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INSTRUCTOR'S SOLUTIONS MANUAL

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PRECALCULUS

SEVENTH EDITION

PRECALCULUS ESSENTIALS

SIXTH EDITION

Robert Blitzer

Miami Dade College





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Chapter P

Fundamental Concepts of Algebra

Section P.1

Check Point Exercises

1. $8 + 6(x - 3)^2 = 8 + 6(13 - 3)^2$
 $= 8 + 6(10)^2$
 $= 8 + 6(100)$
 $= 8 + 600$
 $= 608$
2. a. Since 2016 is 16 years after 2000, substitute 16 for x .
 $T = -x^2 + 361x + 3193$
 $= -(16)^2 + 361(16) + 3193$
 $= 8713$
 The average cost of tuition and fees at public U.S. colleges for the school year ending in 2016 was \$8713.
- b. The formula underestimates the actual answer by \$65.
3. The elements common to $\{3, 4, 5, 6, 7\}$ and $\{3, 7, 8, 9\}$ are 3 and 7.
 $\{3, 4, 5, 6, 7\} \cap \{3, 7, 8, 9\} = \{3, 7\}$
4. The union is the set containing all the elements of either set.
 $\{3, 4, 5, 6, 7\} \cup \{3, 7, 8, 9\} = \{3, 4, 5, 6, 7, 8, 9\}$
5. $\left\{-9, -1.3, 0, 0.\bar{3}, \frac{\pi}{2}, \sqrt{9}, \sqrt{10}\right\}$
 - a. Natural numbers: $\sqrt{9}$ because $\sqrt{9} = 3$
 - b. Whole numbers: $0, \sqrt{9}$
 - c. Integers: $-9, 0, \sqrt{9}$
 - d. Rational numbers: $-9, -1.3, 0, 0.\bar{3}, \sqrt{9}$
 - e. Irrational numbers: $\frac{\pi}{2}, \sqrt{10}$
 - f. Real numbers: $-9, -1.3, 0, 0.\bar{3}, \frac{\pi}{2}, \sqrt{9}, \sqrt{10}$

6. a. $|1 - \sqrt{2}|$
 Because $\sqrt{2} \approx 1.4$, the number inside the absolute value bars is negative. The absolute value of x when $x < 0$ is $-x$. Thus,
 $|1 - \sqrt{2}| = -(1 - \sqrt{2}) = \sqrt{2} - 1$
- b. $|\pi - 3|$
 Because $\pi \approx 3.14$, the number inside the absolute value bars is positive. The absolute value of a positive number is the number itself. Thus,
 $|\pi - 3| = \pi - 3$.
- c. $\frac{|x|}{x}$
 Because $x > 0$, $|x| = x$.
 Thus, $\frac{|x|}{x} = \frac{x}{x} = 1$
7. $|-4 - (5)| = |-9| = 9$
 The distance between -4 and 5 is 9 .
8. $7(4x^2 + 3x) + 2(5x^2 + x)$
 $= 7(4x^2 + 3x) + 2(5x^2 + x)$
 $= 28x^2 + 21x + 10x^2 + 2x$
 $= 38x^2 + 23x$
9. $6 + 4[7 - (x - 2)]$
 $= 6 + 4[7 - x + 2]$
 $= 6 + 4[9 - x]$
 $= 6 + 36 - 4x$
 $= 42 - 4x$

Concept and Vocabulary Check P.1

- C1. expression
- C2. b to the n th power; base; exponent
- C3. formula; modeling; models
- C4. intersection; $A \cap B$
- C5. union; $A \cup B$
- C6. natural

C7. whole

C8. integers

C9. rational

C10. Irrational

C11. rational; irrational

C12. absolute value; x , $-x$

C13. $b+a$; ba

C14. $a+(b+c)$; $(ab)c$

C15. $ab+ac$

C16. 0; inverse; 0; identity

C17. inverse; 1; identity

C18. simplified

C19. a

Exercise Set P.1

1. $7+5(10)=7+50=57$

2. $8+6(5)=8+30=38$

3. $6(3)-8=18-8=10$

4. $8(3)-4=24-4=20$

5. $8^2+3(8)=64+24=88$

6. $6^2+5(6)=36+30=66$

7. $7^2-6(7)+3=49-42+3=7+3=10$

8. $8^2-7(8)+4=64-56+4=8+4=12$

9. $4+5(9-7)^3=4+5(2)^3$
 $=4+5(8)=4+40=44$

10. $6+5(8-6)^3=6+5(2)^3$
 $=6+5(8)$
 $=6+40=46$

11. $8^2-3(8-2)=64-3(6)$
 $=64-18=46$

12. $8^2-4(8-3)=64-4(5)=64-20=44$

13. $\frac{5(x+2)}{2x-14}=\frac{5(10+2)}{2(10)-14}$
 $=\frac{5(12)}{6}$
 $=5 \cdot 2$
 $=10$

14. $\frac{7(x-3)}{2x-16}=\frac{7(9-3)}{2(9)-16}=\frac{7(6)}{2}=7 \cdot 3=21$

15. $\frac{2x+3y}{x+1}; x=-2, y=4$
 $=\frac{2(-2)+3(4)}{-2+1}=\frac{-4+12}{-1}=\frac{8}{-1}=-8$

16. $\frac{2x+y}{xy-2x}; x=-2 \text{ and } y=4$
 $=\frac{2(-2)+4}{(-2)(4)-2(-2)}=\frac{-4+4}{-8+4}=\frac{0}{4}=0$

17. $C=\frac{5}{9}(50-32)=\frac{5}{9}(18)=10$
 50°F is equivalent to 10°C .

18. $C=\frac{5}{9}(F-32)=\frac{5}{9}(86-32)=\frac{5}{9}(54)=30$
 86°F is equivalent to 30°C .

19. $h=4+60t-16t^2=4+60(2)-16(2)^2$
 $=4+120-16(4)=4+120-64$
 $=124-64=60$
 Two seconds after it is kicked, the ball's height is 60 feet.

20. $h=4+60t-16t^2$
 $=4+60(3)-16(3)^2$
 $=4+180-16(9)$
 $=4+180-144$
 $=184-144=40$
 Three seconds after it is kicked, the ball's height is 40 feet.

21. $\{1, 2, 3, 4\} \cap \{2, 4, 5\} = \{2, 4\}$
22. $\{1, 3, 7\} \cap \{2, 3, 8\} = \{3\}$
23. $\{s, e, t\} \cap \{t, e, s\} = \{s, e, t\}$
24. $\{r, e, a, l\} \cap \{l, e, a, r\} = \{r, e, a, l\}$
25. $\{1, 3, 5, 7\} \cap \{2, 4, 6, 8, 10\} = \{ \}$
The empty set is also denoted by $\emptyset$.
26. $\{1, 3, 5, 7\} \cap \{-5, -3, -1\} = \{ \}$ or $\emptyset$
27. $\{a, b, c, d\} \cap \emptyset = \emptyset$
28. $\{w, y, z\} \cap \emptyset = \emptyset$
29. $\{1, 2, 3, 4\} \cup \{2, 4, 5\} = \{1, 2, 3, 4, 5\}$
30. $\{1, 3, 7, 8\} \cup \{2, 3, 8\} = \{1, 2, 3, 7, 8\}$
31. $\{1, 3, 5, 7\} \cup \{2, 4, 6, 8, 10\}$
 $= \{1, 2, 3, 4, 5, 6, 7, 8, 10\}$
32. $\{0, 1, 3, 5\} \cup \{2, 4, 6\} = \{0, 1, 2, 3, 4, 5, 6\}$
33. $\{a, e, i, o, u\} \cup \emptyset = \{a, e, i, o, u\}$
34. $\{e, m, p, t, y\} \cup \emptyset = \{e, m, p, t, y\}$
35. a. $\sqrt{100}$
b. $0, \sqrt{100}$
c. $-9, 0, \sqrt{100}$
d. $-9, -\frac{4}{5}, 0, 0.25, 9.2, \sqrt{100}$
e. $\sqrt{3}$
f. $-9, -\frac{4}{5}, 0, 0.25, \sqrt{3}, 9.2, \sqrt{100}$
36. a. $\sqrt{49}$
b. $0, \sqrt{49}$
c. $-7, 0, \sqrt{49}$
d. $-7, -0.\overline{6}, 0, \sqrt{49}$
e. $\sqrt{50}$
f. $-7, -0.\overline{6}, 0, \sqrt{49}, \sqrt{50}$
37. a. $\sqrt{64}$
b. $0, \sqrt{64}$
c. $-11, 0, \sqrt{64}$
d. $-11, -\frac{5}{6}, 0, 0.75, \sqrt{64}$
e. $\sqrt{5}, \pi$
f. $-11, -\frac{5}{6}, 0, 0.75, \sqrt{5}, \pi, \sqrt{64}$
38. a. $\sqrt{4}$
b. $0, \sqrt{4}$
c. $-5, 0, \sqrt{4}$
d. $-5, -0.\overline{3}, 0, \sqrt{4}$
e. $\sqrt{2}$
f. $-5, -0.\overline{3}, 0, \sqrt{2}, \sqrt{4}$
39. 0
40. Answers will vary. An example is $\frac{1}{2}$.
41. Answers will vary. An example is 2.
42. Answers will vary. An example is -2.
43. true; -13 is to the left of -2 on the number line.
44. false; -6 is to the left of 2 on the number line.
45. true; 4 is to the right of -7 on the number line.
46. true; -13 is to the left of -5 on the number line.
47. true; $-\pi = -\pi$
48. true; -3 is to the right of -13 on the number line.
49. true; 0 is to the right of -6 on the number line.
50. true; 0 is to the right of -13 on the number line.
51. $|300| = 300$
52. $|-203| = 203$

53. $|12 - \pi| = 12 - \pi$
54. $|7 - \pi| = 7 - \pi$
55. $|\sqrt{2} - 5| = 5 - \sqrt{2}$
56. $|\sqrt{5} - 13| = 13 - \sqrt{5}$
57. $\frac{-3}{|-3|} = \frac{-3}{3} = -1$
58. $\frac{-7}{|-7|} = \frac{-7}{7} = -1$
59. $||-3| - |-7|| = |3 - 7| = |-4| = 4$
60. $||-5| - |-13|| = |5 - 13| = |-8| = 8$
61. $|x + y| = |2 + (-5)| = |-3| = 3$
62. $|x - y| = |2 - (-5)| = |7| = 7$
63. $|x| + |y| = |2| + |-5| = 2 + 5 = 7$
64. $|x| - |y| = |2| - |-5| = 2 - 5 = -3$
65. $\frac{y}{|y|} = \frac{-5}{|-5|} = \frac{-5}{5} = -1$
66. $\frac{|x|}{x} + \frac{|y|}{y} = \frac{|2|}{2} + \frac{|-5|}{-5} = \frac{2}{2} + \frac{5}{-5} = 1 + (-1) = 0$
67. The distance is $|2 - 17| = |-15| = 15$.
68. The distance is $|4 - 15| = |-11| = 11$.
69. The distance is $|-2 - 5| = |-7| = 7$.
70. The distance is $|-6 - 8| = |-14| = 14$.
71. The distance is $|-19 - (-4)| = |-19 + 4| = |-15| = 15$.
72. The distance is $|-26 - (-3)| = |-26 + 3| = |-23| = 23$.
73. The distance is $|-3.6 - (-1.4)| = |-3.6 + 1.4| = |-2.2| = 2.2$.
74. The distance is $|-5.4 - (-1.2)| = |-5.4 + 1.2| = |-4.2| = 4.2$.
75. $6 + (-4) = (-4) + 6$;
commutative property of addition
76. $11 \cdot (7 + 4) = 11 \cdot 7 + 11 \cdot 4$;
distributive property of multiplication over addition
77. $6 + (2 + 7) = (6 + 2) + 7$;
associative property of addition
78. $6 \cdot (2 \cdot 3) = 6 \cdot (3 \cdot 2)$;
commutative property of multiplication
79. $(2 + 3) + (4 + 5) = (4 + 5) + (2 + 3)$;
commutative property of addition
80. $7 \cdot (11 \cdot 8) = (11 \cdot 8) \cdot 7$;
commutative property of multiplication
81. $2(-8 + 6) = -16 + 12$;
distributive property of multiplication over addition
82. $-8(3 + 11) = -24 + (-88)$;
distributive property of multiplication over addition
83. $\frac{1}{x+3}(x+3) = 1; x \neq -3$;
inverse property of multiplication
84. $(x+4) + [-(x+4)] = 0$;
inverse property of addition
85. $5(3x+4) - 4 = 5 \cdot 3x + 5 \cdot 4 - 4$
 $= 15x + 20 - 4$
 $= 15x + 16$
86. $2(5x+4) - 3 = 2 \cdot 5x + 2 \cdot 4 - 3$
 $= 10x + 8 - 3$
 $= 10x + 5$
87. $5(3x-2) + 12x = 5 \cdot 3x - 5 \cdot 2 + 12x$
 $= 15x - 10 + 12x$
 $= 27x - 10$
88. $2(5x-1) + 14x = 2 \cdot 5x - 2 \cdot 1 + 14x$
 $= 10x - 2 + 14x$
 $= 24x - 2$

$$\begin{aligned} 89. \quad & 7(3y-5)+2(4y+3) \\ & = 7 \cdot 3y - 7 \cdot 5 + 2 \cdot 4y + 2 \cdot 3 \\ & = 21y - 35 + 8y + 6 \\ & = 29y - 29 \end{aligned}$$

$$\begin{aligned} 90. \quad & 4(2y-6)+3(5y+10) \\ & = 4 \cdot 2y - 4 \cdot 6 + 3 \cdot 5y + 3 \cdot 10 \\ & = 8y - 24 + 15y + 30 \\ & = 23y + 6 \end{aligned}$$

$$\begin{aligned} 91. \quad & 5(3y-2)-(7y+2) = 15y-10-7y-2 \\ & = 8y-12 \end{aligned}$$

$$\begin{aligned} 92. \quad & 4(5y-3)-(6y+3) = 20y-12-6y-3 \\ & = 14y-15 \end{aligned}$$

$$\begin{aligned} 93. \quad & 7-4[3-(4y-5)] = 7-4[3-4y+5] \\ & = 7-4[8-4y] \\ & = 7-32+16y \\ & = 16y-25 \end{aligned}$$

$$\begin{aligned} 94. \quad & 6-5[8-(2y-4)] = 6-5[8-2y+4] \\ & = 6-5[12-2y] \\ & = 6-60+10y \\ & = 10y-54 \end{aligned}$$

