 178,250 were actually sold, this is $178{,}250 - 162{,}500 = 15{,}750$ more gallons than expected.

104. **(a)** January: 9,400 ft; February: 7,500 ft; March: 4,900 ft

(b) $9{,}400 + 7{,}500 + 4{,}900 = 21{,}800$ ft

(c) $9{,}430 + 7{,}450 + 4{,}873 = 21{,}753$ ft

107. Answers depend on the type of calculator used.

1.2 BASIC OPERATIONS WITH REAL NUMBERS

1. $27 + (+23)$. Same sign $27 + 23 = 50$; both positive so, $+50$.

2. $8 + (-19)$. Different signs $|-19| - |8| = 19 - 8 = 11$; larger negative so, -11.

3. $27 + (-13)$. Different signs $|27| - |-13| = 27 - 13 = 14$; larger positive so, 14.

4. $-9 + (-8)$. Same sign $|-9| + |-8| = 9 + 8 = 17$; both negative so, -17.

5. $7 - 16 = 7 + (-16)$. Different signs $|-16| - |7| = 16 - 7 = 9$; larger negative so, -9.

6. $29 - (-8) = 29 + (+8) = 37$

7. $-8 - 16 = -8 + (-16)$. Same sign $|-8| + |-16| = 8 + 16 = 24$; both negative so, -24.

8. $-25 - (-13) = -25 + (+13)$. Different signs $|-25| - |13| = 12$; larger negative so, -12.

9. $-37 - (-49) = -37 + (+49)$. Different signs $|49| - |37| = 49 - 37 = 12$; larger positive so, $+12$.

10. $(-2)(6)$; $|-2| \cdot |6| = 2 \cdot 6 = 12$. Different signs so, -12.

11. $(-3)(-5)$; $|-3| \cdot |-5| = 3 \cdot 5 = 15$. Same sign so $+15$.

12. $(7)(-8)$; $|7| \cdot |-8| = 7 \cdot 8 = 56$. Different signs so, -56.

13. $-38 \div 4$; $|-38| \div |4| = 38 \div 4 = \frac{38}{4} = \frac{19}{2}$. Different signs so $-\frac{19}{2}$.

14. $-45 \div (-9)$; $\frac{|-45|}{|-9|} = \frac{45}{9} = 5$. Same sign so $+5$.

15. $\frac{3}{4} + \frac{-5}{8}$; $\frac{3}{4} = \frac{6}{8}$; $\frac{6}{8} + \frac{-5}{8} = \frac{6 + (-5)}{8} = \frac{1}{8}$

16. $-1\frac{3}{4} + \frac{-2}{3} = -\frac{7}{4} + \frac{-2}{3}$. Same sign $\frac{7}{4} + \frac{2}{3} = \frac{21}{12} + \frac{8}{12} = \frac{29}{12}$. Both negative so $-\frac{29}{12} = -2\frac{5}{12}$.

17. $\frac{-9}{5} + \frac{7}{3}$ common denominator is 15;

$\frac{-9}{5} + \frac{7}{3} = \frac{-27}{15} + \frac{35}{15} = \frac{-27 + 35}{15} = \frac{8}{15}$

18. $\frac{-2}{3} + \frac{5}{6}$ common denominator is 6;

$\frac{-2}{3} + \frac{5}{6} = \frac{-4}{6} + \frac{5}{6} = \frac{-4 + 5}{6} = \frac{1}{6}$

19. $\frac{2}{5} + \frac{-1}{4} = \frac{8}{20} + \frac{-5}{20} = \frac{8 + (-5)}{20} = \frac{3}{20}$

20. $\frac{-4}{5} + \frac{-5}{6} = \frac{-24}{30} + \frac{-25}{30} = \frac{-24 + (-25)}{30} = \frac{-49}{30} = -1\frac{19}{30}$

21. $\frac{3}{8} - \frac{-1}{4} = \frac{3}{8} - \frac{-2}{8} = \frac{3 - (-2)}{8} = \frac{5}{8}$

22. $1\frac{1}{3} - \frac{-5}{6} = \frac{4}{3} - \frac{-5}{6} = \frac{8}{6} - \frac{-5}{6} = \frac{8 - (-5)}{6} = \frac{13}{6} = 2\frac{1}{6}$

23. $\frac{-9}{10} - \frac{2}{3} = \frac{-27}{30} - \frac{20}{30} = \frac{-27 - 20}{30} = \frac{-47}{30} = -1\frac{17}{30}$

24. $\frac{-5}{8} - \frac{-3}{8} = \frac{-5}{16} - \frac{-6}{16} = \frac{-5 - (-6)}{16} = \frac{1}{16}$

25. $\frac{5}{32} - \frac{1}{8} = \frac{5}{32} - \frac{4}{32} = \frac{5 - 4}{32} = \frac{1}{32}$

26. $-\frac{7}{3} - \frac{-6}{7} = \frac{-49}{21} - \frac{-18}{21} = \frac{-49 - (-18)}{21} = \frac{-31}{21} = -1\frac{10}{21}$

27. $\frac{-2}{3} \times \frac{4}{5} = \frac{-2 \times 4}{3 \times 5} = \frac{-8}{15} = -\frac{8}{15}$

28. $\frac{3}{4} \times \frac{-5}{8} = \frac{3 \times (-5)}{4 \times 8} = -\frac{15}{32}$

29. $\frac{-1}{8} \times \frac{-3}{4} = \frac{-1 \times (-3)}{8 \times 4} = \frac{3}{32}$

30. $\frac{9}{16} \times \frac{1}{2} = \frac{9 \times 1}{16 \times 2} = \frac{9}{32}$

31. $-\frac{4}{3} \times \frac{5}{2} = \frac{-4 \times 5}{3 \times 2} = \frac{-20}{6} = -\frac{10}{3}$ or $\frac{-2 \times 2 \times 5}{3 \times 2} = -3\frac{1}{3}$

32. $\frac{-9}{5} \times \frac{-3}{8} = \frac{-9 \times (-3)}{5 \times 8} = \frac{27}{40}$

33. $-\frac{3}{4} \div \frac{-5}{8} = -\frac{3}{4} \times \frac{8}{-5} = \frac{-3 \times 4 \times 2}{4 \times (-5)} = \frac{-6}{-5} = \frac{6}{5} = 1\frac{1}{5}$

34. $1\frac{3}{4} \div \frac{-2}{3} = \frac{7}{4} \div \frac{-2}{3} = \frac{7}{4} \times \frac{3}{-2} = \frac{7 \times 3}{4 \times (-2)} = \frac{21}{-8}$
$= -\frac{21}{8} = -2\frac{5}{8}$

35. $-\frac{3}{5} \div 4 = \frac{-3}{5} \times \frac{1}{4} = \frac{-3 \times 1}{5 \times 4} = \frac{-3}{20} = -\frac{3}{20}$

36. $-\frac{3}{8} \div \frac{1}{4} = \frac{-3}{8} \times \frac{4}{1} = \frac{-3 \times 4}{2 \times 4} = -\frac{3}{2} = 1\frac{1}{2}$

