Answers for Exercises 7, 8, and 25–52 are on page AA1.

EXERCISE SET P.1

Concept Check

1. Which of the following numbers are prime numbers? ii, iv
   i. 39 ii. 53 iii. 102 iv. 97

2. Give an example of a rational number that is not an integer. Answers will vary; for instance, $\frac{2}{3}$

3. If $A = \{-7, -3, 0, 2, 5, 8\}$ and $B = \{-3, -1, 0, 1, 3, 5, 7\}$, what numbers are common to both A and B? -3, 0, and 5

4. Use the numbers $-12, -5, 0, 3, 6$, and 9.
   a. Which number has the greatest absolute value? -12
   b. Which number has the least absolute value? 0

5. If $a < 0$, is a^2 positive or negative? Positive

6. a. Name the endpoints of the interval $[-2, 5)$. -2, 5
   b. Is $0 \in [-2, 5)$? Yes
   c. Is $-2 \in [-2, 5)$? Yes
   d. Is $5 \in [-2, 5)$? No

In Exercises 7 and 8, determine whether each number is an integer, a rational number, an irrational number, a prime number, or a real number.

7. $-\frac{1}{5}, 0, -44, \pi, 3.14, 5.05005000500005\ldots, \sqrt{81}, 53$

8. $\frac{5}{\sqrt{7}}, \frac{5}{7}, 31, -2\frac{1}{2}, 4.235653907493, 51, 0.888\ldots$

In Exercises 9 to 14, list the four smallest elements of each set.

9. $\{2x \mid x \in \text{positive integers}\}$ 2, 4, 6, 8

10. $\{|x| \mid x \in \text{integers}\}$ 0, 1, 2, 3

11. $\{y \mid y = 2x + 1, x \in \text{natural numbers}\}$ 3, 5, 7, 9

12. $\{y \mid y = x^2 - 1, x \in \text{integers}\}$ -1, 0, 3, 8

13. $\{z \mid z = |x|, x \in \text{integers}\}$ 0, 1, 2, 3

14. $\{z \mid z = |x| - x, x \in \text{negative integers}\}$ 2, 4, 6, 8

In Exercises 15 to 24, perform the operations given that $A = \{-3, -2, -1, 0, 1, 2, 3\}$, $B = \{-2, 0, 2, 4, 6\}$, $C = \{0, 1, 2, 3, 4, 5, 6\}$, and $D = \{-3, -1, 1, 3\}$.

15. $A \cup B$ $\{-3, -2, -1, 0, 1, 2, 3, 4, 6\}$

16. $C \cup D$ $\{-3, -1, 0, 1, 2, 3, 4, 5, 6\}$

17. $A \cap C$ $\{0, 1, 2, 3\}$

18. $C \cap D$ $\{1, 3\}$

19. $B \cap D$ $\varnothing$

20. $B \cup (A \cap C)$ $\{-2, 0, 1, 2, 3, 4, 6\}$

21. $D \cap (B \cup C)$ $\{1, 3\}$

22. $(A \cap B) \cup (A \cap C)$ $\{-2, 0, 1, 2, 3\}$

23. $(B \cup C) \cap (B \cup D)$ $\{-2, 0, 1, 2, 3, 4, 6\}$

24. $(A \cap C) \cup (B \cap D)$ $\{0, 1, 2, 3\}$

Indicates Try It Exercises

In Exercises 25 to 36, graph each set. Write sets given in interval notation in set-builder notation, and write sets given in set-builder notation in interval notation.

25. $(-2, 3)$ $\{x \mid -2 < x < 3\}$

26. $[1, 5]$ $\{x \mid 1 \le x \le 5\}$

27. $[-5, -1]$ $\{x \mid -5 \le x \le -1\}$

28. $(-3, 3)$ $\{x \mid -3 < x < 3\}$

29. $[2, \infty)$ $\{x \mid x \ge 2\}$

30. $(-\infty, 4)$ $\{x \mid x < 4\}$

31. $\{x \mid 3 < x < 5\}$ $(3, 5)$

32. $\{x \mid x < -1\}$ $(-\infty, -1)$

33. $\{x \mid x \ge -2\}$ $[-2, \infty)$

34. $\{x \mid -1 \le x < 5\}$ $[-1, 5)$

35. $\{x \mid 0 \le x \le 1\}$ $[0, 1]$

36. $\{x \mid -4 < x \le 5\}$ $(-4, 5]$

In Exercises 37 to 52, graph each set.

37. $(-\infty, 0) \cup [2, 4]$

38. $(-3, 1) \cup (3, 5)$

39. $(-4, 0) \cap [-2, 5]$

40. $(-\infty, 3] \cap (2, 6)$

41. $(1, \infty) \cup (-2, \infty)$

42. $(-4, \infty) \cup (0, \infty)$

43. $(1, \infty) \cap (-2, \infty)$

44. $(-4, \infty) \cap (0, \infty)$

45. $[-2, 4] \cap [4, 5]$

46. $(-\infty, 1] \cap [1, \infty)$

47. $(-2, 4) \cap (4, 5)$

48. $(-\infty, 1) \cap (1, \infty)$

49. $\{x \mid x < -3\} \cup \{x \mid 1 < x < 2\}$

50. $\{x \mid -3 \le x < 0\} \cup \{x \mid x \ge 2\}$

51. $\{x \mid x < -3\} \cup \{x \mid x < 2\}$

52. $\{x \mid x < -3\} \cap \{x \mid x < 2\}$

In Exercises 53 to 62, write each expression without absolute value symbols.