$$\begin{aligned} 95. \quad & 18x^2+4-[6(x^2-2)+5] \\ & = 18x^2+4-[6x^2-12+5] \\ & = 18x^2+4-[6x^2-7] \\ & = 18x^2+4-6x^2+7 \\ & = 18x^2-6x^2+4+7 \\ & = (18-6)x^2+11 = 12x^2+11 \end{aligned}$$

$$\begin{aligned} 96. \quad & 14x^2+5-[7(x^2-2)+4] \\ & = 14x^2+5-[7x^2-14+4] \\ & = 14x^2+5-[7x^2-10] \\ & = 14x^2+5-7x^2+10 \\ & = 14x^2-7x^2+5+10 \\ & = (14-7)x^2+15 \\ & = 7x^2+15 \end{aligned}$$

$$97. \quad -(-14x) = 14x$$

$$98. \quad -(-17y) = 17y$$

$$99. \quad -(2x-3y-6) = -2x+3y+6$$

$$100. \quad -(5x-13y-1) = -5x+13y+1$$

$$101. \quad \frac{1}{3}(3x)+[(4y)+(-4y)] = x+0 = x$$

$$102. \quad \frac{1}{2}(2y)+[(-7x)+7x] = y+0 = y$$

$$\begin{aligned} 103. \quad & |-6| \square |-3| \\ & 6 \square 3 \\ & 6 > 3 \\ & \text{Since } 6 > 3, \quad |-6| > |-3|. \end{aligned}$$

$$\begin{aligned} 104. \quad & |-20| \square |-50| \\ & 20 \square 50 \\ & 20 < 50 \\ & \text{Since } 20 < 50, \quad |-20| < |-50|. \end{aligned}$$

$$\begin{aligned} 105. \quad & \left|\frac{3}{5}\right| \square |-0.6| \\ & |0.6| \square |-0.6| \\ & 0.6 \square 0.6 \\ & 0.6 = 0.6 \\ & \text{Since } 0.6 = 0.6, \quad \left|\frac{3}{5}\right| = |-0.6|. \end{aligned}$$

$$\begin{aligned} 106. \quad & \left|\frac{5}{2}\right| \square |-2.5| \\ & |2.5| \square |-2.5| \\ & 2.5 \square 2.5 \\ & 2.5 = 2.5 \\ & \text{Since } 2.5 = 2.5, \quad \left|\frac{5}{2}\right| = |-2.5|. \end{aligned}$$

$$\begin{aligned}
 107. \quad \frac{30}{40} - \frac{3}{4} &\square \frac{14}{15} \cdot \frac{15}{14} \\
 \frac{30}{40} - \frac{30}{40} &\square \frac{\cancel{14}}{\cancel{15}} \cdot \frac{\cancel{15}}{\cancel{14}} \\
 0 &\square 1 \\
 0 &< 1
 \end{aligned}$$

$$\text{Since } 0 < 1, \frac{30}{40} - \frac{3}{4} < \frac{14}{15} \cdot \frac{15}{14}.$$

$$\begin{aligned}
 108. \quad \frac{17}{18} \cdot \frac{18}{17} &\square \frac{50}{60} - \frac{5}{6} \\
 \frac{\cancel{17}}{\cancel{18}} \cdot \frac{\cancel{18}}{\cancel{17}} &\square \frac{50}{60} - \frac{50}{60} \\
 1 &\square 0 \\
 1 &> 0
 \end{aligned}$$

$$\text{Since } 1 > 0, \frac{17}{18} \cdot \frac{18}{17} > \frac{50}{60} - \frac{5}{6}.$$

$$\begin{aligned}
 109. \quad \frac{8}{13} \div \frac{8}{13} &\square |-1| \\
 \frac{8}{13} \cdot \frac{13}{8} &\square 1 \\
 1 &\square 1 \\
 1 &= 1
 \end{aligned}$$

$$\text{Since } 1 = 1, \frac{8}{13} \div \frac{8}{13} = |-1|.$$

$$\begin{aligned}
 110. \quad |-2| &\square \frac{4}{17} \div \frac{4}{17} \\
 2 &\square \frac{4}{17} \cdot \frac{17}{4} \\
 2 &\square 1 \\
 2 &> 1
 \end{aligned}$$

$$\text{Since } 2 > 1, |-2| > \frac{4}{17} \div \frac{4}{17}.$$

$$\begin{aligned}
 111. \quad 8^2 - 16 \div 2^2 \cdot 4 - 3 &= 64 - 16 \div 4 \cdot 4 - 3 \\
 &= 64 - 4 \cdot 4 - 3 \\
 &= 64 - 16 - 3 \\
 &= 48 - 3 \\
 &= 45
 \end{aligned}$$

$$\begin{aligned}
 112. \quad 10^2 - 100 \div 5^2 \cdot 2 - 3 &= 100 - 100 \div 25 \cdot 2 - 3 \\
 &= 100 - 4 \cdot 2 - 3 \\
 &= 100 - 8 - 3 \\
 &= 92 - 3 \\
 &= 89
 \end{aligned}$$

$$\begin{aligned}
 113. \quad \frac{5 \cdot 2 - 3^2}{[3^2 - (-2)]^2} &= \frac{5 \cdot 2 - 9}{[9 - (-2)]^2} \\
 &= \frac{10 - 9}{[9 + 2]^2} \\
 &= \frac{10 - 9}{11^2} \\
 &= \frac{1}{121}
 \end{aligned}$$

$$\begin{aligned}
 114. \quad \frac{10 \div 2 + 3 \cdot 4}{(12 - 3 \cdot 2)^2} &= \frac{5 + 12}{(12 - 6)^2} \\
 &= \frac{17}{6^2} \\
 &= \frac{17}{36}
 \end{aligned}$$

$$\begin{aligned}
 115. \quad 8 - 3[-2(2 - 5) - 4(8 - 6)] &= 8 - 3[-2(-3) - 4(2)] \\
 &= 8 - 3[6 - 8] \\
 &= 8 - 3[-2] \\
 &= 8 + 6 \\
 &= 14
 \end{aligned}$$

$$\begin{aligned}
 116. \quad 8 - 3[-2(5 - 7) - 5(4 - 2)] &= 8 - 3[-2(-2) - 5(2)] \\
 &= 8 - 3[4 - 10] \\
 &= 8 - 3[-6] \\
 &= 8 + 18 \\
 &= 26
 \end{aligned}$$

$$\begin{aligned}
 117. \quad \frac{2(-2) - 4(-3)}{5 - 8} &= \frac{-4 + 12}{-3} \\
 &= \frac{8}{-3} \\
 &= -\frac{8}{3}
 \end{aligned}$$

$$\begin{aligned}
 118. \quad \frac{6(-4) - 5(-3)}{9 - 10} &= \frac{-24 + 15}{-1} \\
 &= \frac{-9}{-1} \\
 &= 9
 \end{aligned}$$

$$\begin{aligned}
 119. \quad \frac{(5-6)^2 - 2|3-7|}{89-3 \cdot 5^2} &= \frac{(-1)^2 - 2|-4|}{89-3 \cdot 25} \\
 &= \frac{1-2(4)}{89-75} \\
 &= \frac{1-8}{14} \\
 &= \frac{-7}{14} \\
 &= -\frac{1}{2}
 \end{aligned}$$

$$\begin{aligned}
 120. \quad \frac{12 \div 3 \cdot 5|2^2 + 3^2|}{7+3-6^2} &= \frac{12 \div 3 \cdot 5|4+9|}{7+3-36} \\
 &= \frac{4 \cdot 5|13|}{10-36} \\
 &= \frac{20(13)}{-26} \\
 &= \frac{260}{-26} \\
 &= -10
 \end{aligned}$$

$$121. \quad x - (x + 4) = x - x - 4 = -4$$

$$122. \quad x - (8 - x) = x - 8 + x = 2x - 8$$

$$123. \quad 6(-5x) = -30x$$

$$124. \quad 10(-4x) = -40x$$

$$125. \quad 5x - 2x = 3x$$

$$126. \quad 6x - (-2x) = 6x + 2x = 8x$$

$$127. \quad 8x - (3x + 6) = 8x - 3x - 6 = 5x - 6$$

$$128. \quad 8 - 3(x + 6) = 8 - 3x - 18 = -3x - 10$$

$$\begin{aligned}
 129. \quad \text{a.} \quad H &= \frac{7}{10}(220 - a) \\
 H &= \frac{7}{10}(220 - 20) \\
 &= \frac{7}{10}(200) \\
 &= 140
 \end{aligned}$$

The lower limit of the heart rate for a 20-year-old with this exercise goal is 140 beats per minute.

$$\begin{aligned}
 \text{b.} \quad H &= \frac{4}{5}(220 - a) \\
 H &= \frac{4}{5}(220 - 20) \\
 &= \frac{4}{5}(200) \\
 &= 160
 \end{aligned}$$

The upper limit of the heart rate for a 20-year-old with this exercise goal is 160 beats per minute.

$$\begin{aligned}
 130. \quad \text{a.} \quad H &= \frac{1}{2}(220 - a) \\
 H &= \frac{1}{2}(220 - 30) \\
 &= \frac{1}{2}(190) \\
 &= 95
 \end{aligned}$$

The lower limit of the heart rate for a 30-year-old with this exercise goal is 95 beats per minute.

$$\begin{aligned}
 \text{b.} \quad H &= \frac{3}{5}(220 - a) \\
 H &= \frac{3}{5}(220 - 30) \\
 &= \frac{3}{5}(190) \\
 &= 114
 \end{aligned}$$

The upper limit of the heart rate for a 30-year-old with this exercise goal is 114 beats per minute.

$$\begin{aligned}
 131. \quad \text{a.} \quad \text{Model 1} \\
 T &= 975x + 13,547 \\
 &= 975(18) + 13,547 \\
 &= 31,097
 \end{aligned}$$

Model 1 estimates the cost to have been \$31,097 in 2018, which overestimates the actual cost by \$366.

$$\begin{aligned}
 \text{Model 2} \\
 T &= 32x^2 + 331x + 15,479 \\
 &= 32(18)^2 + 331(18) + 15,479 \\
 &= 31,805
 \end{aligned}$$

Model 2 estimates the cost to have been \$31,805 in 2018, which overestimates the actual cost by \$1074.

b. Model 2

$$\begin{aligned} T &= 32x^2 + 331x + 15,479 \\ &= 32(30)^2 + 331(30) + 15,479 \\ &= 54,209 \end{aligned}$$

Model 2 estimates the cost will be \$54,209 in 2030.

132. a. Model 1

$$\begin{aligned} T &= 975x + 13,547 \\ &= 975(10) + 13,547 \\ &= 23,297 \end{aligned}$$

Model 1 estimates the cost to have been \$23,297 in 2010, which overestimates the actual cost by \$1028.

Model 2

$$\begin{aligned} T &= 32x^2 + 331x + 15,479 \\ &= 32(10)^2 + 331(10) + 15,479 \\ &= 21,989 \end{aligned}$$

Model 2 estimates the cost to have been \$21,989 in 2010, which underestimates the actual cost by \$280.

b. Model 2

$$\begin{aligned} T &= 32x^2 + 331x + 15,479 \\ &= 32(25)^2 + 331(25) + 15,479 \\ &= 43,754 \end{aligned}$$

Model 2 estimates the cost will be \$43,754 in 2025.

133. a.
$$\begin{aligned} &0.015x + 0.0175(6000 - x) \\ &= 0.015x + 105 - 0.0175x \\ &= 105 - 0.0025x \end{aligned}$$

b.
$$\begin{aligned} &0.015x + 0.0175(6000 - x) \\ &= 0.015(4400) + 0.0175(6000 - 4400) \\ &= 0.015(4400) + 0.0175(1600) \\ &= 94 \end{aligned}$$

$$\begin{aligned} &105 - 0.0025x \\ &= 105 - 0.0025(4400) \\ &= 94 \end{aligned}$$

Both expressions determine the total interest is \$94

c.
$$\begin{aligned} &105 - 0.0025x \\ &= 105 - 0.0025(3000) \\ &= 97.5 \end{aligned}$$

The total interest is \$97.50

134. a.
$$\begin{aligned} &0.06t + 0.5(50 - t) \\ &= 0.06t + 25 - 0.5t \\ &= 25 - 0.44t \end{aligned}$$

b.
$$\begin{aligned} &0.06t + 0.5(50 - t) \\ &= 0.06t + 0.5(50 - 20) \\ &= 0.06(20) + 0.5(30) \\ &= 16.2 \end{aligned}$$

$$\begin{aligned} &25 - 0.44t \\ &= 25 - 0.44(20) \\ &= 16.2 \end{aligned}$$

Both expressions determine the total distance is 16.2 miles.

c.
$$\begin{aligned} &25 - 0.44t \\ &= 25 - 0.44(25) \\ &= 14 \end{aligned}$$

The total distance is 14 miles

135. – 143. Answers will vary.

144. does not make sense; Explanations will vary. Sample explanation: Models do not always accurately predict future values.

145. does not make sense; Explanations will vary. Sample explanation: To use the model, substitute 0 for x .

146. makes sense

147. does not make sense; Explanations will vary. Sample explanation: The commutative property changes order and the associative property changes groupings.

148. false; Changes to make the statement true will vary. A sample change is: Some rational numbers are not integers.

149. false; Changes to make the statement true will vary. A sample change is: All whole numbers are integers.

150. true

151. false; Changes to make the statement true will vary.
A sample change is: Some irrational numbers are negative.

152. false; Changes to make the statement true will vary.
A sample change is: The term x has a coefficient of 1.

153. false; Changes to make the statement true will vary.
A sample change is:
 $5 + 3(x - 4) = 5 + 3x - 12 = 3x - 7$.

154. false; Changes to make the statement true will vary.
A sample change is: $-x - x = -2x$.

155. true

156. $\sqrt{2} \approx 1.4$
 $1.4 < 1.5$
 $\sqrt{2} < 1.5$

157. $-\pi > -3.5$

158. $-\frac{3.14}{2} = -1.57$
 $-\frac{\pi}{2} \approx -1.571$
 $-1.57 > -1.571$
 $-\frac{3.14}{2} > -\frac{\pi}{2}$

159. a. $b^4 \cdot b^3 = (b \cdot b \cdot b \cdot b)(b \cdot b \cdot b) = b^7$
b. $b^5 \cdot b^5 = (b \cdot b \cdot b \cdot b \cdot b)(b \cdot b \cdot b \cdot b \cdot b) = b^{10}$
c. add the exponents

160. a. $\frac{b^7}{b^3} = \frac{b \cdot b \cdot b \cdot b \cdot b \cdot b \cdot b}{b \cdot b \cdot b} = b^4$
b. $\frac{b^8}{b^2} = \frac{b \cdot b \cdot b \cdot b \cdot b \cdot b \cdot b \cdot b}{b \cdot b} = b^6$

c. subtract the exponents

161. $6.2 \times 10^3 = 6.2 \times 10 \times 10 \times 10 = 6200$
It moves the decimal point 3 places to the right.