37. $-\frac{7}{5} \div \left(-\frac{7}{5}\right) = -\frac{7}{5} \times \frac{-7}{5} = \frac{-7 \times (-7)}{5 \times 5} = \frac{49}{25} = 1\frac{24}{25}$

38. $\frac{2}{3} \div \left(-\frac{7}{3}\right) = \frac{2}{3} \times \frac{-3}{7} = \frac{2 \times (-3)}{3 \times 7} = \frac{-2}{7} = -\frac{2}{7}$

39. $\left(-2 + \frac{2}{3}\right) \times \frac{-1}{2} - \left[\frac{3}{2} \div (-3)\right] + \frac{7}{3} = \frac{-4}{3} \times$

$\frac{-1}{2} - \left(\frac{-1}{2}\right) + \frac{7}{3} = \frac{-4 \times (-1)}{3 \times 2} - \left(\frac{-1}{2}\right) + \frac{7}{3}$

$= \frac{2}{3} - \left(\frac{-1}{2}\right) + \frac{7}{3} = \frac{4}{6} - \frac{-3}{6} + \frac{7}{3} = \frac{7}{6} + \frac{7}{3} = \frac{7}{6}$

$+ \frac{14}{6} = \frac{21}{6} = \frac{7}{2} = 3\frac{1}{2}$

40. $\frac{4}{3} \times \frac{-7}{8} \times \frac{3}{-5} \div \frac{4}{5} + \frac{-5}{8} - \frac{7}{8} = \frac{4 \times (-7)}{3 \times 8}$

$\times \frac{3}{-5} \div \frac{4}{5} + \frac{-5}{8} - \frac{7}{8} = \frac{-7 \times 3}{6 \times (-5)} \div \frac{4}{5} + \frac{-5}{8} - \frac{7}{8}$

$= \frac{7}{10} \div \frac{4}{5} + \frac{-5}{8} - \frac{7}{8} = \frac{7}{10} \times \frac{5}{4} + \frac{-5}{8} - \frac{7}{8}$

$= \frac{7 \times 5}{2 \times 5 \times 4} + \frac{-5}{8} - \frac{7}{8} = \frac{7}{8} + \frac{-5}{8} - \frac{7}{8} =$

$\frac{2}{8} - \frac{7}{8} = -\frac{5}{8}$

41. Add: $17\frac{1}{2} + 15\frac{7}{8} + 29\frac{3}{4} + 15\frac{3}{8} = 17\frac{4}{8} + 15\frac{7}{8} +$
$29\frac{6}{8} + 15\frac{3}{8} = 76\frac{20}{8} = 78\frac{4}{8} = 78\frac{1}{2} = 6'6\frac{1''}{2}$

42. Add: $\frac{5}{32} + \frac{3}{16} = \frac{5}{32} + \frac{6}{32} = \frac{11}{32}$

43. We add the voltages of the batteries: $30 + 15 + (-12) + 24 = 57$. So, the total voltage is 57 V.

44. Subtract: $1\frac{5}{8} - \frac{1}{5} = \frac{13}{8} - \frac{1}{5} = \frac{65}{40} - \frac{8}{40} = \frac{57}{40} = 1\frac{17''}{40}$

45. (a) $4\frac{5}{8} + 3\frac{1}{5} = \frac{37}{8} + \frac{16}{5} = \frac{185}{40} + \frac{128}{40} = \frac{313}{40} = 7\frac{33}{40}$ mi

(b) We need to add the distance between the second and third checkpoints to the answer for (a).
$7\frac{33}{40} + 3\frac{3}{8} = \frac{313}{40} + \frac{27}{8} = \frac{313}{40} + \frac{135}{40} = \frac{448}{40} = 11\frac{8}{40} = 11\frac{1}{5}$ mi

(c) Using the answer from (b), we subtract that answer from the total length of the race.
$14\frac{1}{2} - 11\frac{1}{5} = \frac{29}{2} - \frac{56}{5} = \frac{145}{10} - \frac{112}{10} = \frac{33}{10} = 3\frac{3}{10}$ mi

46. We divide $427\frac{1}{5}$ by $13\frac{3}{4}$.
$427\frac{1}{5} \div 13\frac{3}{4} = \frac{2136}{5} \div \frac{55}{4} = \frac{2136}{5} \times \frac{4}{55} = \frac{8544}{275} = 31\frac{19}{275} \approx 31.07$ mi/gal

47. We want $37 \times 2'3\frac{1''}{2}$. There are $12''$ in 1 foot, so there are $2 \times 12'' = 24''$ in 2 ft. Thus, $2'3\frac{1''}{2} = 24'' + 3\frac{1''}{2} = 27\frac{1''}{2}$. Now, $37 \times 27\frac{1}{2} = \frac{37}{1} \times \frac{55}{2} = \frac{2035}{2} = 1017\frac{1''}{2} = 84'9\frac{1''}{2}$.

48. Each strip requires $1\frac{5}{16} + \frac{1}{8} = 1\frac{7}{17}$ in. of wood for its width. To determine the total number of strips we can get from the sheet of plywood, we will divide 8 ft by $1\frac{7}{16}$ in. Converting 8 ft to $8 \times 12 = 96$ in., we want the answer to $96 \div 1\frac{7}{16} = 96 \div \frac{23}{16} = 96 \times \frac{16}{23} = \frac{1536}{23} \approx 66.78$. You can get a total of 66 strips. (Note that the scrap is a strip $1\frac{1''}{8}$ wide.)

49. We subtract the two smaller lengths from the total length. $7\frac{5}{8} - 3\frac{3}{8} - 3\frac{3}{8} = \frac{61}{8} - \frac{27}{8} - \frac{27}{8}$
$= \frac{34}{8} - \frac{27}{8} = \frac{7}{8}$. The missing length is $\frac{7''}{8}$.

50. Adding the voltages, we get
$-4 + 22 + (-9) + (-7) + 13 + (-6) + (-14) + 5 = 0$
The sum of the voltages is 0 V.

51. (a) $-6.5 - 14.7 = -21.2$ V

(b) The negative sign indicates that the voltage dropped 21.2 V.

52. (a) $23.7 - (-5.2) = 23.7 + 5.2 = 28.9$ V

(b) The positive sign indicates that the voltage increased 28.9 V.

53. 339 lb $+ 159$ lb $+ 96$ lb $+ 31$ lb $= 626$

54. 6×1.628 in. $= 9.75$ in.

