The **set operations** are summarized below.

Set Operations

Let A and B be sets, with universal set U.

The **complement** of set A is the set A' of all elements in the universal set that do *not* belong to set A.

$$A' = \{x \mid x \in U, \quad x \notin A\}$$

The **intersection** of sets A and B, written $A \cap B$, is made up of all the elements belonging to both set A *and* set B.

$$A \cap B = \{x \mid x \in A \text{ and } x \in B\}$$

The **union** of sets A and B, written $A \cup B$, is made up of all the elements belonging to set A *or* to set B.

$$A \cup B = \{x \mid x \in A \text{ or } x \in B\}$$

R.1 Exercises

Identify each set as finite *or* infinite. *Then determine whether* 10 *is an element of the set.* ***See Example 1.***

1. $\{4, 5, 6, \ldots, 15\}$
2. $\{1, 2, 3, 4, 5, \ldots, 75\}$
3. $\{1, \frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \ldots\}$
4. $\{4, 5, 6, \ldots\}$
5. $\{x \mid x \text{ is a natural number greater than } 11\}$
6. $\{x \mid x \text{ is a natural number greater than or equal to } 10\}$
7. $\{x \mid x \text{ is a fraction between 1 and 2}\}$
8. $\{x \mid x \text{ is an even natural number}\}$

Use set notation, and list all the elements of each set. ***See Example 2.***

9. $\{12, 13, 14, \ldots, 20\}$
10. $\{8, 9, 10, \ldots, 17\}$
11. $\{1, \frac{1}{2}, \frac{1}{4}, \ldots, \frac{1}{32}\}$
12. $\{3, 9, 27, \ldots, 729\}$
13. $\{17, 22, 27, \ldots, 47\}$
14. $\{74, 68, 62, \ldots, 38\}$
15. $\{x \mid x \text{ is a natural number greater than 7 and less than 15}\}$
16. $\{x \mid x \text{ is a natural number not greater than 4}\}$

Insert $\in$ *or* $\notin$ *in each blank to make the resulting statement true.* ***See Examples 1 and 2.***

17. 6 _____ $\{3, 4, 5, 6\}$
18. 9 _____ $\{3, 2, 5, 9, 8\}$
19. -4 _____ $\{4, 6, 8, 10\}$
20. -12 _____ $\{3, 5, 12, 14\}$
21. 0 _____ $\{2, 0, 3, 4\}$
22. 0 _____ $\{0, 5, 6, 7, 8, 10\}$
23. $\{3\}$ _____ $\{2, 3, 4, 5\}$
24. $\{5\}$ _____ $\{3, 4, 5, 6, 7\}$
25. $\{0\}$ _____ $\{0, 1, 2, 5\}$
26. $\{2\}$ _____ $\{2, 4, 6, 8\}$
27. 0 _____ $\emptyset$
28. $\emptyset$ _____ $\emptyset$

Determine whether each statement is true *or* false. ***See Examples 1–3.***

29. $3 \in \{2, 5, 6, 8\}$

30. $6 \in \{-2, 5, 8, 9\}$

31. $1 \in \{3, 4, 5, 11, 1\}$

32. $12 \in \{18, 17, 15, 13, 12\}$

33. $9 \notin \{2, 1, 5, 8\}$

34. $3 \notin \{7, 6, 5, 4\}$

35. $\{2, 5, 8, 9\} = \{2, 5, 9, 8\}$

36. $\{3, 0, 9, 6, 2\} = \{2, 9, 0, 3, 6\}$

37. $\{5, 8, 9\} = \{5, 8, 9, 0\}$

38. $\{3, 7, 12, 14\} = \{3, 7, 12, 14, 0\}$

39. $\{x \mid x \text{ is a natural number less than } 3\} = \{1, 2\}$

40. $\{x \mid x \text{ is a natural number greater than } 10\} = \{11, 12, 13, \ldots\}$

Let $A = \{2, 4, 6, 8, 10, 12\}$, $B = \{2, 4, 8, 10\}$, $C = \{4, 10, 12\}$, $D = \{2, 10\}$, *and* $U = \{2, 4, 6, 8, 10, 12, 14\}$.

Determine whether each statement is true *or* false. ***See Example 3.***

41. $A \subseteq U$

42. $C \subseteq U$

43. $D \subseteq B$

44. $D \subseteq A$

45. $A \subseteq B$

46. $B \subseteq C$

47. $\emptyset \subseteq A$

48. $\emptyset \subseteq \emptyset$

49. $\{4, 8, 10\} \subseteq B$

50. $\{0, 2\} \subseteq D$

51. $B \subseteq D$

52. $A \subseteq C$

Insert $\subseteq$ *or* $\not\subseteq$ *in each blank to make the resulting statement true.* ***See Example 3.***

53. $\{2, 4, 6\}$ _____ $\{3, 2, 5, 4, 6\}$

54. $\{1, 5\}$ _____ $\{0, -1, 2, 3, 1, 5\}$

55. $\{0, 1, 2\}$ _____ $\{1, 2, 3, 4, 5\}$

56. $\{5, 6, 7, 8\}$ _____ $\{1, 2, 3, 4, 5, 6, 7\}$

57. $\emptyset$ _____ $\{1, 4, 6, 8\}$

58. $\emptyset$ _____ $\emptyset$

Determine whether each statement is true *or* false. ***See Examples 4–6.***

59. $\{5, 7, 9, 19\} \cap \{7, 9, 11, 15\} = \{7, 9\}$

60. $\{8, 11, 15\} \cap \{8, 11, 19, 20\} = \{8, 11\}$

61. $\{2, 1, 7\} \cup \{1, 5, 9\} = \{1\}$

62. $\{6, 12, 14, 16\} \cup \{6, 14, 19\} = \{6, 14\}$

63. $\{3, 2, 5, 9\} \cap \{2, 7, 8, 10\} = \{2\}$

64. $\{8, 9, 6\} \cup \{9, 8, 6\} = \{8, 9\}$

65. $\{3, 5, 9, 10\} \cap \emptyset = \{3, 5, 9, 10\}$

66. $\{3, 5, 9, 10\} \cup \emptyset = \{3, 5, 9, 10\}$

67. $\{1, 2, 4\} \cup \{1, 2, 4\} = \{1, 2, 4\}$

68. $\{1, 2, 4\} \cap \{1, 2, 4\} = \emptyset$

69. $\emptyset \cup \emptyset = \emptyset$

70. $\emptyset \cap \emptyset = \emptyset$

Let $U = \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13\}$, $M = \{0, 2, 4, 6, 8\}$, $N = \{1, 3, 5, 7, 9, 11, 13\}$, $Q = \{0, 2, 4, 6, 8, 10, 12\}$, *and* $R = \{0, 1, 2, 3, 4\}$.

Use these sets to find each of the following. Identify any disjoint sets. ***See Examples 4–6.***

71. $M \cap R$

72. $M \cap U$

73. $M \cup N$

74. $M \cup R$

75. $M \cap N$

76. $U \cap N$

77. $N \cup R$

78. $M \cup Q$

79. N'

80. Q'

81. $M' \cap Q$

82. $Q \cap R'$

83. $\emptyset \cap R$

84. $\emptyset \cap Q$

85. $N \cup \emptyset$

86. $R \cup \emptyset$

87. $(M \cap N) \cup R$

88. $(N \cup R) \cap M$

89. $(Q \cap M) \cup R$

90. $(R \cup N) \cap M'$

91. $(M' \cup Q) \cap R$

92. $Q \cap (M \cup N)$

93. $Q' \cap (N' \cap U)$

94. $(U \cap \emptyset') \cup R$