Section P.2

Check Point Exercises

1. a. $(2x^3y^6)^4 = (2)^4(x^3)^4(y^6)^4 = 16x^{12}y^{24}$

b. $(-6x^2y^5)(3xy^3) = (-6) \cdot 3 \cdot x^2 \cdot x \cdot y^5 \cdot y^3$
 $= -18x^3y^8$

c. $\frac{100x^{12}y^2}{20x^{16}y^{-4}} = \left(\frac{100}{20}\right)\left(\frac{x^{12}}{x^{16}}\right)\left(\frac{y^2}{y^{-4}}\right)$
 $= 5x^{12-16}y^{2-(-4)}$
 $= 5x^{-4}y^6$
 $= \frac{5y^6}{x^4}$

d. $\left(\frac{5x}{y^4}\right)^{-2} = \frac{(5)^{-2}(x)^{-2}}{(y^4)^{-2}}$
 $= \frac{(5)^{-2}(x)^{-2}}{(y^4)^{-2}}$
 $= \frac{5^{-2}x^{-2}}{y^{-8}}$
 $= \frac{y^8}{5^2x^2}$
 $= \frac{y^8}{25x^2}$

2. a. $-2.6 \times 10^9 = -2,600,000,000$

b. $3.017 \times 10^{-6} = 0.000003017$

3. a. $5,210,000,000 = 5.21 \times 10^9$

b. $-0.00000006893 = -6.893 \times 10^{-8}$

4. $410 \times 10^7 = (4.1 \times 10^2) \times 10^7$
 $= 4.1 \times (10^2 \times 10^7)$
 $= 4.1 \times 10^9$

$$\begin{aligned}
 5 \quad \text{a.} \quad & (7.1 \times 10^5)(5 \times 10^{-7}) \\
 & = 7.1 \cdot 5 \times 10^5 \cdot 10^{-7} \\
 & = 35.5 \times 10^{-2} \\
 & = (3.55 \times 10^1) \times 10^{-2} \\
 & = 3.55 \times (10^1 \times 10^{-2}) \\
 & = 3.55 \times 10^{-1}
 \end{aligned}$$

$$\begin{aligned}
 \text{b.} \quad & \frac{1.2 \times 10^6}{3 \times 10^{-3}} = \frac{1.2}{3} \cdot \frac{10^6}{10^{-3}} \\
 & = 0.4 \times 10^{6-(-3)} \\
 & = 0.4 \times 10^9 \\
 & = 4 \times 10^8
 \end{aligned}$$

$$\begin{aligned}
 6. \quad & \frac{13,500,000,000,000}{309,000,000} = \frac{1.35 \times 10^{13}}{3.09 \times 10^8} = \frac{1.35}{3.09} \cdot \frac{10^{13}}{10^8} \\
 & = 0.44 \times 10^5 \\
 & = 44,000
 \end{aligned}$$

Each citizen would have to pay \$44,000 in 2010. This would be an increase of \$33,000, per citizen, between 2010 and 2020.

Concept and Vocabulary Check P.2

C1. b^{m+n} ; add

C2. b^{m-n} ; subtract

C3. 1

C4. $\frac{1}{b^n}$

C5. false

C6. b^n

C7. true

C8. a number greater than or equal to 1 and less than 10; integer

C9. true

C10. False

Exercise Set P.2

$$1. \quad 5^2 \cdot 2 = (5 \cdot 5) \cdot 2 = 25 \cdot 2 = 50$$

$$2. \quad 6^2 \cdot 2 = (6 \cdot 6) \cdot 2 = 36 \cdot 2 = 72$$

$$3. \quad (-2)^6 = (-2)(-2)(-2)(-2)(-2)(-2) = 64$$

$$4. \quad (-2)^4 = (-2)(-2)(-2)(-2) = 16$$

$$5. \quad -2^6 = -2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 = -64$$

$$6. \quad -2^4 = -2 \cdot 2 \cdot 2 \cdot 2 = -16$$

$$7. \quad (-3)^0 = 1$$

$$8. \quad (-9)^0 = 1$$

$$9. \quad -3^0 = -1$$

$$10. \quad -9^0 = -1$$

$$11. \quad 4^{-3} = \frac{1}{4^3} = \frac{1}{4 \cdot 4 \cdot 4} = \frac{1}{64}$$

$$12. \quad 2^{-6} = \frac{1}{2^6} = \frac{1}{2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2} = \frac{1}{64}$$

$$13. \quad 2^2 \cdot 2^3 = 2^{2+3} = 2^5 = 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 = 32$$

$$14. \quad 3^3 \cdot 3^2 = 3^{3+2} = 3^5 = 3 \cdot 3 \cdot 3 \cdot 3 \cdot 3 = 243$$

$$15. \quad (2^2)^3 = 2^{2 \cdot 3} = 2^6 = 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 = 64$$

$$16. \quad (3^3)^2 = 3^{3 \cdot 2} = 3^6 = 3 \cdot 3 \cdot 3 \cdot 3 \cdot 3 \cdot 3 = 729$$

$$17. \quad \frac{2^8}{2^4} = 2^{8-4} = 2^4 = 2 \cdot 2 \cdot 2 \cdot 2 = 16$$

$$18. \quad \frac{3^8}{3^4} = 3^{8-4} = 3^4 = 3 \cdot 3 \cdot 3 \cdot 3 = 81$$

$$19. \quad 3^{-3} \cdot 3 = 3^{-3+1} = 3^{-2} = \frac{1}{3^2} = \frac{1}{3 \cdot 3} = \frac{1}{9}$$

$$20. \quad 2^{-3} \cdot 2 = 2^{-3+1} = 2^{-2} = \frac{1}{2^2} = \frac{1}{2 \cdot 2} = \frac{1}{4}$$

$$21. \quad \frac{2^3}{2^7} = 2^{3-7} = 2^{-4} = \frac{1}{2^4} = \frac{1}{2 \cdot 2 \cdot 2 \cdot 2} = \frac{1}{16}$$

$$22. \quad \frac{3^4}{3^7} = 3^{4-7} = 3^{-3} = \frac{1}{3^3} = \frac{1}{3 \cdot 3 \cdot 3} = \frac{1}{27}$$

$$23. \quad x^{-2}y = \frac{1}{x^2} \cdot y = \frac{y}{x^2}$$

$$24. \quad xy^{-3} = x \cdot \frac{1}{y^3} = \frac{x}{y^3}$$

$$25. \quad x^0y^5 = 1 \cdot y^5 = y^5$$

$$26. \quad x^7 \cdot y^0 = x^7 \cdot 1 = x^7$$

$$27. \quad x^3 \cdot x^7 = x^{3+7} = x^{10}$$

$$28. \quad x^{11} \cdot x^5 = x^{11+5} = x^{16}$$

$$29. \quad x^{-5} \cdot x^{10} = x^{-5+10} = x^5$$

$$30. \quad x^{-6} \cdot x^{12} = x^{-6+12} = x^6$$

$$31. \quad (x^3)^7 = x^{3 \cdot 7} = x^{21}$$

$$32. \quad (x^{11})^5 = x^{11 \cdot 5} = x^{55}$$

$$33. \quad (x^{-5})^3 = x^{-5 \cdot 3} = x^{-15} = \frac{1}{x^{15}}$$

$$34. \quad (x^{-6})^4 = x^{-6 \cdot 4} = x^{-24} = \frac{1}{x^{24}}$$

$$35. \quad \frac{x^{14}}{x^7} = x^{14-7} = x^7$$

$$36. \quad \frac{x^{30}}{x^{10}} = x^{30-10} = x^{20}$$

$$37. \quad \frac{x^{14}}{x^{-7}} = x^{14-(-7)} = x^{14+7} = x^{21}$$

$$38. \quad \frac{x^{30}}{x^{-10}} = x^{30-(-10)} = x^{30+10} = x^{40}$$

$$39. \quad (8x^3)^2 = 8^2(x^3)^2 = 8^2x^{3 \cdot 2} = 64x^6$$

$$40. \quad (6x^4)^2 = (6)^2(x^4)^2 = 6^2x^{4 \cdot 2} = 36x^8$$

$$41. \quad \left(-\frac{4}{x}\right)^3 = \frac{(-4)^3}{x^3} = -\frac{64}{x^3}$$

$$42. \quad \left(-\frac{6}{y}\right)^3 = \frac{(-6)^3}{y^3} = -\frac{216}{y^3}$$

$$\begin{aligned} 43. \quad (-3x^2y^5)^2 &= (-3)^2(x^2)^2 \cdot (y^5)^2 \\ &= 9x^{2 \cdot 2}y^{5 \cdot 2} \\ &= 9x^4y^{10} \end{aligned}$$

$$\begin{aligned} 44. \quad (-3x^4y^6)^3 &= (-3)^3(x^4)^3(y^6)^3 \\ &= -27x^{4 \cdot 3}y^{6 \cdot 3} \\ &= -27x^{12}y^{18} \end{aligned}$$

$$45. \quad (3x^4)(2x^7) = 3 \cdot 2x^4 \cdot x^7 = 6x^{4+7} = 6x^{11}$$

$$46. \quad (11x^5)(9x^{12}) = 11 \cdot 9x^5x^{12} = 99x^{5+12} = 99x^{17}$$

$$\begin{aligned} 47. \quad (-9x^3y)(-2x^6y^4) &= (-9)(-2)x^3x^6yy^4 \\ &= 18x^{3+6}y^{1+4} \\ &= 18x^9y^5 \end{aligned}$$

$$\begin{aligned} 48. \quad (-5x^4y)(-6x^7y^{11}) &= (-5)(-6)x^4x^7yy^{11} \\ &= 30x^{4+7}y^{1+11} \\ &= 30x^{11}y^{12} \end{aligned}$$

$$49. \quad \frac{8x^{20}}{2x^4} = \left(\frac{8}{2}\right)\left(\frac{x^{20}}{x^4}\right) = 4x^{20-4} = 4x^{16}$$

$$50. \quad \frac{20x^{24}}{10x^6} = \left(\frac{20}{10}\right)\left(\frac{x^{24}}{x^6}\right) = 2x^{24-6} = 2x^{18}$$

$$\begin{aligned} 51. \quad \frac{25a^{13} \cdot b^4}{-5a^2 \cdot b^3} &= \left(\frac{25}{-5}\right)\left(\frac{a^{13}}{a^2}\right)\left(\frac{b^4}{b^3}\right) \\ &= -5a^{13-2}b^{4-3} \\ &= -5a^{11}b \end{aligned}$$

$$\begin{aligned} 52. \quad \frac{35a^{14}b^6}{-7a^7b^3} &= \left(\frac{35}{-7}\right)\left(\frac{a^{14}}{a^7}\right)\left(\frac{b^6}{b^3}\right) \\ &= -5a^{14-7}b^{6-3} \\ &= -5a^7b^3 \end{aligned}$$

$$53. \quad \frac{14b^7}{7b^{14}} = \left(\frac{14}{7}\right)\left(\frac{b^7}{b^{14}}\right) = 2 \cdot b^{7-14} = 2b^{-7} = \frac{2}{b^7}$$

$$\begin{aligned} 54. \quad \frac{20b^{10}}{10b^{20}} &= \left(\frac{20}{10}\right)\left(\frac{b^{10}}{b^{20}}\right) \\ &= 2b^{10-20} \\ &= 2b^{-10} \\ &= \frac{2}{b^{10}} \end{aligned}$$

$$\begin{aligned} 55. \quad (4x^3)^{-2} &= (4^{-2})(x^3)^{-2} \\ &= 4^{-2}x^{-6} \\ &= \frac{1}{4^2x^6} \\ &= \frac{1}{16x^6} \end{aligned}$$

$$\begin{aligned} 56. \quad (10x^2)^{-3} &= 10^{-3}x^{2(-3)} \\ &= 10^{-3}x^{-6} \\ &= \frac{1}{10^3x^6} \\ &= \frac{1}{1000x^6} \end{aligned}$$

$$\begin{aligned} 57. \quad \frac{24x^3 \cdot y^5}{32x^7y^{-9}} &= \frac{3}{4}x^{3-7}y^{5-(-9)} \\ &= \frac{3}{4}x^{-4}y^{14} \\ &= \frac{3y^{14}}{4x^4} \end{aligned}$$

$$\begin{aligned} 58. \quad \frac{10x^4y^9}{30x^{12}y^{-3}} &= \frac{1}{3}x^{4-12}y^{9-(-3)} \\ &= \frac{1}{3}x^{-8}y^{12} \\ &= \frac{y^{12}}{3x^8} \end{aligned}$$

$$59. \quad \left(\frac{5x^3}{y}\right)^{-2} = \frac{5^{-2}x^{-6}}{y^{-2}} = \frac{y^2}{25x^6}$$

$$\begin{aligned} 60. \quad \left(\frac{3x^4}{y}\right)^{-3} &= \left(\frac{y}{3x^4}\right)^3 \\ &= \frac{y^3}{3^3x^{4 \cdot 3}} \\ &= \frac{y^3}{27x^{12}} \end{aligned}$$

$$\begin{aligned} 61. \quad \left(\frac{-15a^4b^2}{5a^{10}b^{-3}}\right)^3 &= \left(\frac{-3b^{2-(-3)}}{a^{10-4}}\right)^3 \\ &= \left(\frac{-3b^5}{a^6}\right)^3 \\ &= \frac{-27b^{15}}{a^{18}} \end{aligned}$$

$$\begin{aligned} 62. \quad \left(\frac{-30a^{14}b^8}{10a^{17}b^{-2}}\right)^3 &= \left(\frac{-3b^{8-(-2)}}{a^{17-14}}\right)^3 \\ &= \left(\frac{-3b^{10}}{a^3}\right)^3 \\ &= \frac{-27b^{30}}{a^9} \end{aligned}$$