55. $|-285 - 1675| = |-1960| = 1960$ V

56. A loss of 76,300;
$-345,000 + 268,700 = -76,300$

57. $-\$1,135,900$ or a loss of $\$1,135,900$
$\$1,837,500 - \$2,973,400 = -\$1,135,900$

58. $(12 \times 11.95) = (3 \times 79.99) = \$383.37$

59. 8125 wafers on each tool;
$\dfrac{55,000 \text{ wafers a week}}{8 \text{ tools}} = 8$ wafers

60. 73,125 wafers each week
8125 wafers a week $\times$ 9 tools $= 73,125$

61. 8 in. $=$ Rise, 9 in. $=$ Run

62. $2\frac{13}{32} - \frac{7}{64} = 2\frac{26}{64} - \frac{7}{64} = 2\frac{19}{64}$

63. $8\frac{59}{64}$;
$4\frac{7}{8} + 2\frac{7}{33} + 1\frac{33}{64} + \frac{5}{16} 4\frac{56}{64} + 2\frac{14}{64} + 1\frac{33}{64} + \frac{20}{64}$
$\frac{56 + 14 + 33 + 20}{64} = \frac{123}{64} 1\frac{59}{64}$
$4 + 2 + 1 = 7$
$7 + 1\frac{59}{64} = 8\frac{59}{64}$

64. (a) $2\frac{7}{8}$;
$3\frac{1}{4} - \frac{3}{8} = 3\frac{2}{8} - \frac{3}{8}$
$\frac{26}{8} - \frac{3}{8} = \frac{23}{8} = 2\frac{7}{8}$

(b) $2\frac{9}{16}$;
$6\frac{5}{8} - 3\frac{1}{4} = 3\frac{3}{8}$
$3\frac{3}{8} - \frac{13}{16} = 3\frac{6}{16} - \frac{13}{16}$
$\frac{54}{16} - \frac{13}{16} = \frac{41}{16} = 2\frac{9}{16}$

65. (a) $303\frac{3}{4}$;
$\frac{27}{8} \cdot \frac{90}{1} = \frac{2430}{8} = 303\frac{3}{4}$ yards

(b) 304 yards

66. $2.812 - 0.437 = 2.375$

67. (a) $8.426 - (2 \times 1.027) = \dfrac{6.372}{4} = 1.593$

(b) $8.426 - 1.027 = 7.399$

(c) $\dfrac{3.826}{2} = 1.913$

68. (a) 5.329

(b) 1.4298

(c) 1.0695

Notice that in order to determine (a) you need to know the length of (b). Thus we begin by determining (b) and will then find (a). We can see that 1.1625

+ 1.3512 + 1.3814 + (b) + 1.3814 + 1.3512 + 1.1625 = 9.220

7.7902 + (b) = 9.220

(b) = 9.220 − 7.7902

(b) = 1.4298

Now that we know the length (b) we can determine the length (a).

(a) = (b) + 1.3814 + 1.3512 + 1.1625

(a) = 1.4298 + 1.3814 + 1.3512 + 1.1625

(a) = 1.4298

Finally we will find the two numbers (c) and (d).

(c) = 1.7875 + 2.8225 = 4.6100

If you add (d) and the length just to its right, 0.718, you should get 1.7875.

Thus (d) = 1.7875 − 0.718 = 1.0695.

69. $14' − 7\frac{1}{2}''$,

$81' \times \frac{12''}{1'} = 972'' + 1.5'' = 973.5''$

$973.5'' − (48 \times 2) = \frac{877.5}{5} = 175.5$

$175.5'' = 14' − 7\frac{1}{2}''$

70. 40 doses;

$24 \times 2 = 48$

71. $44\frac{1}{2}'' − 11\frac{5}{8}'' − \frac{1}{16}'' − 13\frac{7}{32}'' − \frac{1}{16}'' = 19\frac{17}{32}''$

72. $48'' − 5\frac{3}{8}'' − 12\frac{1}{4}'' − 8\frac{7}{32}'' − 11\frac{9}{16}'' − 3\frac{5}{8}'' = 6\frac{31}{32}''$

73. $12\frac{1}{2}$ ft is 150 in. Only one $76\frac{1}{2}''$ piece can be cut from each length of trim, with $150'' − 76\frac{1}{2}'' − \frac{1}{8}'' = 73\frac{3}{8}''$ left over. Each of six windows has two $76\frac{1}{2}''$ sides, so the sides for these six windows will require 12 pieces. The amount left over from each of these 12 pieces is enough for the bottom of each of the 11 windows. So, all that is left are the sides of the five windows that are $64\frac{1}{2}''$ high. Two pieces of $64\frac{1}{2}''$ trim can be cut from each $12\frac{1}{2}''$ length of trim. So, these windows will require another 5 pieces of trim. Thus, 12 + 5 = 17 pieces of trim should be ordered.

74. The total hours worked were
$7\frac{3}{4} + 7\frac{1}{6} + 8 + 8\frac{3}{5} + 9\frac{3}{8} + 10\frac{1}{2} + 11\frac{2}{3} = 63\frac{7}{120}$ h.
This is $63\frac{7}{120} − 56 = 7\frac{7}{120}$ h more than the estimate.

75. There will be 25 cuts and each one will use
$3\frac{7}{16}'' + \frac{3}{32}'' = 3\frac{17}{32}''$ of band iron. The 25 cuts will use a total of $25 \times 3\frac{17}{32}'' = 88\frac{9}{32}''$ of band iron. The stock that is left over will be $117\frac{3}{4}'' − 88\frac{9}{32}'' = 29\frac{15}{32}''$.

76. $\frac{1}{2}$ of $\frac{1}{4}$ gr is $\frac{1}{2} \times \frac{1}{4}$ gr $= \frac{1}{8}$ gr.

77. $2\frac{1}{2} \times 250 = 625$ mg

1.3 EXPONENTS

1. $5^3 = 5 \times 5 \times 5 = 125$

2. $3.8^0 = 1$ by Rule 6

3. $\left(\frac{2}{3}\right)^{-1} = \frac{2^{-1}}{3^{-1}} = \frac{1/2}{1/3} = \frac{1}{2} \times \frac{3}{1} = \frac{3}{2}$

4. $\left(\frac{3}{5}\right)^{-2} = \frac{3^{-2}}{5^{-2}} = \frac{5^2}{3^2} = \frac{25}{9}$

5. $(−4)^2 = (−4)(−4) = 16$

6. $(−5)^4 = (−5)(−5)(−5)(−5) = 625$

7. $\frac{7}{7^3} = \frac{7^1}{7^3} = 7^{1−3} = 7^{-2} = \frac{1}{7^2} = \frac{1}{49}$

8. $−3^2 = −(3^2) = −(3 \cdot 3) = −9$

9. $3^2 \cdot 3^4 = 3^{2+4} = 3^6$

10. $d^8 d^5 = d^{8+5} = d^{13}$

11. $2^4 \cdot 2^3 \cdot 2^5 = 2^{4+3+5} = 2^{12}$

12. $f^3 f^4 f^1 = f^{3+4+1} = f^8$

13. $\frac{2^5}{2^3} = 2^{5−3} = 2^2$

14. $\frac{5^{14}}{5^3} = 5^{14−3} = 5^{11}$

15. $(2^3)^2 = 2^{3 \times 2} = 2^6$

16. $(5^7)^3 = 5^{7 \times 3} = 5^{21}$

17. $(x^4)^5 = x^{4 \times 5} = x^{20}$

18. $(xy^3)^4 = (x^1 y^3)^4 = x^{1 \times 4} y^{3 \times 4} = x^4 y^{12}$

19. $(a^{-2}b)^{-3} = a^{-2 \times (-3)} b^{-3} = a^6 b^{-3} = \frac{a^6}{b^3}$

20. $\left(\frac{2}{3}\right)^4 = \frac{2^4}{3^4}$; Rule 4a

21. $\left(\frac{x}{4}\right)^3 = \frac{x^3}{4^3}$

22. $\left(\frac{a}{b^3}\right)^5 = \frac{a^5}{b^{3 \times 5}} = \frac{a^5}{b^{15}}$