53. $-|-5|$ -5

54. $-|-4|^2$ -16

55. $|3| \cdot |-4|$ 12

56. $|3| - |-7|$ -4

57. $|\pi^2 + 10|$ $\pi^2 + 10$

58. $|\pi^2 - 10|$ $10 - \pi^2$

59. $|x - 4| + |x + 5|$, given $0 < x < 1$ 9

60. $|x + 6| + |x - 2|$, given $0 < x < 2$ 8

61. $|2x| - |x - 1|$, given $0 < x < 1$ $3x - 1$

62. $|x + 1| + |x - 3|$, given $x > 3$ $2x - 2$

In Exercises 63 to 74, use absolute value notation to describe the given situation.

63. $d(m, n)$ $|m - n|$

64. $d(p, 8)$ $|p - 8|$

65. The distance between x and 3 $|x - 3|$

66. The distance between a and -2 $|a + 2|$

67. The distance between x and -2 is 4. $|x + 2| = 4$

68. The distance between z and 5 is 1. $|z - 5| = 1$

69. The distance between a and 4 is less than 5. $|a - 4| < 5$

70. The distance between z and 5 is greater than 7. $|z - 5| > 7$

71. The distance between x and -2 is greater than 4. $|x + 2| > 4$

72. The distance between y and -3 is greater than 6. $|y + 3| > 6$

73. The distance between x and 4 is greater than 0 and less than 1. $0 < |x - 4| < 1$

74. The distance between y and -3 is greater than 0 and less than 0.5. $0 < |y + 3| < 0.5$

In Exercises 75 to 82, evaluate the expression.

75. $-5^3(-4)^2$ -2000

76. $-\dfrac{-6^3}{(-3)^4}$ $\dfrac{8}{3}$

77. $4 + (3 - 8)^2$ 29

78. $-2 \cdot 3^4 - (6 - 7)^6$ -163

79. $28 \div (-7 + 5)^2$ 7

80. $(3 - 5)^2(3^2 - 5^2)$ -64

81. $7 + 2[3(-2)^3 - 4^2 \div 8]$ -45

82. $5 - 4[3 - 6(2 \cdot 3^2 - 12 \div 4)]$ 353

In Exercises 83 to 94, evaluate the variable expression for $x = 3$, $y = -2$, and $z = -1$.

83. $-y^3$ 8

84. $-y^2$ -4

85. $2xyz$ 12

86. $-3xz$ 9

87. $-2x^2y^2$ -72

88. $2y^3z^2$ -16

89. $xy - z(x - y)^2$ 19

90. $(z - 2y)^2 - 3z^3$ 12

91. $\dfrac{x^2 + y^2}{x + y}$ 13

92. $\dfrac{2xy^2z^4}{(y - z)^4}$ 24

93. $\dfrac{3y}{x} - \dfrac{2z}{y}$ -3

94. $(x - z)^2(x + z)^2$ 64

In Exercises 95 to 108, state the property of real numbers or the property of equality that is used.

95. $(ab^2)c = a(b^2c)$ Associative property of multiplication

96. $2x - 3y = -3y + 2x$ Commutative property of addition

97. $4(2a - b) = 8a - 4b$ Distributive property

98. $6 + (7 + a) = 6 + (a + 7)$ Commutative property of addition

99. $(3x)y = y(3x)$ Commutative property of multiplication

100. $4ab + 0 = 4ab$ Identity property of addition

101. $1 \cdot (4x) = 4x$ Identity property of multiplication

102. $7(a + b) = 7(b + a)$ Commutative property of addition

103. $x^2 + 1 = x^2 + 1$ Reflexive property of equality

104. If $a + b = 2$, then $2 = a + b$. Symmetric property of equality

105. If $2x + 1 = y$ and $y = 3x - 2$, then $2x + 1 = 3x - 2$. Transitive property of equality

106. If $4x + 2y = 7$ and $x = 3$, then $4(3) + 2y = 7$. Substitution property of equality

107. $4 \cdot \dfrac{1}{4} = 1$ Inverse property of multiplication

108. $ab + (-ab) = 0$ Inverse property of addition

109. Is division of real numbers an associative operation? Give a reason for your answer. No. $(8 \div 4) \div 2 = 2 \div 2 = 1$, $8 \div (4 \div 2) = 8 \div 2 = 4$

110. Is subtraction of real numbers a commutative operation? Give a reason for your answer. No. $5 - 3 = 2$, $3 - 5 = -2$

111. Which of the properties of real numbers are satisfied by the integers? All but the multiplicative inverse property

112. Which of the properties of real numbers are satisfied by the rational numbers? All

In Exercises 113 to 122, simplify the variable expression.