$$63. \quad \left(\frac{3a^{-5}b^2}{12a^3b^{-4}}\right)^0 = 1$$

$$64. \quad \left(\frac{4a^{-5}b^3}{12a^3b^{-5}}\right)^0 = 1$$

$$65. \quad 3.8 \times 10^2 = 380$$

$$66. \quad 9.2 \times 10^2 = 920$$

$$67. \quad 6 \times 10^{-4} = 0.0006$$

$$68. \quad 7 \times 10^{-5} = 0.00007$$

$$69. \quad -7.16 \times 10^6 = -7,160,000$$

$$70. \quad -8.17 \times 10^6 = -8,170,000$$

$$71. \quad 7.9 \times 10^{-1} = 0.79$$

$$72. \quad 6.8 \times 10^{-1} = 0.68$$

$$73. \quad -4.15 \times 10^{-3} = -0.00415$$

$$74. -3.14 \times 10^{-3} = -0.00314$$

$$75. -6.00001 \times 10^{10} = -60,000,100,000$$

$$76. -7.00001 \times 10^{10} = -70,000,100,000$$

$$77. 32,000 = 3.2 \times 10^4$$

$$78. 64,000 = 6.4 \times 10^4$$

$$79. 638,000,000,000,000,000 \\ = 6.38 \times 10^{17}$$

$$80. 579,000,000,000,000,000 = 5.79 \times 10^{17}$$

$$81. -5716 = -5.716 \times 10^3$$

$$82. -3829 = -3.829 \times 10^3$$

$$83. 0.0027 = 2.7 \times 10^{-3}$$

$$84. 0.0083 = 8.3 \times 10^{-3}$$

$$85. -0.00000000504 = -5.04 \times 10^{-9}$$

$$86. -0.00000000405 = -4.05 \times 10^{-9}$$

$$87. (3 \times 10^4)(2.1 \times 10^3) = (3 \times 2.1)(10^4 \times 10^3) \\ = 6.3 \times 10^{4+3} = 6.3 \times 10^7$$

$$88. (2 \times 10^4)(4.1 \times 10^3) = 8.2 \times 10^7$$

$$89. (1.6 \times 10^{15})(4 \times 10^{-11}) = (1.6 \times 4)(10^{15} \times 10^{-11}) \\ = 6.4 \times 10^{15+(-11)} \\ = 6.4 \times 10^4$$

$$90. (1.4 \times 10^{15})(3 \times 10^{-11}) = (1.4 \times 3)(10^{15} \times 10^{-11}) \\ = 4.2 \times 10^{15+(-11)} \\ = 4.2 \times 10^4$$

$$91. (6.1 \times 10^{-8})(2 \times 10^{-4}) = (6.1 \times 2)(10^{-8} \times 10^{-4}) \\ = 12.2 \times 10^{-8+(-4)} \\ = 12.2 \times 10^{-12} \\ = 1.22 \times 10^{-11}$$

$$92. (5.1 \times 10^{-8})(3 \times 10^{-4}) = 15.3 \times 10^{-12} \\ = 1.53 \times 10^{-11}$$

$$93. (4.3 \times 10^8)(6.2 \times 10^4) \\ = (4.3 \times 6.2)(10^8 \times 10^4) \\ = 26.66 \times 10^{8+4} \\ = 26.66 \times 10^{12} \\ = 2.666 \times 10^{13} \approx 2.67 \times 10^{13}$$

$$94. (8.2 \times 10^8)(4.6 \times 10^4) \\ = 37.72 \times 10^{8+4} = 37.72 \times 10^{12} \\ = 3.772 \times 10^{13} \approx 3.77 \times 10^{13}$$

$$95. \frac{8.4 \times 10^8}{4 \times 10^5} = \frac{8.4}{4} \times \frac{10^8}{10^5} \\ = 2.1 \times 10^{8-5} = 2.1 \times 10^3$$

$$96. \frac{6.9 \times 10^8}{3 \times 10^5} = 2.3 \times 10^{8-5} = 2.3 \times 10^3$$

$$97. \frac{3.6 \times 10^4}{9 \times 10^{-2}} = \frac{3.6}{9} \times \frac{10^4}{10^{-2}} \\ = 0.4 \times 10^{4-(-2)} \\ = 0.4 \times 10^6 = 4 \times 10^5$$

$$98. \frac{1.2 \times 10^4}{2 \times 10^{-2}} = 0.6 \times 10^{4-(-2)} = 0.6 \times 10^6 \\ = (6 \times 10^{-1}) \times 10^6 = 6 \times 10^5$$

$$99. \frac{4.8 \times 10^{-2}}{2.4 \times 10^6} = \frac{4.8}{2.4} \times \frac{10^{-2}}{10^6} \\ = 2 \times 10^{-2-6} = 2 \times 10^{-8}$$

$$100. \frac{7.5 \times 10^{-2}}{2.5 \times 10^6} = 3 \times 10^{-2-6} = 3 \times 10^{-8}$$

$$101. \frac{2.4 \times 10^{-2}}{4.8 \times 10^{-6}} = \frac{2.4}{4.8} \times \frac{10^{-2}}{10^{-6}} \\ = 0.5 \times 10^{-2-(-6)} \\ = 0.5 \times 10^4 = 5 \times 10^3$$

$$\begin{aligned} 102. \quad \frac{1.5 \times 10^{-2}}{5 \times 10^{-6}} &= 0.5 \times 10^{-2-(-6)} \\ &= 0.5 \times 10^4 = 5 \times 10^3 \end{aligned}$$

$$\begin{aligned} 103. \quad \frac{480,000,000,000}{0.00012} &= \frac{4.8 \times 10^{11}}{1.2 \times 10^{-4}} \\ &= \frac{4.8}{1.2} \times \frac{10^{11}}{10^{-4}} \\ &= 4 \times 10^{11-(-4)} \\ &= 4 \times 10^{15} \end{aligned}$$

$$\begin{aligned} 104. \quad \frac{282,000,000,000}{0.00141} &= \frac{2.82 \times 10^{11}}{1.41 \times 10^{-3}} \\ &= 2 \times 10^{11-(-3)} \\ &= 2 \times 10^{14} \end{aligned}$$

$$\begin{aligned} 105. \quad \frac{0.00072 \times 0.003}{0.00024} &= \frac{(7.2 \times 10^{-4})(3 \times 10^{-3})}{2.4 \times 10^{-4}} \\ &= \frac{7.2 \times 3}{2.4} \times \frac{10^{-4} \cdot 10^{-3}}{10^{-4}} = 9 \times 10^{-3} \end{aligned}$$

$$\begin{aligned} 106. \quad \frac{66000 \times 0.001}{0.003 \times 0.002} &= \frac{(6.6 \times 10^4)(1 \times 10^{-3})}{(3 \times 10^{-3})(2 \times 10^{-3})} \\ &= \frac{6.6 \times 10^1}{6 \times 10^{-6}} = 1.1 \times 10^{1-(-6)} \\ &= 1.1 \times 10^7 \end{aligned}$$

$$\begin{aligned} 107. \quad \frac{(x^{-2}y)^{-3}}{(x^2y^{-1})^3} &= \frac{x^6y^{-3}}{x^6y^{-3}} \\ &= x^{6-6}y^{-3-(-3)} = x^0y^0 = 1 \end{aligned}$$

$$\begin{aligned} 108. \quad \frac{(xy^{-2})^{-2}}{(x^{-2}y)^{-3}} &= \frac{x^{-2}y^4}{x^6y^{-3}} \\ &= x^{-2-6}y^{4-(-3)} = x^{-8}y^7 = \frac{y^7}{x^8} \end{aligned}$$

$$\begin{aligned} 109. \quad (2x^{-3}yz^{-6})(2x)^{-5} &= 2x^{-3}yz^{-6} \cdot 2^{-5}x^{-5} \\ &= 2^{-4}x^{-8}yz^{-6} = \frac{y}{2^4x^8z^6} = \frac{y}{16x^8z^6} \end{aligned}$$

$$\begin{aligned} 110. \quad (3x^{-4}yz^{-7})(3x)^{-3} &= 3x^{-4}yz^{-7} \cdot 3^{-3}x^{-3} \\ &= 3^{-2}x^{-7}yz^{-7} = \frac{y}{3^2x^7z^7} = \frac{y}{9x^7z^7} \end{aligned}$$

$$\begin{aligned} 111. \quad \left(\frac{x^3y^4z^5}{x^{-3}y^{-4}z^{-5}} \right)^{-2} &= (x^6y^8z^{10})^{-2} \\ &= x^{-12}y^{-16}z^{-20} = \frac{1}{x^{12}y^{16}z^{20}} \end{aligned}$$

$$\begin{aligned} 112. \quad \left(\frac{x^4y^5z^6}{x^{-4}y^{-5}z^{-6}} \right)^{-4} &= (x^8y^{10}z^{12})^{-4} \\ &= x^{-32}y^{-40}z^{-48} = \frac{1}{x^{32}y^{40}z^{48}} \end{aligned}$$

$$\begin{aligned} 113. \quad \frac{(2^{-1}x^{-2}y^{-1})^{-2}(2x^{-4}y^3)^{-2}(16x^{-3}y^3)^0}{(2x^{-3}y^{-5})^2} &= \frac{(2^2x^2y^2)(2^{-2}x^8y^{-6})(1)}{(2^2x^{-6}y^{-10})} \\ &= \frac{x^{18}y^6}{4} \end{aligned}$$

$$\begin{aligned} 114. \quad \frac{(2^{-1}x^{-3}y^{-1})^{-2}(2x^{-6}y^4)^{-2}(9x^3y^{-3})^0}{(2x^{-4}y^{-6})^2} &= \frac{(2^2x^6y^2)(2^{-2}x^{12}y^{-8})(1)}{(2^2x^{-8}y^{-12})} \\ &= \frac{x^{26}y^6}{4} \end{aligned}$$

$$115. \quad \text{a. } 5.19 \times 10^{11}$$

$$\text{b. } 4.8 \times 10^7$$

$$\begin{aligned} \text{c. } \frac{5.19 \times 10^{11}}{4.8 \times 10^7} &= \frac{5.19}{4.8} \times \frac{10^{11}}{10^7} \\ &\approx 1.0813 \times 10^4 \\ &\approx 10,813 \end{aligned}$$

\$10,813 yearly per person

$$\text{d. } \frac{10,813}{12} \approx 901$$

\$901 monthly per person

116. a. 3.3×10^{10}

b. 2.57×10^7

$$\begin{aligned} \text{c. } \frac{3.3 \times 10^{10}}{2.57 \times 10^7} &= \frac{3.3}{2.57} \times \frac{10^{10}}{10^7} \\ &\approx 1.284 \times 10^3 \\ &\approx 1284 \\ &\text{\$1284 yearly per person} \end{aligned}$$

$$\begin{aligned} \text{d. } \frac{1284}{12} &= 107 \\ &\text{\$107 monthly per person} \end{aligned}$$

117. Medicaid

$$\begin{aligned} \frac{1.98 \times 10^{11}}{5.34 \times 10^7} &= \frac{1.98}{5.34} \times \frac{10^{11}}{10^7} \\ &\approx 0.3708 \times 10^4 \\ &\approx 3708 \end{aligned}$$

Medicare

$$\begin{aligned} \frac{2.94 \times 10^{11}}{4.23 \times 10^7} &= \frac{2.94}{4.23} \times \frac{10^{11}}{10^7} \\ &\approx 0.6950 \times 10^4 \\ &\approx 6950 \end{aligned}$$

Medicare provides the greater yearly per person benefit by, \\$6950 \\$3708, or \\$3242.

118. a. 2.55×10^{13}

b. 2.54×10^{11}

$$\begin{aligned} \text{c. } \frac{2.55 \times 10^{13}}{2.54 \times 10^{11}} &= \frac{2.55}{2.54} \times \frac{10^{13}}{10^{11}} \\ &\approx 1.00 \times 10^2 \\ &\approx 100 \\ &\text{approximately 100 years} \end{aligned}$$

119. a. 2.55×10^{13}

b. 6×10^4

$$\begin{aligned} \text{c. } \frac{2.55 \times 10^{13}}{6 \times 10^4} &= \frac{2.55}{6} \times \frac{10^{13}}{10^4} \\ &= 0.425 \times 10^9 \\ &= 425,000,000 \\ &\text{425,000,000 Americans} \end{aligned}$$

120. a. 9.84×10^{11}

b. 3.2×10^7

$$\begin{aligned} \text{c. } \frac{9.84 \times 10^{11}}{3.2 \times 10^7} &= \frac{9.84}{3.2} \times \frac{10^{11}}{10^7} \\ &= 3.075 \times 10^4 \\ &= 30,750 \\ &\text{30,750 years} \end{aligned}$$

121. – 128. Answers will vary.

129. does not make sense; Explanations will vary.
Sample explanation: $36(x^3)^9 = 36x^{27}$ not $36x^{12}$.

130. makes sense

131. does not make sense; Explanations will vary.
Sample explanation: 4.6×10^{12} represents over 4 trillion. The entire world population is measured in billions (10^9).

132. makes sense

133. false; Changes to make the statement true will vary.
A sample change is: $4^{-2} > 4^{-3}$.

134. true

135. false; Changes to make the statement true will vary.
A sample change is: $(-2)^4 \neq 2^{-4}$ because $16 \neq \frac{1}{16}$.

136. false; Changes to make the statement true will vary.
A sample change is: $5^2 \cdot 5^{-2} = 2^5 \cdot 2^{-5}$.

137. false; Changes to make the statement true will vary.
A sample change is: $534.7 \neq 5347$.

138. false; Changes to make the statement true will vary.
A sample change is:
$$\frac{8 \times 10^{30}}{2 \times 10^{-5}} = 4 \times 10^{30-(-5)} = 4 \times 10^{35}.$$

139. false; Changes to make the statement true will vary.
A sample change is:
$$(7 \times 10^5) + (2 \times 10^{-3}) = 700,000.002.$$

140. true

141. The doctor has gathered:

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

So, $1 - \frac{3}{4} = \frac{1}{4}$ is remaining.

142. $b^A = MN, b^C = M, b^D = N$

$$b^A = b^C b^D$$

$$A = C + D$$

143. $\frac{70 \text{ bts}}{\cancel{\text{min}}} \cdot \frac{60 \cancel{\text{min}}}{\cancel{\text{hr}}} \cdot \frac{24 \cancel{\text{hrs}}}{\cancel{\text{day}}} \cdot \frac{365 \cancel{\text{days}}}{\cancel{\text{yr}}} \cdot 80 \cancel{\text{yrs}}$

$$= 70 \cdot 60 \cdot 24 \cdot 365 \cdot 80 \text{ beats}$$

$$= 2943360000 \text{ beats}$$

$$= 2.94336 \times 10^9 \text{ beats}$$

$$\approx 2.94 \times 10^9 \text{ beats}$$

The heartbeats approximately 2.94×10^9 times over a lifetime of 80 years.