23. $\left(\frac{a^2 b}{c^3}\right)^4 = \frac{a^{2 \times 4} b^4}{c^{3 \times 4}} = \frac{a^8 b^4}{c^{12}}$

24. $4^{-3} = \dfrac{1}{4^3}$; Rule 7

25. $x^{-7} = \dfrac{1}{x^7}$

26. $\dfrac{1}{p^{-5}} = p^5$

27. $\left(\dfrac{1}{5}\right)^3 = \dfrac{1}{5^3}$

28. $\dfrac{x^4}{x^2} = x^{4-2} = x^2$

29. $\dfrac{7^3}{7^8} = 7^{3-8} = 7^{-5} = \dfrac{1}{7^5}$

30. $\dfrac{5^2}{5^{10}} = 5^{2-10} = 5^{-8} = \dfrac{1}{5^8}$

31. $\dfrac{a^2 y^3}{a^5 y^7} = a^{2-5}y^{3-7} = a^{-3}y^{-4} = \dfrac{1}{a^3}\dfrac{1}{y^4} = \dfrac{1}{a^3 y^4}$

32. $\dfrac{x^4 y b^2}{x y^3 b^5} = x^{4-1}y^{1-3}b^{2-5} = x^3 y^{-2} b^{-3} = \dfrac{x^3}{y^2 b^3}$

33. $\dfrac{a^2 p^5 y^3}{a^6 p^5 y} = a^{2-6}p^{5-5}y^{3-1} = a^{-4}p^0 y^2 = \dfrac{y^2}{a^4}$

34. $\dfrac{p^3 q^4 r^2}{p^4 r^2} = p^{3-4}q^4 r^{2-2} = p^{-1}q^4 r^0 = \dfrac{q^4}{p}$

35. $(pr^2)^{-1} = \dfrac{1}{pr^2}$

36. $\left(\dfrac{2x^2}{y}\right)^{-1} = \dfrac{y}{2x^2}$

37. $\left(\dfrac{4y^3}{5^2}\right)^{-1} = \dfrac{5^2}{4y^3}$

38. $\left(\dfrac{4x^3}{y^2}\right)^{-2} = \dfrac{4^{-2}x^{-6}}{y^{-4}} = \dfrac{y^4}{4^2 x^6}$

    or $\left(\dfrac{4x^3}{y^2}\right)^{-2} = \left(\dfrac{y^2}{4x^3}\right)^2 = \dfrac{y^4}{16x^6}$

39. $\left(\dfrac{2b^2}{y^5}\right)^{-3} = \dfrac{2^{-3}b^{-6}}{y^{-15}} = \dfrac{y^{15}}{2^3 b^6}$

    or $\left(\dfrac{2b^2}{y^5}\right)^{-3} = \left(\dfrac{y^5}{2b^2}\right)^3 = \dfrac{y^{15}}{8b^6}$

40. $(-8pr^2)^{-3} = (-8)^{-3}p^{-3}r^{-6} = \dfrac{1}{-8^3 p^3 r^6} = \dfrac{-1}{8^3 p^3 r^6}$

41. $(-b^4)^6 = (-b^4)(-b^4)(-b^4)(-b^4)(-b^4)(-b^4) = b^{24}$

42. $ap^2(-a^2 p^3)^2 = ap^2(a^4 p^6) = a^{1+4}p^{2+6} = a^5 p^8$

43. 5

44. 6

45. 12

46. 11

47. 2

48. -4

49. -3

50. 3

51. 2

52. -3

53. $\frac{2}{3}$

54. $\frac{-3}{10}$

55. 0.2

56. 0.5

57. -0.1

58. 0.5

59. 3

60. 5

61. 8.32

62. 7.91

63. $\sqrt[3]{5}\,\sqrt[3]{25} = \sqrt[3]{5\cdot 25} = \sqrt[3]{5^3} = 5$

64. $\sqrt[5]{-3}\,\sqrt[5]{81} = \sqrt[5]{-3}\,\sqrt[5]{(-3)^4}$
    $= \sqrt[5]{(-3)^5} = -3$

65. $\sqrt[4]{8}\,\sqrt[4]{9} = \sqrt[4]{8\cdot 9} = \sqrt[4]{72}$

66. $\sqrt[6]{12}\,\sqrt[6]{48} = \sqrt[6]{12\cdot 48} = \sqrt[6]{576} = \sqrt[6]{64}\,\sqrt[6]{9} = $
    $2\sqrt[6]{3^2} = 2\sqrt[6]{3}$

67. $\dfrac{\sqrt{75}}{\sqrt{3}} = \sqrt{\dfrac{75}{3}} = \sqrt{25} = 5$

68. $\dfrac{\sqrt{112}}{\sqrt{7}} = \sqrt{\dfrac{112}{7}} = \sqrt{16} = 4$

69. $\dfrac{\sqrt[3]{5}}{\sqrt[3]{40}} = \sqrt[3]{\dfrac{5}{40}} = \sqrt[3]{\dfrac{1}{8}} = \dfrac{1}{2}$

70. $\dfrac{\sqrt[3]{11}}{\sqrt[3]{297}} = \sqrt[3]{\dfrac{11}{297}} = \sqrt[3]{\dfrac{1}{27}} = \dfrac{1}{3}$

71. $\sqrt[3]{2^3} + \sqrt[4]{5^4} = 2 + 5 = 7$

72. $\sqrt{3^2} - \sqrt[3]{2^3} = 3 - 2 = 1$

73. $\sqrt[3]{\left(\dfrac{2}{3}\right)^3} - \sqrt[4]{\left(\dfrac{1}{3}\right)^4} = \dfrac{2}{3} - \dfrac{1}{3} = \dfrac{1}{3}$

74. $\sqrt[5]{\left(\dfrac{3}{4}\right)^5} + \sqrt[3]{\left(\dfrac{5}{4}\right)^3} = \dfrac{3}{4} + \dfrac{5}{4} = \dfrac{8}{4} = 2$

75. $\sqrt{5^{2/3}} = \left(\sqrt{5^{1/3}}\right)^2 = 5^{1/3}$

76. $\sqrt{7^{2/5}} = \left(\sqrt{7^{1/5}}\right)^2 = 7^{1/5}$

77. $\sqrt[3]{16^{3/4}} = \left(\sqrt[3]{16^{1/4}}\right)^3 = 16^{1/4} = \sqrt[4]{16} = 2$