113. $2 + 3(2x - 5)$ $6x - 13$

114. $4 + 2(2a - 3)$ $4a - 2$

115. $5 - 3(4x - 2y)$ $-12x + 6y + 5$

116. $7 - 2(5n - 8m)$ $16m - 10n + 7$

117. $3(2a - 4b) - 4(a - 3b)$ $2a$

118. $5(4r - 7t) - 2(10r + 3t)$ $-41t$

119. $5a - 2[3 - 2(4a + 3)]$ $21a + 6$

120. $6 + 3[2x - 4(3x - 2)]$ $-30x + 30$

121. $\dfrac{3}{4}(5a + 2) - \dfrac{1}{2}(3a - 5)$ $\dfrac{9}{4}a + 4$

122. $-\dfrac{2}{5}(2x + 3) + \dfrac{3}{4}(3x - 7)$ $\dfrac{29}{20}x - \dfrac{129}{20}$

123. **Area of a Triangle** The area of a triangle is given by

$$\text{Area} = \frac{1}{2}bh$$

where b is the base of the triangle and h is its height. Find the area of a triangle whose base is 3 inches and whose height is 4 inches. 6 in.^{2}

124. **Volume of a Box** The volume of a rectangular box is given by

$$\text{Volume} = lwh$$

where l is the length, w is the width, and h is the height of the box. Find the volume of a classroom that has a length of 40 feet, a width of 30 feet, and a height of 12 feet. 1440 ft^3

125. **Heart Rate** The heart rate, in beats per minute, of a certain runner during a cool-down period can be approximated by

$$\text{Heart rate} = 65 + \frac{53}{4t + 1}$$

where t is the number of minutes after the start of cool-down. Find the runner's heart rate after 10 minutes. Round to the nearest natural number. 66 beats per minute

126. **Body Mass Index** According to the National Institutes of Health, body mass index (BMI) is a measure of body fat based on height and weight that applies to both adult men and women, with values between 18.5 and 24.9 considered healthy. BMI is calculated as $\text{BMI} = \frac{705w}{h^2}$, where w is the person's weight in pounds and h is the person's height in inches. Find the BMI for a person who weighs 160 pounds and is 5 feet 10 inches tall. Round to the nearest natural number.
23

127. **Physics** The height, in feet, of a ball t seconds after it is thrown upward is given by

$$\text{Height} = -16t^2 + 80t + 4$$

Find the height of the ball 2 seconds after it has been thrown upward.
100 ft

128. **Chemistry** Salt is being added to water in such a way that the concentration of salt, in grams per liter, is given by $\text{concentration} = \frac{50t}{t + 1}$, where t is the time in minutes after the introduction of the salt. Find the concentration of salt after 24 minutes. 48 g/L

129. **Sabermetrics** *Slugging percentage* (SLG) is one of the measurements of a baseball player's performance. It is given by the ratio $\frac{\text{singles} + 2 \cdot 2B + 3 \cdot 3B + 4 \cdot 4B}{AB}$, where singles is the number of singles, $2B$ is the number of doubles, $3B$ is the number of triples, and $4B$ is the number of home runs hit by a player. The abbreviation AB is the number of at bats the player had. In 2011, Miguel Cabrera had 197 singles, 48 doubles, 0 triples, 30 home runs, and 572 at bats. Find his SLG. Round to the nearest thousandth. 0.722

130. **Sabermetrics** *Pythagorean expectation* is a formula that tries to determine how many games a team "should have" won during a season. It is based on the number of runs scored by a team in one season and the number of runs allowed by the team for the season. Pythagorean expectation is given by the ratio $\frac{(\text{runs scored})^2}{(\text{runs scored})^2 + (\text{runs allowed})^2}$. Multiplying this ratio by the number of games played in a season (162) gives the number of games the team "should have" won. In 2011, the Boston Red Sox won 90 games, scored 875 runs, and allowed 757 runs. According to the Pythagorean expectation, how many games should the Red Sox have won? Round to the nearest whole number. 93 games

Enrichment Exercises

In Exercises 131 and 132, let *A* and *B* be any two sets.

131. If $A \cap B = B$, what can be said about B? B is a subset of A.

132. If $A \cup B = B$, what can be said about A? A is a subset of B.

In Exercises 133 to 136, let *A* be any set. Perform the given operation.

133. $A \cup A$ A

134. $A \cap A$ A

135. $A \cup \varnothing$ A

136. $A \cap \varnothing$ $\varnothing$

137. If a and b are the coordinates of two points on a number line, give an example of a point whose coordinates are between a and b. Answers may vary; for instance, $\frac{a + b}{2}$

138. Define an operation denoted by $\oplus$ and given by $a \oplus b = a^2 + b^2$. Does $\oplus$ satisfy the commutative property? Does $\oplus$ satisfy the associative property? Yes; no

139. A *deleted delta neighborhood* of a number a on a number line is the set of all points x that are within δ (the Greek letter delta) units of a but not including a. Write the deleted delta neighborhood of a using absolute value notation.
$0 < |x - a| < \delta$