144. Answers will vary.

145. a. $\sqrt{16} \cdot \sqrt{4} = 4 \cdot 2 = 8$

b. $\sqrt{16 \cdot 4} = \sqrt{64} = 8$

c. $\sqrt{16} \cdot \sqrt{4} = \sqrt{16 \cdot 4}$

146. a. $\sqrt{300} \approx 17.32$

b. $10\sqrt{3} \approx 17.32$

c. $\sqrt{300} = 10\sqrt{3}$

147. a. $21x + 10x = 31x$

b. $21\sqrt{2} + 10\sqrt{2} = 31\sqrt{2}$

2. a. $\sqrt{75} = \sqrt{25 \cdot 3} = \sqrt{25} \sqrt{3} = 5\sqrt{3}$

b. $\sqrt{5x} \cdot \sqrt{10x} = \sqrt{5x \cdot 10x}$
 $= \sqrt{50x^2}$
 $= \sqrt{25 \cdot 2x^2}$
 $= \sqrt{25x^2} \cdot \sqrt{2}$
 $= 5x\sqrt{2}$

3. a. $\sqrt{\frac{25}{16}} = \frac{\sqrt{25}}{\sqrt{16}} = \frac{5}{4}$

b. $\frac{\sqrt{150x^3}}{\sqrt{2x}} = \sqrt{\frac{150x^3}{2x}}$
 $= \sqrt{75x^2}$
 $= \sqrt{25x^2} \cdot \sqrt{3}$
 $= 5x\sqrt{3}$

4. a. $8\sqrt{13} + 9\sqrt{13} = (8+9)\sqrt{13}$
 $= 17\sqrt{13}$

b. $\sqrt{17x} - 20\sqrt{17x}$
 $= 1\sqrt{17x} - 20\sqrt{17x}$
 $= (1-20)\sqrt{17x}$
 $= -19\sqrt{17x}$

5. a. $5\sqrt{27} + \sqrt{12}$
 $= 5\sqrt{9 \cdot 3} + \sqrt{4 \cdot 3}$
 $= 5 \cdot 3\sqrt{3} + 2\sqrt{3}$
 $= 15\sqrt{3} + 2\sqrt{3}$
 $= (15+2)\sqrt{3}$
 $= 17\sqrt{3}$

b. $6\sqrt{18x} - 4\sqrt{8x}$
 $= 6\sqrt{9 \cdot 2x} - 4\sqrt{4 \cdot 2x}$
 $= 6 \cdot 3\sqrt{2x} - 4 \cdot 2\sqrt{2x}$
 $= 18\sqrt{2x} - 8\sqrt{2x}$
 $= (18-8)\sqrt{2x}$
 $= 10\sqrt{2x}$

Section P.3

Check Point Exercises

1. a. $\sqrt{81} = 9$

b. $-\sqrt{9} = -3$

c. $\sqrt{\frac{1}{25}} = \frac{1}{5}$

d. $\sqrt{36+64} = \sqrt{100} = 10$

e. $\sqrt{36} + \sqrt{64} = 6 + 8 = 14$

6. a. If we multiply numerator and denominator by $\sqrt{3}$, the denominator becomes $\sqrt{3} \cdot \sqrt{3} = \sqrt{9} = 3$. Therefore, multiply by 1, choosing $\frac{\sqrt{3}}{\sqrt{3}}$ for 1.

$$\frac{5}{\sqrt{3}} = \frac{5}{\sqrt{3}} \cdot \frac{\sqrt{3}}{\sqrt{3}} = \frac{5\sqrt{3}}{\sqrt{9}} = \frac{5\sqrt{3}}{3}$$

- b. The *smallest* number that will produce a perfect square in the denominator of $\frac{6}{\sqrt{12}}$ is $\sqrt{3}$ because $\sqrt{12} \cdot \sqrt{3} = \sqrt{36} = 6$. So multiply by 1, choosing $\frac{\sqrt{3}}{\sqrt{3}}$ for 1.

$$\frac{6}{\sqrt{12}} = \frac{6}{\sqrt{12}} \cdot \frac{\sqrt{3}}{\sqrt{3}} = \frac{6\sqrt{3}}{\sqrt{36}} = \frac{6\sqrt{3}}{6} = \sqrt{3}$$

7. Multiply by $\frac{4-\sqrt{5}}{4-\sqrt{5}}$.

$$\begin{aligned} \frac{8}{4+\sqrt{5}} &= \frac{8}{4+\sqrt{5}} \cdot \frac{4-\sqrt{5}}{4-\sqrt{5}} \\ &= \frac{8(4-\sqrt{5})}{4^2 - (\sqrt{5})^2} \\ &= \frac{8(4-\sqrt{5})}{16-5} \\ &= \frac{8(4-\sqrt{5})}{11} \text{ or } \frac{32-8\sqrt{5}}{11} \end{aligned}$$

8. a. $\sqrt[3]{40} = \sqrt[3]{8 \cdot 5} = \sqrt[3]{8} \cdot \sqrt[3]{5} = 2\sqrt[3]{5}$
 b. $\sqrt[5]{8} \cdot \sqrt[5]{8} = \sqrt[5]{64} = \sqrt[5]{32} \cdot \sqrt[5]{2} = 2\sqrt[5]{2}$
 c. $\sqrt[3]{\frac{125}{27}} = \frac{\sqrt[3]{125}}{\sqrt[3]{27}} = \frac{5}{3}$

9.
$$\begin{aligned} &3\sqrt[3]{81} - 4\sqrt[3]{3} \\ &= 3\sqrt[3]{27 \cdot 3} - 4\sqrt[3]{3} \\ &= 3 \cdot 3\sqrt[3]{3} - 4\sqrt[3]{3} \\ &= 9\sqrt[3]{3} - 4\sqrt[3]{3} \\ &= (9-4)\sqrt[3]{3} \\ &= 5\sqrt[3]{3} \end{aligned}$$

10. a. $25^{\frac{1}{2}} = \sqrt{25} = 5$

b. $8^{\frac{1}{3}} = \sqrt[3]{8} = 2$

c. $-81^{\frac{1}{4}} = -\sqrt[4]{81} = -3$

d. $(-8)^{\frac{1}{3}} = \sqrt[3]{-8} = -2$

e. $27^{-\frac{1}{3}} = \frac{1}{27^{\frac{1}{3}}} = \frac{1}{\sqrt[3]{27}} = \frac{1}{3}$

11. a. $27^{\frac{4}{3}} = (\sqrt[3]{27})^4 = (3)^4 = 81$

b. $4^{\frac{3}{2}} = (\sqrt[2]{4})^3 = (2)^3 = 8$

c. $32^{-\frac{2}{5}} = \frac{1}{32^{\frac{2}{5}}} = \frac{1}{(\sqrt[5]{32})^2} = \frac{1}{2^2} = \frac{1}{4}$

12. a.
$$\begin{aligned} &(2x^{4/3})(5x^{8/3}) \\ &= 2 \cdot 5x^{4/3} \cdot x^{8/3} \\ &= 10x^{(4/3)+(8/3)} \\ &= 10x^{12/3} \\ &= 10x^4 \end{aligned}$$

b.
$$\begin{aligned} \frac{20x^4}{5x^{3/2}} &= \left(\frac{20}{5}\right)\left(\frac{x^4}{x^{3/2}}\right) \\ &= 4x^{4-(3/2)} \\ &= 4x^{(8/2)-(3/2)} \\ &= 4x^{5/2} \end{aligned}$$

13. $\sqrt[6]{x^3} = x^{3/6} = x^{1/2} = \sqrt{x}$

Concept and Vocabulary Check P.3

C1. principal

C2. 8^2

C3. $|a|$

C4. $\sqrt{a} \cdot \sqrt{b}$

C5. $\frac{\sqrt{a}}{\sqrt{b}}$

C6. $18\sqrt{3}$

C7. $5; 6\sqrt{3}$

C8. $7 - \sqrt{3}$

C9. $\sqrt{10} + \sqrt{2}$

C10. index; radicand

C11. $(-2)^5$

C12. $a; |a|$

C13. $\sqrt[n]{a}$

C14. $2; 8$

Exercise Set P.3

1. $\sqrt{36} = \sqrt{6^2} = 6$

2. $\sqrt{25} = \sqrt{5^2} = 5$

3. $-\sqrt{36} = -\sqrt{6^2} = -6$

4. $-\sqrt{25} = -\sqrt{5^2} = -5$

5. $\sqrt{-36}$, The square root of a negative number is not real.

6. $\sqrt{-25}$, The square root of a negative number is not real.

7. $\sqrt{25 - 16} = \sqrt{9} = 3$

8. $\sqrt{144 + 25} = \sqrt{169} = 13$

9. $\sqrt{25} - \sqrt{16} = 5 - 4 = 1$

10. $\sqrt{144} + \sqrt{25} = 12 + 5 = 17$

11. $\sqrt{(-13)^2} = \sqrt{169} = 13$

12. $\sqrt{(-17)^2} = \sqrt{289} = 17$

13. $\sqrt{50} = \sqrt{25 \cdot 2} = \sqrt{25} \sqrt{2} = 5\sqrt{2}$

14. $\sqrt{27} = \sqrt{9 \cdot 3} = \sqrt{9} \sqrt{3} = 3\sqrt{3}$

15.
$$\begin{aligned}\sqrt{45x^2} &= \sqrt{9x^2 \cdot 5} \\ &= \sqrt{9x^2} \sqrt{5} \\ &= \sqrt{9} \sqrt{x^2} \sqrt{5} \\ &= 3|x| \sqrt{5}\end{aligned}$$

16.
$$\begin{aligned}\sqrt{125x^2} &= \sqrt{25x^2 \cdot 5} \\ &= \sqrt{25x^2} \sqrt{5} \\ &= \sqrt{25} \sqrt{x^2} \sqrt{5} \\ &= 5|x| \sqrt{5}\end{aligned}$$

17.
$$\begin{aligned}\sqrt{2x} \cdot \sqrt{6x} &= \sqrt{2x \cdot 6x} \\ &= \sqrt{12x^2} \\ &= \sqrt{4x^2} \cdot \sqrt{3} \\ &= 2x\sqrt{3}\end{aligned}$$

18.
$$\begin{aligned}\sqrt{10x} \cdot \sqrt{8x} &= \sqrt{10x \cdot 8x} \\ &= \sqrt{80x^2} \\ &= \sqrt{16x^2} \cdot \sqrt{5} \\ &= 4x\sqrt{5}\end{aligned}$$

19. $\sqrt{x^3} = \sqrt{x^2} \cdot \sqrt{x} = x\sqrt{x}$

20. $\sqrt{y^3} = \sqrt{y^2} \cdot \sqrt{y} = y\sqrt{y}$

21.
$$\begin{aligned}\sqrt{2x^2} \cdot \sqrt{6x} &= \sqrt{2x^2 \cdot 6x} \\ &= \sqrt{12x^3} \\ &= \sqrt{4x^2} \cdot \sqrt{3x} \\ &= 2x\sqrt{3x}\end{aligned}$$

22.
$$\begin{aligned}\sqrt{6x} \cdot \sqrt{3x^2} &= \sqrt{6x \cdot 3x^2} \\ &= \sqrt{18x^3} \\ &= \sqrt{9x^2} \cdot \sqrt{2x} \\ &= 3x\sqrt{2x}\end{aligned}$$

23. $\sqrt{\frac{1}{81}} = \frac{\sqrt{1}}{\sqrt{81}} = \frac{1}{9}$

$$24. \sqrt{\frac{1}{49}} = \frac{\sqrt{1}}{\sqrt{49}} = \frac{1}{7}$$

$$25. \sqrt{\frac{49}{16}} = \frac{\sqrt{49}}{\sqrt{16}} = \frac{7}{4}$$

$$26. \sqrt{\frac{121}{9}} = \frac{\sqrt{121}}{\sqrt{9}} = \frac{11}{3}$$

$$27. \frac{\sqrt{48x^3}}{\sqrt{3x}} = \sqrt{\frac{48x^3}{3x}} = \sqrt{16x^2} = 4x$$

$$28. \frac{\sqrt{72x^3}}{\sqrt{8x}} = \sqrt{\frac{72x^3}{8x}} = \sqrt{9x^2} = 3x$$

$$\begin{aligned} 29. \frac{\sqrt{150x^4}}{\sqrt{3x}} &= \sqrt{\frac{150x^4}{3x}} \\ &= \sqrt{50x^3} \\ &= \sqrt{25x^2} \cdot \sqrt{2x} \\ &= 5x\sqrt{2x} \end{aligned}$$

$$\begin{aligned} 30. \frac{\sqrt{24x^4}}{\sqrt{3x}} &= \sqrt{\frac{24x^4}{3x}} \\ &= \sqrt{8x^3} \\ &= \sqrt{4x^2} \cdot \sqrt{2x} \\ &= 2x\sqrt{2x} \end{aligned}$$

$$\begin{aligned} 31. \frac{\sqrt{200x^3}}{\sqrt{10x^{-1}}} &= \sqrt{\frac{200x^3}{10x^{-1}}} \\ &= \sqrt{20x^{3-(-1)}} \\ &= \sqrt{20x^4} \\ &= \sqrt{4 \cdot 5x^4} \\ &= 2x^2\sqrt{5} \end{aligned}$$

$$\begin{aligned} 32. \frac{\sqrt{500x^3}}{\sqrt{10x^{-1}}} &= \sqrt{\frac{500x^3}{10x^{-1}}} = \sqrt{50x^{3-(-1)}} \\ &= \sqrt{50x^4} = \sqrt{25 \cdot 2x^4} = 5x^2\sqrt{2} \end{aligned}$$

$$33. 7\sqrt{3} + 6\sqrt{3} = (7+6)\sqrt{3} = 13\sqrt{3}$$

$$34. 8\sqrt{5} + 11\sqrt{5} = (8+11)\sqrt{5} = 19\sqrt{5}$$

$$35. 6\sqrt{17x} - 8\sqrt{17x} = (6-8)\sqrt{17x} = -2\sqrt{17x}$$

$$36. 4\sqrt{13x} - 6\sqrt{13x} = (4-6)\sqrt{13x} = -2\sqrt{13x}$$

$$\begin{aligned} 37. \sqrt{8} + 3\sqrt{2} &= \sqrt{4 \cdot 2} + 3\sqrt{2} \\ &= 2\sqrt{2} + 3\sqrt{2} \\ &= (2+3)\sqrt{2} \\ &= 5\sqrt{2} \end{aligned}$$

$$\begin{aligned} 38. \sqrt{20} + 6\sqrt{5} &= \sqrt{4 \cdot 5} + 6\sqrt{5} \\ &= 2\sqrt{5} + 6\sqrt{5} \\ &= (2+6)\sqrt{5} \\ &= 8\sqrt{5} \end{aligned}$$

$$\begin{aligned} 39. \sqrt{50x} - \sqrt{8x} &= \sqrt{25 \cdot 2x} - \sqrt{4 \cdot 2x} \\ &= 5\sqrt{2x} - 2\sqrt{2x} \\ &= (5-2)\sqrt{2x} \\ &= 3\sqrt{2x} \end{aligned}$$