78. $\sqrt[4]{27^{4/3}} = 27^{1/3} = 3$

79. $16^{3/4} = (\sqrt[4]{16})^3 = 2^3 = 8$

80. $(-27)^{2/3} = (-3)^2 = 9$

81. $(-8)^{2/3} = (-2)^2 = 4$

82. $25^{3/2} = (\sqrt{25})^3 = 5^3 = 125$

83. $8^{-2/3} = (\sqrt[3]{8})^{-2} = 2^{-2} = \dfrac{1}{2^2} = \dfrac{1}{4}$

84. $9^{-3/2} = (\sqrt{9})^{-3} = 3^{-3} = \dfrac{1}{3^3} = \dfrac{1}{27}$

85. $(-27)^{4/3} = (\sqrt[3]{-27})^4 = (-3)^4 = 81$

86. $(-32)^{3/5} = (\sqrt[5]{-32})^3 = -2^3 = -8$

87. $\sqrt{\dfrac{81}{(8)(0.01)}} = \dfrac{\sqrt{81}}{\sqrt{8}\sqrt{0.01}} = \dfrac{9}{2\sqrt{2}(0.1)} = \dfrac{9}{0.2\sqrt{2}}$

88. $\sqrt[3]{\dfrac{(27)(0.008)^2}{0.027}} = \dfrac{\sqrt[3]{27}(\sqrt[3]{0.008})^2}{\sqrt[3]{0.027}} = \dfrac{3(0.2)^2}{0.3}$

$= \dfrac{3(0.04)}{0.3} = 0.4$

89. $\sqrt[3]{\dfrac{(0.125)^3\sqrt{144}}{3/2}} = \dfrac{\sqrt[3]{(0.125)^3}\sqrt[3]{\sqrt{144}}}{\sqrt[3]{3/2}} =$

$\dfrac{\sqrt[3]{(0.125)^3}\sqrt[3]{12}}{\frac{\sqrt[3]{3}}{\sqrt[3]{2}}} = 0.125\sqrt[3]{\dfrac{12 \cdot 2}{3}} =$

$0.125\sqrt[3]{8} = 0.125 \times 2 = 0.25$

90. $\sqrt{\dfrac{64}{(0.25)(0.16)}} = \dfrac{8}{(0.5)(0.4)} = \dfrac{8}{0.2} = 40$

91. First we simplify $((2\pi\,fC)^{-1})^2$ as $(2\pi\,fC)^{-2}$. Next, we compute $(2\pi\,fC)^{-2}$. Substituting the given values of f and C and using the $\boxed{\pi}$ key on the calculator, we obtain $(2\pi\,fC)^{-2} = 0.030159289^{-2} = 1099.405205$. To this, add 40^2, with the result of 2699.405205. Then $\sqrt{2699.405205} = 51.95580049$ gives the answer of 51.96 Ω when rounded off to two decimal places.

92. Substituting the given values, we obtain

$R = \left(\dfrac{1}{0.8} + \dfrac{1}{0.45}\right)^{-1} + 0.76 =$

$\left(\dfrac{0.45 + 0.8}{(0.8)(0.45)}\right)^{-1} + 0.76 = \dfrac{(0.8)(0.45)}{0.8 + 0.45} +$

$0.75 = \dfrac{0.36}{1.25} + 0.76 = 0.288 + 0.76 = 1.048$

The total resistance is 1.048 Ω. Note: On a calcula-tor such as a TI-8x[1] you could have keyed this as

$\boxed{(}\;1\;\boxed{\div}\;.8\;\boxed{+}\;1\;\boxed{\div}\;.45\,)\;\boxed{x^{-1}}\;\boxed{+}\;.76\;\boxed{\text{ENTER}}$

93. Substituting the given values, we obtain

$R = 6.5 + \left(\dfrac{1}{5} + \dfrac{1}{6} + \dfrac{1}{7.5}\right)^{-1} =$

$6.5 + \left(\dfrac{6+5}{(5)(6)} + \dfrac{1}{7.5}\right)^{-1} = 6.5 +$

$\left(\dfrac{11}{30} + \dfrac{1}{7.5}\right)^{-1} = 6.5 + \left(\dfrac{11}{30} + \dfrac{4}{30}\right)^{-1} =$

$6.5 + \left(\dfrac{11+4}{30}\right)^{-1} = 6.5 + \left(\dfrac{15}{30}\right)^{-1} = 6.5 +$

$\left(\dfrac{1}{2}\right)^{-1} = 6.5 + 2 = 8.5$

The total resistance is 8.5 Ω.

Note: On a calculator such as a TI-8x, you could have keyed this as

$6.5\;\boxed{+}\;\boxed{(}\;1\;\boxed{\div}\;5\;\boxed{+}\;1\;\boxed{+}\;6\;\boxed{+}\;1\;\boxed{\div}\;7.5\;\boxed{)}$

$\boxed{x^{-1}}\;\boxed{\text{ENTER}}$

94. Substituting the given values, we obtain

$A = 1{,}200\left(1 + \dfrac{0.068}{12}\right)^{12 \cdot 5} =$

$1{,}200\left(1 + \dfrac{0.068}{12}\right)^{60} \approx 1684.32$

The total amount of money accumulated after 5 years is \$1684.32.

95. $\lambda = \dfrac{3 \times 10^8}{1.435 \times 10^8} = 2.091$ m

96. about 4.601 days

97. $v_L = \sqrt{\dfrac{K}{\rho}} = \sqrt{\dfrac{2.1 \times 10^9}{1000}} = \sqrt{\dfrac{2.1 \times 10^9}{10^3}} =$

$\sqrt{2.1 \times 10^{9-3}} = = \sqrt{2.1 \times 10^6} \approx$

1449.1377 m/sec

98. 2.473 m/sec

99. $c = \sqrt{\dfrac{(2.5) \times (212)}{8}} = 8.14$ cm

100. $A = \sqrt{\dfrac{45}{764}} = 0.24$ A

101. 1.50 A;

$A = \sqrt{\dfrac{220}{98}}$

---

[1]The notation TI-8x refers to something that is true for any of the TI-81, TI-82, TI-83, TI-84, TI-85, TI-86, TI-89, or TI-92 calculators.

102. We are given $D^3 = T \div 02S = \frac{T}{0.2S}$. Substituting the given values for T and S, we obtain

$$D^3 = \frac{T}{0.2S} = \frac{136000}{0.2(38500)} \approx 17.6623.$$

Thus, $D = \sqrt[3]{\dfrac{136000}{0.2(38500)}} \approx 2.6043.$

103. **(a)** For -7^2, press $(-)$ 7 $\wedge$ 2 ENTER . The result should be -49. For $(-7)^2$, press $($ $(-)$ 7 $)$ $\wedge$ 2 ENTER . The result should be 49. Note that you could have used the x^2 key rather than the $\wedge$ 2 keystroke combination.

(b) Different.

(c) The notation -7^2 is a short way of writing $(-1)7^2 = (-1)49 = -49$.

The notation $(-7)^2$ means $(-7)(-7) = 49$.

104. **(a)** For $(2^3)^2$, press $($ 2 $\wedge$ 3 $)$ $\wedge$ 2 ENTER . The result should be 64. For 2^{3^2}, the keystrokes you should use will depend on the type of calculator

you are using. On a TI-8x, press 2 $\wedge$ $($ 3 $\wedge$ 2 $)$ ENTER ; on a Casio calculator, press 2 x^y $($ 3 x^y 2 $)$ ENTER ; on a Sharp calculator, press 2 a^b 3 a^b 2 ENTER . The result should be 512.

(b) Different.

(c) The notation $(2^3)^2 = (8)^2 = 64$. The notation 2^{3^2} means $2^{(3^2)} = 2^9 = 512$.

105. **(a)** $\sqrt{81} = 9$ and $-\sqrt{81} = -9$

(b) 9

(c) $\sqrt[3]{-27} = -3$ and $-\sqrt[3]{27} = 0.3$

(d) -3

106. No solutions found

107. **(a)** 4

(b) 4

(c) Yes

(d) Both represent the cube root of 64

1.4 SIGNIFICANT DIGITS AND ROUNDING OFF

1. Exact

2. Approximate

3. Approximate

4. Exact; exact

5. Approximate

6. Approximate

7. 3

8. 3

9. 3

10. 3

11. 1

12. 3

13. 4

14. 6

15. **(a)** 6.05
(b) 6.05

16. **(a)** 6.324
(b) Both

17. **(a)** 5.01
(b) 0.027

18. **(a)** 19,020
(b) 19,020

19. **(a)** 27,0$\tilde{0}$0
(b) 27,0$\tilde{0}$0

20. **(a)** Both
(b) 0.003

21. **(a)** 86
(b) 0.2

22. **(a)** 305.00
(b) Both

23. **(a)** 140.070
(b) 140.070

24. **(a)** 4
(b) 4.4
(c) 4.36

25. **(a)** 10
(b) 14
(c) 14.4

26. **(a)** 4
(b) 4.1
(c) 4.07

27. **(a)** 7
(b) 7.0
(c) 7.04

28. **(a)** 0.006
(b) 0.0062
(c) 0.00616

29. **(a)** 400
(b) 4$\tilde{0}$0
(c) 403

30. **(a)** 0.04
(b) 0.037
(c) 0.0373

31. **(a)** 300
(b) 310
(c) 305

32. **(a)** 4
(b) 4.4
(c) 4.36

33. **(a)** 10
(b) 14
(c) 14.4

34. **(a)** 4
(b) 4.1
(c) 4.06

35. **(a)** 7
(b) 7.0
(c) 7.04

36. **(a)** 0.006
(b) 0.0062
(c) 0.00616

37. **(a)** 400
(b) 4$\tilde{0}$0
(c) 403

38. **(a)** 0.04
(b) 0.037
(c) 0.0372

39. **(a)** 300
(b) 3$\tilde{0}$0
(c) 305

40. **(a)** 30
(b) 25.3
(c) 25.335

41. (a) 90
   (b) 89.9
   (c) 89.899

42. (a) 130
   (b) 125.4
   (c) 125.376

43. (a) 240
   (b) 237.3
   (c) 237.302

44. (a) 100
   (b) 97.0
   (c) 96.999

45. (a) 440
   (b) 438.0
   (c) 437.998

46. (a) 10
   (b) 12.3
   (c) 12.341

47. (a) 80
   (b) 78.7
   (c) 78.671

48. Absolute error = 0.005 m; relative error = 0.0004; percent error = 0.04%

49. Length: Absolute error is measured value minus true value, so $23.72 - 24 = -0.28$ mm. Relative error is absolute error divided by true value, so $\frac{-0.28}{24} = -0.0117$. Percent error is relative error × 100, so $-0.0117 \times 100 = -1.17\%$

Width: Absolute error; $8.35 - 8 = 0.35$ mm. Relative error; $\frac{0.35}{8} = 0.0438$. Percent error; $0.0438 \times 100 = 4.38\%$ Thickness: Absolute error; $2.98 - 3 = -0.02$ mm. Relative error; $\frac{-0.02}{3} = -0.0067$. Percent error; $-0.0067 \times 100 = -0.67\%$.

50. 24.68

51. 99.37

52. 410.8

53. 1618

54. 82

55. 1020

56. 0.0085

57. 17

58. There are two front lamps, so they draw a total of 2 × 0.417 = 0.834 A. The two tail lamps draw a total current of 2 × 0.457 = 0.914 A. Thus the total for the five lamps is 0.834 + 0.914 + 0.736 = 2.484. Rounded off to three significant digits, this is 2.48 A.

59. To find the total length, we need to multiply 37 × 132 × 0.072. The product is 351.648, which is 351.65 when rounded to five significant digits.

60. (a) We want the product of 379 and 11 ft $10\frac{1}{8}$ in. Convert 11 ft $10\frac{1}{8}$ in. to $11 \times 12 + 10\frac{1}{8}$ in. $= 142\frac{1}{8}$ in. $= 142.125$ in. Now when we multiply this by 379, we obtain 53865.375 in. This is correct to three decimal places, so the answer to **(a)** is 53,865.375 in. $= 4{,}488$ ft $9\frac{3}{8}$ in.
(b) Rounded off to three significant digits, the answer is 53,900 in. = 4,491 ft 8 in.

61. The cutter removes 18 × 0.086 mm = 1.548 mm with each revolution. The total of 597.3 revolutions will remove 597.3 × 1.548 = 924.6204 mm. Rounded off to four significant digits, this is 924.6 mm.

62. (a) April: 12,800 ft; May: 14,000 ft; and June: 9,400 ft.
(b) 12,800 + 14,000 + 9,400 = 36,200 ft.
(c) 12,789 + 13,952 + 9,374 = 36,115 ft.

63. (a) 14,770 m.
(b) 14,765 m.
(c) 14,765.5 m.