$$\begin{aligned} 40. \sqrt{63x} - \sqrt{28x} &= \sqrt{9 \cdot 7x} - \sqrt{4 \cdot 7x} \\ &= 3\sqrt{7x} - 2\sqrt{7x} \\ &= (3-2)\sqrt{7x} \\ &= \sqrt{7x} \end{aligned}$$

$$\begin{aligned} 41. 3\sqrt{18} + 5\sqrt{50} &= 3\sqrt{9 \cdot 2} + 5\sqrt{25 \cdot 2} \\ &= 3 \cdot 3\sqrt{2} + 5 \cdot 5\sqrt{2} \\ &= 9\sqrt{2} + 25\sqrt{2} \\ &= (9+25)\sqrt{2} \\ &= 34\sqrt{2} \end{aligned}$$

$$\begin{aligned} 42. 4\sqrt{12} - 2\sqrt{75} &= 4\sqrt{4 \cdot 3} - 2\sqrt{25 \cdot 3} \\ &= 4 \cdot 2\sqrt{3} - 2 \cdot 5\sqrt{3} \\ &= 8\sqrt{3} - 10\sqrt{3} \\ &= (8-10)\sqrt{3} \\ &= -2\sqrt{3} \end{aligned}$$

$$\begin{aligned} 43. 3\sqrt{8} - \sqrt{32} + 3\sqrt{72} - \sqrt{75} \\ &= 3\sqrt{4 \cdot 2} - \sqrt{16 \cdot 2} + 3\sqrt{36 \cdot 2} - \sqrt{25 \cdot 3} \\ &= 3 \cdot 2\sqrt{2} - 4\sqrt{2} + 3 \cdot 6\sqrt{2} - 5\sqrt{3} \\ &= 6\sqrt{2} - 4\sqrt{2} + 18\sqrt{2} - 5\sqrt{3} \\ &= 20\sqrt{2} - 5\sqrt{3} \end{aligned}$$

$$\begin{aligned}
 44. \quad & 3\sqrt{54} - 2\sqrt{24} - \sqrt{96} + 4\sqrt{63} \\
 &= 3\sqrt{9 \cdot 6} - 2\sqrt{4 \cdot 6} - \sqrt{16 \cdot 6} + 4\sqrt{9 \cdot 7} \\
 &= 3 \cdot 3\sqrt{6} - 2 \cdot 2\sqrt{6} - 4\sqrt{6} + 4 \cdot 3\sqrt{7} \\
 &= 9\sqrt{6} - 4\sqrt{6} - 4\sqrt{6} + 12\sqrt{7} \\
 &= \sqrt{6} + 12\sqrt{7}
 \end{aligned}$$

$$45. \quad \frac{1}{\sqrt{7}} = \frac{1}{\sqrt{7}} \cdot \frac{\sqrt{7}}{\sqrt{7}} = \frac{\sqrt{7}}{7}$$

$$46. \quad \frac{2}{\sqrt{10}} = \frac{2}{\sqrt{10}} \cdot \frac{\sqrt{10}}{\sqrt{10}} = \frac{2\sqrt{10}}{10} = \frac{\sqrt{10}}{5}$$

$$47. \quad \frac{\sqrt{2}}{\sqrt{5}} = \frac{\sqrt{2}}{\sqrt{5}} \cdot \frac{\sqrt{5}}{\sqrt{5}} = \frac{\sqrt{10}}{5}$$

$$48. \quad \frac{\sqrt{7}}{\sqrt{3}} = \frac{\sqrt{7}}{\sqrt{3}} \cdot \frac{\sqrt{3}}{\sqrt{3}} = \frac{\sqrt{21}}{3}$$

$$\begin{aligned}
 49. \quad & \frac{13}{3+\sqrt{11}} = \frac{13}{3+\sqrt{11}} \cdot \frac{3-\sqrt{11}}{3-\sqrt{11}} \\
 &= \frac{13(3-\sqrt{11})}{3^2 - (\sqrt{11})^2} \\
 &= \frac{13(3-\sqrt{11})}{9-11} \\
 &= \frac{13(3-\sqrt{11})}{-2}
 \end{aligned}$$

$$\begin{aligned}
 50. \quad & \frac{3}{3+\sqrt{7}} = \frac{3}{3+\sqrt{7}} \cdot \frac{3-\sqrt{7}}{3-\sqrt{7}} \\
 &= \frac{3(3-\sqrt{7})}{3^2 - (\sqrt{7})^2} \\
 &= \frac{3(3-\sqrt{7})}{9-7} \\
 &= \frac{3(3-\sqrt{7})}{2}
 \end{aligned}$$

$$\begin{aligned}
 51. \quad & \frac{7}{\sqrt{5}-2} = \frac{7}{\sqrt{5}-2} \cdot \frac{\sqrt{5}+2}{\sqrt{5}+2} \\
 &= \frac{7(\sqrt{5}+2)}{(\sqrt{5})^2 - 2^2} \\
 &= \frac{7(\sqrt{5}+2)}{5-4} \\
 &= 7(\sqrt{5}+2)
 \end{aligned}$$

$$\begin{aligned}
 52. \quad & \frac{5}{\sqrt{3}-1} = \frac{5}{\sqrt{3}-1} \cdot \frac{\sqrt{3}+1}{\sqrt{3}+1} \\
 &= \frac{5(\sqrt{3}+1)}{(\sqrt{3})^2 - 1^2} \\
 &= \frac{5(\sqrt{3}+1)}{3-1} \\
 &= \frac{5(\sqrt{3}+1)}{2}
 \end{aligned}$$

$$\begin{aligned}
 53. \quad & \frac{6}{\sqrt{5}+\sqrt{3}} = \frac{6}{\sqrt{5}+\sqrt{3}} \cdot \frac{\sqrt{5}-\sqrt{3}}{\sqrt{5}-\sqrt{3}} \\
 &= \frac{6(\sqrt{5}-\sqrt{3})}{(\sqrt{5})^2 - (\sqrt{3})^2} \\
 &= \frac{6(\sqrt{5}-\sqrt{3})}{5-3} \\
 &= \frac{6(\sqrt{5}-\sqrt{3})}{2} \\
 &= 3(\sqrt{5}-\sqrt{3})
 \end{aligned}$$

$$\begin{aligned}
 54. \quad & \frac{11}{\sqrt{7}-\sqrt{3}} = \frac{11}{\sqrt{7}-\sqrt{3}} \cdot \frac{\sqrt{7}+\sqrt{3}}{\sqrt{7}+\sqrt{3}} \\
 &= \frac{11(\sqrt{7}+\sqrt{3})}{(\sqrt{7})^2 - (\sqrt{3})^2} \\
 &= \frac{11(\sqrt{7}+\sqrt{3})}{7-3} \\
 &= \frac{11(\sqrt{7}+\sqrt{3})}{4}
 \end{aligned}$$

$$55. \quad \sqrt[3]{125} = \sqrt[3]{5^3} = 5$$

$$56. \quad \sqrt[3]{8} = \sqrt[3]{2^3} = 2$$

$$57. \quad \sqrt[3]{-8} = \sqrt[3]{(-2)^3} = -2$$

$$58. \quad \sqrt[3]{-125} = \sqrt[3]{(-5)^3} = -5$$

$$59. \quad \sqrt[4]{-16} \text{ is not a real number.}$$

$$60. \quad \sqrt[4]{-81} \text{ is not a real number.}$$

$$61. \quad \sqrt[4]{(-3)^4} = |-3| = 3$$

$$62. \quad \sqrt[4]{(-2)^4} = |-2| = 2$$

63. $\sqrt[5]{(-3)^5} = -3$

64. $\sqrt[5]{(-2)^5} = -2$

65. $\sqrt[5]{-\frac{1}{32}} = \sqrt[5]{-\frac{1}{2^5}} = -\frac{1}{2}$

66. $\sqrt[6]{\frac{1}{64}} = \frac{\sqrt[6]{1}}{\sqrt[6]{2^6}} = \frac{1}{2}$

67. $\sqrt[3]{32} = \sqrt[3]{8 \cdot 4} = \sqrt[3]{8} \sqrt[3]{4} = 2 \cdot \sqrt[3]{4}$

68. $\sqrt[3]{150}$ cannot be simplified further.

69. $\sqrt[3]{x^4} = \sqrt[3]{x^3 \cdot x} = x \cdot \sqrt[3]{x}$

70. $\sqrt[3]{x^5} = \sqrt[3]{x^3 x^2} = x \sqrt[3]{x^2}$

71. $\sqrt[3]{9} \cdot \sqrt[3]{6} = \sqrt[3]{54} = \sqrt[3]{27 \cdot 2} = \sqrt[3]{27} \sqrt[3]{2} = 3 \sqrt[3]{2}$

72. $\sqrt[3]{12} \cdot \sqrt[3]{4} = \sqrt[3]{48} = \sqrt[3]{8 \cdot 6} = 2 \sqrt[3]{6}$

73. $\frac{\sqrt[5]{64x^6}}{\sqrt[5]{2x}} = \sqrt[5]{\frac{64x^6}{2x}} = \sqrt[5]{32x^5} = 2x$

74. $\frac{\sqrt[4]{162x^5}}{\sqrt[4]{2x}} = \sqrt[4]{\frac{162x^5}{2x}} = \sqrt[4]{81x^4} = 3x$

75. $4\sqrt[5]{2} + 3\sqrt[5]{2} = 7\sqrt[5]{2}$

76. $6\sqrt[5]{3} + 2\sqrt[5]{3} = 8\sqrt[5]{3}$

77. $5\sqrt[3]{16} + \sqrt[3]{54} = 5\sqrt[3]{8 \cdot 2} + \sqrt[3]{27 \cdot 2}$
 $= 5 \cdot 2\sqrt[3]{2} + 3\sqrt[3]{2}$
 $= 10\sqrt[3]{2} + 3\sqrt[3]{2}$
 $= 13\sqrt[3]{2}$

78. $3\sqrt[3]{24} + \sqrt[3]{81} = \sqrt[3]{8 \cdot 3} + \sqrt[3]{27 \cdot 3}$
 $= 3 \cdot 2\sqrt[3]{3} + 3\sqrt[3]{3}$
 $= 6\sqrt[3]{3} + 3\sqrt[3]{3}$
 $= 9\sqrt[3]{3}$

79. $\sqrt[3]{54xy^3} - y\sqrt[3]{128x}$
 $= \sqrt[3]{27 \cdot 2xy^3} - y\sqrt[3]{64 \cdot 2x}$
 $= 3y\sqrt[3]{2x} - 4y\sqrt[3]{2x}$
 $= -y\sqrt[3]{2x}$

80. $\sqrt[3]{24xy^3} - y\sqrt[3]{81x}$
 $= \sqrt[3]{8 \cdot 3xy^3} - y\sqrt[3]{27 \cdot 3x}$
 $= 2y\sqrt[3]{3x} - 3y\sqrt[3]{3x}$
 $= -y\sqrt[3]{3x}$

81. $\sqrt{2} + \sqrt[3]{8} = \sqrt{2} + 2$

82. $\sqrt{3} + \sqrt[3]{15}$ will not simplify.

83. $36^{1/2} = \sqrt{36} = 6$

84. $121^{1/2} = \sqrt{121} = 11$

85. $8^{1/3} = \sqrt[3]{8} = 2$

86. $27^{1/3} = \sqrt[3]{27} = 3$

87. $125^{2/3} = (\sqrt[3]{125})^2 = 5^2 = 25$

88. $8^{2/3} = (\sqrt[3]{8})^2 = 4$

89. $32^{-4/5} = \frac{1}{32^{4/5}} = \frac{1}{2^4} = \frac{1}{16}$

90. $16^{-5/2} = \frac{1}{16^{5/2}} = \frac{1}{(\sqrt{16})^5} = \frac{1}{4^5} = \frac{1}{1024}$

91. $(7x^{1/3})(2x^{1/4}) = 7 \cdot 2x^{1/3} \cdot x^{1/4}$
 $= 14 \cdot x^{1/3+1/4}$
 $= 14x^{7/12}$

92. $(3x^{2/3})(4x^{3/4}) = 3 \cdot 4x^{2/3} \cdot x^{3/4}$
 $= 12 \cdot x^{2/3+3/4}$
 $= 12x^{17/12}$

$$\begin{aligned} 93. \quad \frac{20x^{1/2}}{5x^{1/4}} &= \left(\frac{20}{5}\right)\left(\frac{x^{1/2}}{x^{1/4}}\right) \\ &= 4 \cdot x^{1/2-1/4} \\ &= 4x^{1/4} \end{aligned}$$

$$94. \quad \frac{72x^{3/4}}{9x^{1/3}} = \left(\frac{72}{9}\right)\left(\frac{x^{3/4}}{x^{1/3}}\right) = 8 \cdot x^{3/4-1/3} = 8x^{5/12}$$

$$95. \quad (x^{2/3})^3 = x^{2/3 \cdot 3} = x^2$$

$$96. \quad (x^{4/5})^5 = x^{4/5 \cdot 5} = x^4$$

$$97. \quad (25x^4y^6)^{1/2} = 25^{1/2}x^{4 \cdot 1/2}y^{6 \cdot 1/2} = 5x^2|y|^3$$

$$98. \quad (125x^9y^6)^{1/3} = 125^{1/3}x^{9/3}y^{6/3} = 5x^3y^2$$

$$99. \quad \frac{\left(3y^{\frac{1}{4}}\right)^3}{y^{\frac{1}{12}}} = \frac{27y^{\frac{3}{4}}}{y^{\frac{1}{12}}} = 27y^{\frac{3}{4}-\frac{1}{12}}$$

$$= 27y^{\frac{8}{12}} = 27y^{\frac{2}{3}}$$

$$\begin{aligned} 100. \quad \frac{(2y^{1/5})^4}{y^{3/10}} &= \frac{2^4(y^{1/5})^4}{y^{3/10}} \\ &= \frac{16y^{4/5}}{y^{3/10}} = 16y^{4/5-3/10} = 16y^{1/2} \end{aligned}$$

$$101. \quad \sqrt[4]{5^2} = 5^{2/4} = 5^{1/2} = \sqrt{5}$$

$$102. \quad \sqrt[4]{7^2} = 7^{2/4} = 7^{1/2} = \sqrt{7}$$

$$103. \quad \sqrt[3]{x^6} = x^{6/3} = x^2$$

$$104. \quad \sqrt[4]{x^{12}} = x^{12/4} = |x|^3$$

$$105. \quad \sqrt[6]{x^4} = \sqrt[6/2]{x^{4/2}} = \sqrt[3]{x^2}$$

$$106. \quad \sqrt[9]{x^6} = \sqrt[9/3]{x^{6/3}} = \sqrt[3]{x^2}$$

$$107. \quad \sqrt[9]{x^6y^3} = x^{\frac{6}{9}}y^{\frac{3}{9}} = x^{\frac{2}{3}}y^{\frac{1}{3}} = \sqrt[3]{x^2y}$$