1.5 SCIENTIFIC AND ENGINEERING NOTATION

1. 4.2×10^4

2. 3.7×10^8

3. 3.8×10^{-4}

4. 7.5×10^{-6}

5. $9.807\ 00 \times 10^9$

6. 8.700×10^7

7. 9.70×10^{-5}

8. 4.00×10^{-1}

9. 4.3×10^0

10. 2.07×10^0

11. 74×10^3

12. 910×10^6

13. 470×10^{-6}

14. 7.5×10^{-6}

15. 9.80700×10^9

16. 57.00×10^6

17. 53.10×10^{-6}

18. 700×10^{-3}

19. 5.6×10^0

20. 3.08×10^0

21. 4500

22. 370000

23. 40500000

24. 305000000

25. 0.000063

26. 0.0000000187

27. 72

28. 0.96

29. 75 000

30. 19 000 000

31. 47 500 000 000

32. 317 000 000 000

33. 0.000 0392 0

34. 0.001 75

35. 83.15

36. 0.000 000 391 25

37. $(7.6 \times 10^5) \times (2.04 \times 10^{10}) = 15.504 \times 10^{15} = 1.5504 \times 10^{16}$

38. $(4.32 \times 10^7) \times (8.5 \times 10^8) = 36.72 \times 10^{15} = 3.672 \times 10^{16}$

39. $(3.5 \times 10^{-5}) \times (7.6 \times 10^{-7}) = 26.6 \times 10^{-12} = 2.66 \times 10^{-11}$

40. $(4.2 \times 10^{-4}) \times (7.5 \times 10^{-5}) = 31.5 \times 10^{-9} = 3.15 \times 10^{-8}$

41. $(8.4 \times 10^8) \times (3.5 \times 10^{-4}) = 29.4 \times 10^4 = 2.94 \times 10^5$

42. $(4.2 \times 10^{-6}) \times (2.3 \times 10^4) = 9.66 \times 10^{-2}$

43. $(7.04 \times 10^4) \times (3.2 \times 10^{-6}) = 22.528 \times 10^{-2} = 2.2528 \times 10^{-1}$

44. $(3.02 \times 10^{-4}) \times (4.37 \times 10^9) = 13.1974 \times 10^5 = 1.31974 \times 10^6$

45. $(2.88 \times 10^{10}) \div (2.4 \times 10^5) = 1.2 \times 10^5$

46. $(5.55 \times 10^{10}) \div (3.7 \times 10^5) = 1.5 \times 10^5$

47. $(3.75 \times 10^5) \div (1.5 \times 10^8) = 2.5 \times 10^{-3}$

48. $(7.98 \times 10^4) \div (8.4 \times 10^8) = 0.95 \times 10^{-4} = 9.5 \times 10^{-5}$

49. $(3.2 \times 10^{-3}) \div (1.6 \times 10^{-7}) = 2 \times 10^4$

50. $(4.8 \times 10^{-4}) \div (3 \times 10^{-7}) = 1.6 \times 10^3$

51. $(3.6 \times 10^{-7}) \div (2 \times 10^{-4}) = 1.8 \times 10^{-3}$

52. $(9.8 \times 10^{-9}) \div (1.4 \times 10^{-5}) = 7 \times 10^{-4}$

53. $(8.76 \times 10^6)(2.46 \times 10^8)(6.4 \times 10^9) = 137.91744 \times 10^{6+8+9} = 137.91744 \times 10^{23} = 1.3791744 \times 10^{25} \approx 1.38 \times 10^{25}$

54. $(4.36 \times 10^6)(6.25 \times 10^8)(3.87 \times 10^{10}) = 105.4575 \times 10^{24} = 1.054575 \times 10^{26} \approx 1.05 \times 10^{26}$

55. $(2.5 \times 10^5)(6.3 \times 10^8) \div (6.3 \times 10^{-9}) = 2.5 \times 10^{5+8-(-9)} = 2.5 \times 10^{22}$

56. $(2.52 \times 10^4)(8 \times 10^6) \div (3.97 \times 10^9) = 5.0780856 \times 10^{4+6-9} = 5.0780856 \times 10^1 \approx 5.08 \times 10^1$

57. $(5.2 \times 10^{-6})(4.8 \times 10^8) \div (6.4 \times 10^{-12}) = 3.9 \times 10^{-6+8-(-12)} = 3.9 \times 10^{14}$

58. $(9.6 \times 10^7)(8.1 \times 10^5) \div (2.43 \times 10^{14}) = 32 \times 10^{7+5-14} = 3.2 \times 10^{-1}$

59. 675 (answers may vary)

60. 2 200 (answers may vary)

61. $(3 \times 10^{11})(3.7 \times 10^{-6}) = 11.1 \times 10^5 = 1.11 \times 10^6$ mm

62. $(1.5 \times 10^8) \div (3 \times 10^5) = 0.5 \times 10^3 = 5 \times 10^2 = 500$ sec; $500 \div 60 = 8.33$ min

63. $(1.6606 \times 10^{-27})(1.2 \times 10^1)(1.4 \times 10^7) = 2.789808 \times 10^{-27+1+7} = 2.789808 \times 10^{-19}$ kg

64. $(1.6606 \times 10^{-27})(5.5 \times 10^1)(2.3 \times 10^8) = 21.00659 \times 10^{-18} = 2.100659 \times 10^{-17}$ kg

65. One neutron; approximately $(1.6750 \times 10^{-27}) \div (9.1095 \times 10^{-31}) = 1.84 \times 10^3$ times heavier

66. $X_L = 2\pi fL = 2\pi (1 \times 10^7)(1.5 \times 10^{-2}) \approx 9.425 \times 10^5 = 942\ 500\ \Omega$

67. $X_L = 2\pi fL = 2\pi (18 \times 10^6)(2.5 \times 10^{-3}) \approx 282.74 \times 10^3$. The inductive reactance is about $282.74 \times 10^3\ \Omega$.

68. Since the density is the mass divided by the volume, we have

$$
\begin{aligned}
\text{density} &= \frac{5.975 \times 10^{24}}{1.083 \times 10^{21}} \\
&= \frac{5.975}{1.083} \times \frac{10^{24}}{10^{21}} \\
&= \frac{5.975}{1.083} \times 10^{24-21} \\
&\approx 5.517 \times 10^3
\end{aligned}
$$

The density of the earth is about 5.517×10^3 kg/m^3.

69. Easier to express very large and very small numbers. Historically, to use slide rules, numbers were first written in scientific notation.

70. Makes conversion from one unit to another in the metric system more convenient.

CHAPTER 1 REVIEW

1. (a) Integers, rational numbers, real numbers
   (b) Rational numbers, real numbers
   (c) Irrational numbers, real numbers

2. (a) $\sqrt{42}$
   (b) 16
   (c) $\frac{5}{8}$

3. (a) $\frac{3}{2}$
   (b) $\frac{-1}{8}$
   (c) -5

4. (a) 5
   (b) -17
   (c) $-4\sqrt{2}$

5. (a) Commutative law for addition

(b) Distributive law

(c) Additive identity

(d) Multiplicative inverse

6. 64

7. -44

8. 53

9. $37 - (-61) = 37 + 61 = 98$

10. -32

11. $\frac{2}{3} + \frac{-5}{6} = \frac{4}{6} + \frac{-5}{6} = \frac{4-5}{6} = -\frac{1}{6}$

12. $\frac{4}{5} - \frac{5}{6} = \frac{24}{30} - \frac{25}{30} = -\frac{1}{30}$

13. -3

14. -3

15. $-\frac{2}{5}$

16. $3\frac{3}{4} \times -4\frac{1}{3} = \frac{15}{4} \times \frac{-13}{3} = \frac{5}{4} \times \frac{-13}{1} = -\frac{65}{4}$