$$108. \quad \sqrt[12]{x^4y^8} = |x|^{\frac{4}{12}}|y|^{\frac{8}{12}} = |x|^{\frac{1}{3}}|y|^{\frac{2}{3}} = \sqrt[3]{|x|y^2}$$

$$109. \quad \sqrt[3]{\sqrt[4]{16} + \sqrt[4]{625}} = \sqrt[3]{2 + 25} = \sqrt[3]{27} = 3$$

$$\begin{aligned} 110. \quad \sqrt[3]{\sqrt{\sqrt{169} + \sqrt{9}} + \sqrt[3]{1000} + \sqrt[3]{216}} \\ &= \sqrt[3]{\sqrt{13+3} + \sqrt{10+6}} \\ &= \sqrt[3]{\sqrt{16} + \sqrt{16}} \\ &= \sqrt[3]{4+4} = \sqrt[3]{8} \\ &= 2 \end{aligned}$$

$$\begin{aligned} 111. \quad (49x^{-2}y^4)^{-1/2} (xy^{1/2}) \\ &= (49)^{-1/2} (x^{-2})^{-1/2} (y^4)^{-1/2} (xy^{1/2}) \\ &= \frac{1}{49^{1/2}} x^{(-2)(-1/2)} y^{(4)(-1/2)} (xy^{1/2}) \\ &= \frac{1}{7} x^1 y^{-2} \cdot xy^{1/2} = \frac{1}{7} x^{1+1} y^{-2+(1/2)} \\ &= \frac{1}{7} x^2 y^{-3/2} = \frac{x^2}{7y^{3/2}} \end{aligned}$$

$$\begin{aligned} 112. \quad (8x^{-6}y^3)^{1/3} (x^{5/6}y^{-1/3})^6 \\ &= 8^{1/3} x^{(-6)(1/3)} y^{(3)(1/3)} x^{(5/6)(6)} y^{(-1/3)(6)} \\ &= 2x^{-2}y^1x^5y^{-2} = 2x^{-2+5}y^{1+(-2)} \\ &= 2x^3y^{-1} = \frac{2x^3}{y} \end{aligned}$$

$$\begin{aligned} 113. \quad \left(\frac{x^{-5/4}y^{1/3}}{x^{-3/4}}\right)^{-6} &= \left(x^{(-5/4)-(-3/4)}y^{1/3}\right)^{-6} \\ &= \left(x^{-2/4}y^{1/3}\right)^{-6} = x^{(-2/4)(-6)}y^{(1/3)(-6)} \\ &= x^3y^{-2} = \frac{x^3}{y^2} \end{aligned}$$

$$\begin{aligned} 114. \quad \left(\frac{x^{1/2}y^{-7/4}}{y^{-5/4}}\right)^{-4} &= \left(x^{1/2}y^{(-7/4)-(-5/4)}\right)^{-4} \\ &= \left(x^{1/2}y^{-2/4}\right)^{-4} = x^{(1/2)(-4)}y^{(-2/4)(-4)} \\ &= x^{-2}y^2 = \frac{y^2}{x^2} \end{aligned}$$

115. a.
$$P = \frac{x(13 + \sqrt{x})}{5\sqrt{x}}$$

$$= \frac{25(13 + \sqrt{25})}{5\sqrt{25}}$$

$$= \frac{25(13 + 5)}{5(5)}$$

$$= 18$$
18% of 25-year-olds must pay more taxes.

b.
$$P = \frac{x(13 + \sqrt{x})}{5\sqrt{x}}$$

$$= \frac{13x + x\sqrt{x}}{5\sqrt{x}} \cdot \frac{\sqrt{x}}{\sqrt{x}}$$

$$= \frac{13x\sqrt{x} + x^2}{5x}$$

$$= \frac{13\sqrt{x} + x}{5}$$

c.
$$P = \frac{13\sqrt{x} + x}{5}$$

$$= \frac{13\sqrt{25} + 25}{5}$$

$$= \frac{13(5) + 25}{5}$$

$$= 18$$

Yes we get the same amount, 18%.
No, this does not prove we have correctly rationalized the denominator. Explanations will vary.

116. a. For 2020: $E = 5\sqrt{x} + 34.1$

$$= 5\sqrt{10} + 34.1$$
For 2050: $E = 5\sqrt{x} + 34.1$

$$= 5\sqrt{40} + 34.1$$

$$= 5 \cdot 2\sqrt{10} + 34.1$$

$$= 10\sqrt{10} + 34.1$$

Difference:

$$(10\sqrt{10} + 34.1) - (5\sqrt{10} + 34.1)$$

$$= 10\sqrt{10} + 34.1 - 5\sqrt{10} - 34.1$$

$$= 10\sqrt{10} - 5\sqrt{10} + 34.1 - 34.1$$

$$= 5\sqrt{10}$$
The difference is $5\sqrt{10}$.

b. $5\sqrt{10} \approx 15.8$
This underestimates the difference projected by the graph of $65.8 - 47.3 = 18.5$ by 2.7. This represents a difference of 2.7 million people.

117.
$$\frac{2}{\sqrt{5}-1} \cdot \frac{\sqrt{5}+1}{\sqrt{5}+1} = \frac{2(\sqrt{5}+1)}{5-1}$$

$$= \frac{2(\sqrt{5}+1)}{4}$$

$$= \frac{\sqrt{5}+1}{2}$$

$$\approx 1.62$$

About 1.62 to 1.

118.
$$R_a = R_f \sqrt{1 - \left(\frac{v}{c}\right)^2}$$

$$= R_f \sqrt{1 - \left(\frac{0.9c}{c}\right)^2}$$

$$= R_f \sqrt{1 - (0.9)^2}$$

$$= R_f \sqrt{0.19}$$

$$\approx 0.44R_f$$

$$R_a = 0.44R_f$$

$$44 = 0.44R_f$$

$$\frac{44}{0.44} = \frac{0.44R_f}{0.44}$$

$$100 = R_f$$

If you are gone for 44 weeks, then 100 weeks will have passed for your friend.

119. Perimeter:

$$\begin{aligned}P &= 2l + 2w \\&= 2 \cdot \sqrt{125} + 2 \cdot 2\sqrt{20} \\&= 2 \cdot \sqrt{25 \cdot 5} + 4\sqrt{4 \cdot 5} \\&= 2 \cdot 5\sqrt{5} + 4 \cdot 2\sqrt{5} \\&= 10\sqrt{5} + 8\sqrt{5} \\&= 18\sqrt{5} \text{ feet}\end{aligned}$$

Area:

$$\begin{aligned}A &= lw \\&= \sqrt{125} \cdot 2\sqrt{20} \\&= 2\sqrt{125 \cdot 20} \\&= 2\sqrt{2500} \\&= 2 \cdot 50 \\&= 100 \text{ square feet}\end{aligned}$$

120. Perimeter:

$$\begin{aligned}P &= 2l + 2w \\&= 2 \cdot 4\sqrt{20} + 2 \cdot \sqrt{80} \\&= 8\sqrt{4 \cdot 5} + 2\sqrt{16 \cdot 5} \\&= 8 \cdot 2\sqrt{5} + 2 \cdot 4\sqrt{5} \\&= 16\sqrt{5} + 8\sqrt{5} \\&= 24\sqrt{5} \text{ feet}\end{aligned}$$

Area:

$$\begin{aligned}A &= lw \\&= 4\sqrt{20} \cdot \sqrt{80} \\&= 4\sqrt{20 \cdot 80} \\&= 4\sqrt{1600} \\&= 4 \cdot 40 \\&= 160 \text{ square feet}\end{aligned}$$

121. – 128. Answers will vary.

129. makes sense

130. makes sense

131. does not make sense; Explanations will vary. Sample explanation: $2\sqrt{20} + 4\sqrt{75}$ simplifies to $4\sqrt{5} + 20\sqrt{3}$ and thus the radical terms are not common.

132. does not make sense; Explanations will vary. Sample explanation: Finding the n th root first often gives smaller numbers on the middle step.

133. false; Changes to make the statement true will vary. A sample change is: $7^{\frac{1}{2}} \cdot 7^{\frac{1}{2}} = 7^1 = 7$.

134. false; Changes to make the statement true will vary. A sample change is: $(8)^{-\frac{1}{3}} = \frac{1}{(8)^{\frac{1}{3}}} = \frac{1}{\sqrt[3]{8}} = \frac{1}{2}$.

135. false; Changes to make the statement true will vary. The cube root of -8 is the real number -2 .

136. false; Changes to make the statement true will vary. A sample change is: $\frac{\sqrt{20}}{8} = \frac{\sqrt{5}}{4}$.

137. $(5 + \sqrt{3})(5 - \sqrt{3}) = 22$
 $25 - 3 = 22$
 $3 = 3$

138. $\sqrt{25x^{14}} = 5x^7$

139. $\sqrt{13 + \sqrt{2} + \frac{7}{3 + \sqrt{2}}}$
 $= \sqrt{13 + \sqrt{2} + \frac{7}{3 + \sqrt{2}} \cdot \frac{3 - \sqrt{2}}{3 - \sqrt{2}}}$
 $= \sqrt{13 + \sqrt{2} + \frac{21 - 7\sqrt{2}}{9 - 2}}$
 $= \sqrt{13 + \sqrt{2} + \frac{21 - 7\sqrt{2}}{7}}$
 $= \sqrt{13 + \sqrt{2} + 3 - \sqrt{2}}$
 $= \sqrt{16}$
 $= 4$

140. a. $3^{\frac{1}{2}} \geq 3^{\frac{1}{3}}$
 Calculator Check: $1.7321 > 1.4422$

b. $\sqrt{7} + \sqrt{18} \geq \sqrt{7 + 18}$
 Calculator Check: $6.8884 > 5$

141. a. $\frac{ab}{a^2 + ab + b^2} + \left(\frac{ac - ad - bc + bd}{ac - ad + bc - bd} + \frac{a^3 - b^3}{a^3 + b^3} \right) = \frac{ab}{a^2 + ab + b^2} + \left(\frac{a(c - d) - b(c - d)}{a(c - d) + b(c - d)} \cdot \frac{a^3 + b^3}{a^3 - b^3} \right)$
 $= \frac{ab}{a^2 + ab + b^2} + \left(\frac{(c - d)(a - b)}{(c - d)(a + b)} \cdot \frac{(a + b)(a^2 - ab + b^2)}{(a - b)(a^2 + ab + b^2)} \right) = \frac{ab}{a^2 + ab + b^2} + \frac{a^2 - ab + b^2}{a^2 + ab + b^2}$
 $= \frac{ab + a^2 - ab + b^2}{a^2 + ab + b^2} = \frac{a^2 + b^2}{a^2 + ab + b^2}$

Her son is 8 years old.

b. Son's portion:

$$\begin{aligned}\frac{8^{-\frac{4}{3}} + 2^{-2}}{16^{-\frac{3}{4}} + 2^{-1}} &= \frac{\frac{1}{(\sqrt[3]{8})^4} + \frac{1}{2^2}}{\frac{1}{(\sqrt[4]{16})^3} + \frac{1}{2}} \\ &= \frac{\frac{1}{2^4} + \frac{1}{4}}{\frac{1}{2^3} + \frac{1}{2}} \\ &= \frac{\frac{1}{16} + \frac{1}{4}}{\frac{1}{8} + \frac{1}{2}} \\ &= \frac{\frac{5}{16}}{\frac{5}{8}} \\ &= \frac{8}{16} \\ &= \frac{1}{2}\end{aligned}$$

Mom's portion:

$$\frac{1}{2} \left(1 - \frac{1}{2} \right) = \frac{1}{2} \left(\frac{1}{2} \right) = \frac{1}{4}$$

142. $(2x^3y^2)(5x^4y^7) = 10x^7y^9$

143. $2x^4(8x^4 + 3x) = 2x^4(8x^4) + 2x^4(3x)$
 $= 16x^8 + 6x^5$

144. $2x(x^2 + 4x + 5) + 3(x^2 + 4x + 5)$
 $= 2x^3 + 8x^2 + 10x + 3x^2 + 12x + 15$
 $= 2x^3 + 8x^2 + 3x^2 + 10x + 12x + 15$
 $= 2x^3 + 11x^2 + 22x + 15$

Section P.4

Check Point Exercises

1. a. $(-17x^3 + 4x^2 - 11x - 5) + (16x^3 - 3x^2 + 3x - 15)$
 $= (-17x^3 + 16x^3) + (4x^2 - 3x^2) + (-11x + 3x) + (-5 - 15)$
 $= -x^3 + x^2 - 8x - 20$

b. $(13x^2 - 9x^2 - 7x + 1) - (-7x^3 + 2x^2 - 5x + 9)$
 $= (13x^2 - 9x^2 - 7x + 1) + (7x^3 - 2x^2 + 5x - 9)$
 $= (13x^2 + 7x^3) + (-9x^2 - 2x^2) + (-7x + 5x) + (1 - 9)$
 $= 20x^3 - 11x^2 - 2x - 8$
2. $(5x - 2)(3x^2 - 5x + 4)$
 $= 5x(3x^2 - 5x + 4) - 2(3x^2 - 5x + 4)$
 $= 5x \cdot 3x^2 - 5x \cdot 5x + 5x \cdot 4 - 2 \cdot 3x^2 + 2 \cdot 5x - 2 \cdot 4$
 $= 15x^3 - 25x^2 + 20x - 6x^2 + 10x - 8$
 $= 15x^3 - 31x^2 + 30x - 8$
3. $(7x - 5)(4x - 3) = 7x \cdot 4x + 7x(-3) + (-5)4x + (-5)(-3)$
 $= 28x^2 - 21x - 20x + 15$
 $= 28x^2 - 41x + 15$
4. a. $(7x - 6y)(3x - y) = (7x)(3x) + (7x)(-y) + (-6y)(3x) + (-6y)(-y)$
 $= 21x^2 - 7xy - 18xy + 6y^2$
 $= 21x^2 - 25xy + 6y^2$

b. $(2x + 4y)^2 = (2x)^2 + 2(2x)(4y) + (4y)^2$
 $= 4x^2 + 16xy + 16y^2$
5. a. $(3x + 2 + 5y)(3x + 2 - 5y) = (3x + 2)^2 - (5y)^2$
 $= 9x^2 + 12x + 4 - 25y^2$
 $= 9x^2 + 12x - 25y^2 + 4$

b. $(2x + y + 3)^2 = (2x + y)^2 + 2(2x + y)(3) + 3^2$
 $= 4x^2 + 4xy + y^2 + 12x + 6y + 9$
 $= 4x^2 + 4xy + 12x + y^2 + 6y + 9$

Concept and Vocabulary Check P.4

- C1. whole
- C2. standard
- C3. monomial
- C4. binomial
- C5. trinomial
- C6. n
- C7. like;
- C8. distributive; $4x^3 - 8x^2 + 6$; $7x^3$
- C9. $5x$; 3; like
- C10. $3x^2$; $5x$; $21x$; 35
- C11. $A^2 - B^2$; minus
- C12. $A^2 + 2AB + B^2$; squared; product of the terms; squared
- C13. $A^2 - 2AB + B^2$; minus; product of the terms; plus
- C14. $n+m$

Exercise Set P.4

- 1. yes; $2x + 3x^2 - 5 = 3x^2 + 2x - 5$
- 2. no; The term $3x^{-1}$ does not have a whole number exponent.
- 3. no; The form of a polynomial involves addition and subtraction, not division.
- 4. yes; $x^2 - x^3 + x^4 - 5 = x^4 - x^3 + x^2 - 5$
- 5. $3x^2$ has degree 2
 $-5x$ has degree 1
4 has degree 0
 $3x^2 - 5x + 4$ has degree 2.
- 6. $-4x^3$ has degree 3
 $7x^2$ has degree 2
 -11 has degree 0
 $-4x^3 + 7x^2 - 11$ has degree 3.