17. $\frac{2}{3} \div \frac{1}{4} = \frac{2}{3} \times \frac{4}{1} = \frac{8}{3}$

18. $\frac{1}{5} \div \frac{-2}{15} = \frac{1}{5} \times \frac{15}{-2} = \frac{1}{1} \times \frac{3}{-2} = -\frac{3}{2}$

19. $2\frac{1}{2} \div 3\frac{1}{4} = \frac{5}{2} \div \frac{13}{4} = \frac{5}{2} \times \frac{4}{13} = \frac{5}{1} \times \frac{2}{13} = \frac{10}{13}$

20. $-4\frac{1}{3} \div -3\frac{1}{6} = -\frac{13}{3} \div -\frac{19}{6} = -\frac{13}{3} \times -\frac{6}{19} = \frac{26}{19}$

21. $2^5 = 2 \times 2 \times 2 \times 2 \times 2 = 32$

22. $(-3)^4 = (-3)(-3)(-3)(-3) = 81$

23. $(-4)^3 = (-4)(-4)(-4) = -64$

24. $8^{1/3} = \sqrt[3]{8} = 2$

25. $4^{1/2} = \sqrt{4} = 2$

26. $(-64)^{1/3} = \sqrt[3]{-64} = -4$

27. $2^5 \cdot 2^3 = 2^{5+3} = 2^8$

28. $3^5 \cdot 3^4 = 3^{5+4} = 3^9$

29. $2^{-3} \cdot 2^5 = 2^{-3+5} = 2^2$

30. $16^{-4} \cdot 16^{-3} = 16^{-7} = \frac{1}{16^7}$

31. $(4^3)^5 = 4^{3 \cdot 5} = 4^{15}$

32. $(2^{-3})^4 = 2^{(-3)4} = 2^{-12} = \frac{1}{2^{12}}$

33. $(4^{1/3})^3 = 4^1 = 4$

34. $(5^{1/4})^{2/3} = 5^{1/4 \cdot 2/3} = 5^{1/6}$

35. $\dfrac{a^2b^3}{ab^4} = \dfrac{a^{2-1}}{b^{4-3}} = \dfrac{a}{b}$

36. $\dfrac{x^2y^3z}{x^3yz} = \dfrac{y^{3-1}}{x^{3-2}} = \dfrac{y^2}{x}$

37. $(ax^2)^{-2} = a^{-2}x^{-4} = \dfrac{1}{a^2x^4}$ or $(ax^2)^{-2} = \dfrac{1}{(ax^2)^2} = \dfrac{1}{a^2x^4}$

38. $\dfrac{(by^{-2})^2}{(cy^{-4})^{1/4}} = \dfrac{b^2y^{-4}}{c^{1/4}y^{-1}} = \dfrac{b^2}{c^{1/4}y^3}$

39. (a) 2.37

(b) 2.37

40. (a) 2.02

(b) 0.002

41. (a) Both

(b) 0.7

42. (a) Both

(b) 0.0021

(c) 2.1

(d) 2.05

43. (a) 7.4

(b) 7.35

(c) 7.4

(d) 7.35

44. (a) 18

(b) 18.3

(c) 18.3

(d) 18.29

45. (a) 2.1

(b) 2.05

46. (a) 4.0

(b) 4.03

(c) 4.0

(d) 4.03

47. 3.71×10^{11}

48. 2.54×10^{15}

49. 2.4×10^{-11}

50. 4.91×10^{-20}

51. 29.08×10^{15}

52. 753×10^{21}

53. 75×10^{-24}

54. 193×10^{-18}

55. 12

56. -4

57. 5

58. $\frac{6}{11}$

59. (a) An order of 418 items is $\frac{418}{12} \approx 34.83$ dozen. The discount is given only for a full dozen; thus the manufacturer gets a discount on 34 dozen items. The total amount of the discount is $34 \times 12 \times 0.14 = 57.12$, or $57.12.

(b) The total cost before the discount of the 418 items is $418 \times 13.79 = 5764.22$. Subtracting the discount of $57.12, you get $5764.22 - 57.12 = 5707.10$. Thus, the total cost of the order is $5,707.10.

60. (a) Substituting the given data in the above formula, we have

$$E = \frac{3}{2}kT = \frac{3}{2}(8.61733 \times 10^{-5})(295)$$
$$\approx 0.0381316853$$

The average kinetic energy of particles at room temperature ($T = 295$ K) is about 0.038 eV.

(b) Substituting the given data in the above formula, we have

$$E = \frac{3}{2}kT = \frac{3}{2}(8.617\,33 \times 10^{-5})(5.714 \times 10^{3})$$

$$\approx 0.7385913543$$

The average kinetic energy of particles at the surface of the sun ($T = 5.714 \times 10^{3}$ K) is about 0.739 eV.

CHAPTER 1 TEST

1. (a) $\left|\frac{4}{3}\right| = \frac{4}{3}$

  (b) $\left|\frac{1}{2} - \frac{5}{8}\right| = \left|\frac{4}{8} - \frac{5}{8}\right| = \left|-\frac{1}{8}\right| = \frac{1}{8}$

  (c) $|-6| = 6$

2. $-\frac{7}{3}$

3. $\frac{5}{8}$

4. 111

5. -112

6. -70

7. $\frac{5}{3} + 5\frac{2}{3} = \frac{5}{3} + \frac{17}{3} = \frac{22}{3}$ or $7\frac{1}{3}$

8. $\frac{7}{4} - \left(-\frac{3}{5}\right) = \frac{35}{20} + \frac{12}{20} = \frac{47}{20}$

9. $-4\frac{1}{2} \times 2\frac{1}{3} = -\frac{9}{2} \times \frac{7}{3} = -\frac{21}{2}$

10. $-\frac{5}{7} \div \frac{15}{28} = -\frac{5}{7} \times \frac{28}{15} = -\frac{4}{3}$

11. $-2\frac{1}{3} \div -4\frac{5}{6} = -\frac{7}{3} \div -\frac{29}{6} = -\frac{7}{3} \times -\frac{6}{29} = \frac{14}{29}$

12. $(-5)^{3} = (-5)(-5)(-5) = -125$

13. $4^{3/2} = (\sqrt{4})^{3} = 2^{3} = 8$

14. $2^{6} \cdot 2^{-4} = 2^{6-4} = 2^{2} = 4$

15. $(5^{1/4})^{8} = 5^{(1/4)8} = 5^{2} = 25$

16. $3^{5/2} \div 3^{-3/2} = 3^{5/2-(-3/2)} = 3^{5/2+3/2} = 3^{4} = 81$

17. $\dfrac{a^{3}b^{5}}{a^{4}b^{2}} = \dfrac{b^{5-2}}{a^{4-3}} = \dfrac{b^{3}}{a}$

18. 4.516

19. 0.000 51

20. 4.75×10^{13}

21. $\sqrt{\dfrac{49}{25}} = \dfrac{\sqrt{49}}{\sqrt{25}} = \dfrac{7}{5}$

22. 92.5×10^{12}