7. x^2 has degree 2
 $-4x^3$ has degree 3
 $9x$ has degree 1
 $-12x^4$ has degree 4
 63 has degree 0
 $x^2 - 4x^3 + 9x - 12x^4 + 63$ has degree 4.
8. x^2 has degree 2
 $-8x^3$ has degree 3
 $15x^4$ has degree 4
 91 has degree 0
 $x^2 - 8x^3 + 15x^4 + 91$ has degree 4.
9. $(-6x^3 + 5x^2 - 8x + 9) + (17x^3 + 2x^2 - 4x - 13) = (-6x^3 + 17x^3) + (5x^2 + 2x^2) + (-8x - 4x) + (9 - 13)$
 $= 11x^3 + 7x^2 - 12x - 4$
The degree is 3.
10. $(-7x^3 + 6x^2 - 11x + 13) + (19x^3 - 11x^2 + 7x - 17) = (-7x^3 + 19x^3) + (6x^2 - 11x^2) + (-11x + 7x) + (13 - 17)$
 $= 12x^3 - 5x^2 - 4x - 4$
The degree is 3.
11. $(17x^3 - 5x^2 + 4x - 3) - (5x^3 - 9x^2 - 8x + 11) = (17x^3 - 5x^2 + 4x - 3) + (-5x^3 + 9x^2 + 8x - 11)$
 $= (17x^3 - 5x^3) + (-5x^2 + 9x^2) + (4x + 8x) + (-3 - 11)$
 $= 12x^3 + 4x^2 + 12x - 14$
The degree is 3.
12. $(18x^4 - 2x^3 - 7x + 8) - (9x^4 - 6x^3 - 5x + 7) = (18x^4 - 2x^3 - 7x + 8) + (-9x^4 + 6x^3 + 5x - 7)$
 $= (18x^4 - 9x^4) + (-2x^3 + 6x^3) + (-7x + 5x) + (8 - 7)$
 $= 9x^4 + 4x^3 - 2x + 1$
The degree is 4.
13. $(5x^2 - 7x - 8) + (2x^2 - 3x + 7) - (x^2 - 4x - 3) = (5x^2 - 7x - 8) + (2x^2 - 3x + 7) + (-x^2 + 4x + 3)$
 $= (5x^2 + 2x^2 - x^2) + (-7x - 3x + 4x) + (-8 + 7 + 3)$
 $= 6x^2 - 6x + 2$
The degree is 2.
14. $(8x^2 + 7x - 5) - (3x^2 - 4x) - (-6x^3 - 5x^2 + 3) = (8x^2 + 7x - 5) + (-3x^2 + 4x) + (6x^3 + 5x^2 - 3)$
 $= 6x^3 + (8x^2 - 3x^2 + 5x^2) + (7x + 4x) + (-5 - 3)$
 $= 6x^3 + 10x^2 + 11x - 8$
The degree is 3.
15. $(x+1)(x^2 - x + 1) = x(x^2) - x \cdot x + x \cdot 1 + 1(x^2) - 1 \cdot x + 1 \cdot 1$
 $= x^3 - x^2 + x + x^2 - x + 1$
 $= x^3 + 1$

16. $(x+5)(x^2-5x+25) = x(x^2) - x(5x) + x(25) + 5(x^2) - 5(5x) + 5(25)$
 $= x^3 - 5x^2 + 25x + 5x^2 - 25x + 125$
 $= x^3 + 125$
17. $(2x-3)(x^2-3x+5) = (2x)(x^2) + (2x)(-3x) + (2x)(5) + (-3)(x^2) + (-3)(-3x) + (-3)(5)$
 $= 2x^3 - 6x^2 + 10x - 3x^2 + 9x - 15$
 $= 2x^3 - 9x^2 + 19x - 15$
18. $(2x-1)(x^2-4x+3) = (2x)(x^2) + (2x)(-4x) + (2x)(3) + (-1)(x^2) + (-1)(-4x) + (-1)(3)$
 $= 2x^3 - 8x^2 + 6x - x^2 + 4x - 3$
 $= 2x^3 - 9x^2 + 10x - 3$
19. $(x+7)(x+3) = x^2 + 3x + 7x + 21 = x^2 + 10x + 21$
20. $(x+8)(x+5) = x^2 + 5x + 8x + 40 = x^2 + 13x + 40$
21. $(x-5)(x+3) = x^2 + 3x - 5x - 15 = x^2 - 2x - 15$
22. $(x-1)(x+2) = x^2 + 2x - x - 2 = x^2 + x - 2$
23. $(3x+5)(2x+1) = (3x)(2x) + 3x(1) + 5(2x) + 5 = 6x^2 + 3x + 10x + 5 = 6x^2 + 13x + 5$
24. $(7x+4)(3x+1) = (7x)(3x) + 7x(1) + 4(3x) + 4(1) = 21x^2 + 7x + 12x + 4 = 21x^2 + 19x + 4$
25. $(2x-3)(5x+3) = (2x)(5x) + (2x)(3) + (-3)(5x) + (-3)(3) = 10x^2 + 6x - 15x - 9 = 10x^2 - 9x - 9$
26. $(2x-5)(7x+2) = (2x)(7x) + (2x)(2) + (-5)(7x) + (-5)(2) = 14x^2 + 4x - 35x - 10 = 14x^2 - 31x - 10$
27. $(5x^2-4)(3x^2-7) = (5x^2)(3x^2) + (5x^2)(-7) + (-4)(3x^2) + (-4)(-7) = 15x^4 - 35x^2 - 12x^2 + 28 = 15x^4 - 47x^2 + 28$
28. $(7x^2-2)(3x^2-5) = (7x^2)(3x^2) + (7x^2)(-5) + (-2)(3x^2) + (-2)(-5) = 21x^4 - 35x^2 - 6x^2 + 10 = 21x^4 - 41x^2 + 10$
29. $(8x^3+3)(x^2-5) = (8x^3)(x^2) + (8x^3)(-5) + (3)(x^2) + (3)(-5) = 8x^5 - 40x^3 + 3x^2 - 15$
30. $(7x^3+5)(x^2-2) = (7x^3)(x^2) + (7x^3)(-2) + (5)(x^2) + (5)(-2) = 7x^5 - 14x^3 + 5x^2 - 10$
31. $(x+3)(x-3) = x^2 - 3^2 = x^2 - 9$
32. $(x+5)(x-5) = x^2 - 5^2 = x^2 - 25$
33. $(3x+2)(3x-2) = (3x)^2 - 2^2 = 9x^2 - 4$
34. $(2x+5)(2x-5) = (2x)^2 - 5^2 = 4x^2 - 25$
35. $(5-7x)(5+7x) = 5^2 - (7x)^2 = 25 - 49x^2$
36. $(4-3x)(4+3x) = 4^2 - (3x)^2 = 16 - 9x^2$

37. $(4x^2 + 5x)(4x^2 - 5x) = (4x^2)^2 - (5x)^2 = 16x^4 - 25x^2$
38. $(3x^2 + 4x)(3x^2 - 4x) = (3x^2)^2 - (4x)^2 = 9x^4 - 16x^2$
39. $(1 - y^5)(1 + y^5) = (1)^2 - (y^5)^2 = 1 - y^{10}$
40. $(2 - y^5)(2 + y^5) = (2)^2 - (y^5)^2 = 4 - y^{10}$
41. $(x + 2)^2 = x^2 + 2 \cdot x \cdot 2 + 2^2 = x^2 + 4x + 4$
42. $(x + 5)^2 = x^2 + 2 \cdot x \cdot 5 + 5^2 = x^2 + 10x + 25$
43. $(2x + 3)^2 = (2x)^2 + 2(2x)(3) + 3^2 = 4x^2 + 12x + 9$
44. $(3x + 2)^2 = (3x)^2 + 2(3x)(2) + 2^2 = 9x^2 + 12x + 4$
45. $(x - 3)^2 = x^2 - 2 \cdot x \cdot 3 + 3^2 = x^2 - 6x + 9$
46. $(x - 4)^2 = x^2 - 2 \cdot x \cdot 4 + 4^2 = x^2 - 8x + 16$
47. $(4x^2 - 1)^2 = (4x^2)^2 - 2(4x^2)(1) + 1^2 = 16x^4 - 8x^2 + 1$
48. $(5x^2 - 3)^2 = (5x^2)^2 - 2(5x^2)(3) + 3^2 = 25x^4 - 30x^2 + 9$
49. $(7 - 2x)^2 = 7^2 - 2(7)(2x) + (2x)^2 = 49 - 28x + 4x^2 = 4x^2 - 28x + 49$
50. $(9 - 5x)^2 = 9^2 - 2(9)(5x) + (5x)^2 = 81 - 90x + 25x^2$ or $25x^2 - 90x + 81$
51. $(x + 1)^3 = x^3 + 3 \cdot x^2 \cdot 1 + 3x \cdot 1^2 + 1^3 = x^3 + 3x^2 + 3x + 1$
52. $(x + 2)^3 = x^3 + 3 \cdot x^2 \cdot 2 + 3 \cdot x \cdot 2^2 + 2^3 = x^3 + 6x^2 + 12x + 8$
53. $(2x + 3)^3 = (2x)^3 + 3 \cdot (2x)^2 \cdot 3 + 3(2x) \cdot 3^2 + 3^3 = 8x^3 + 36x^2 + 54x + 27$
54. $(3x + 4)^3 = (3x)^3 + 3(3x)^2 \cdot 4 + 3(3x) \cdot 4^2 + 4^3 = 27x^3 + 108x^2 + 144x + 64$
55. $(x - 3)^3 = x^3 - 3 \cdot x^2 \cdot 3 + 3 \cdot x \cdot 3^2 - 3^3 = x^3 - 9x^2 + 27x - 27$
56. $(x - 1)^3 = x^3 - 3x^2 \cdot 1 + 3x \cdot 1^2 - 1^3 = x^3 - 3x^2 + 3x - 1$
57. $(3x - 4)^3 = (3x)^3 - 3(3x)^2 \cdot 4 + 3(3x) \cdot 4^2 - 4^3 = 27x^3 - 108x^2 + 144x - 64$
58. $(2x - 3)^3 = (2x)^3 - 3(2x)^2 \cdot 3 + 3(2x) \cdot 3^2 - 3^3 = 8x^3 - 36x^2 + 54x - 27$
59.
$$\begin{aligned}(x + 5y)(7x + 3y) &= x(7x) + x(3y) + (5y)(7x) + (5y)(3y) \\ &= 7x^2 + 3xy + 35xy + 15y^2 \\ &= 7x^2 + 38xy + 15y^2\end{aligned}$$
60.
$$\begin{aligned}(x + 9y)(6x + 7y) &= x(6x) + x(7y) + (9y)(6x) + (9y)(7y) \\ &= 6x^2 + 7xy + 54xy + 63y^2 \\ &= 6x^2 + 61xy + 63y^2\end{aligned}$$

61. $(x-3y)(2x+7y) = x(2x) + x(7y) + (-3y)(2x) + (-3y)(7y)$
 $= 2x^2 + 7xy - 6xy - 21y^2$
 $= 2x^2 + xy - 21y^2$
62. $(3x-y)(2x+5y) = (3x)(2x) + (3x)(5y) + (-y)(2x) + (-y)(5y)$
 $= 6x^2 + 15xy - 2xy - 5y^2$
 $= 6x^2 + 13xy - 5y^2$
63. $(3xy-1)(5xy+2) = (3xy)(5xy) + (3xy)(2) + (-1)(5xy) + (-1)(2)$
 $= 15x^2y^2 + 6xy - 5xy - 2$
 $= 15x^2y^2 + xy - 2$
64. $(7x^2y+1)(2x^2y-3) = (7x^2y)(2x^2y) + (7x^2y)(-3) + (1)2x^2y + (1)(-3)$
 $= 14x^4y^2 - 21x^2y + 2x^2y - 3$
 $= 14x^4y^2 - 19x^2y - 3$
65. $(7x+5y)^2 = (7x)^2 + 2(7x)(5y) + (5y)^2 = 49x^2 + 70xy + 25y^2$
66. $(9x+7y)^2 = (9x)^2 + 2(9x)(7y) + (7y)^2 = 81x^2 + 126xy + 49y^2$
67. $(x^2y^2-3)^2 = (x^2y^2)^2 - 2(x^2y^2)(3) + 3^2 = x^4y^4 - 6x^2y^2 + 9$
68. $(x^2y^2-5)^2 = (x^2y^2)^2 - 2(x^2y^2)(5) + 5^2 = x^4y^4 - 10x^2y^2 + 25$
69. $(x-y)(x^2+xy+y^2) = x(x^2) + x(xy) + x(y^2) + (-y)(x^2) + (-y)(xy) + (-y)(y^2)$
 $= x^3 + x^2y + xy^2 - x^2y - xy^2 - y^3$
 $= x^3 - y^3$
70. $(x+y)(x^2-xy+y^2) = x(x^2) + x(-xy) + x(y^2) + y(x^2) + y(-xy) + y(y^2)$
 $= x^3 - x^2y + xy^2 + x^2y - xy^2 + y^3$
 $= x^3 + y^3$
71. $(3x+5y)(3x-5y) = (3x)^2 - (5y)^2 = 9x^2 - 25y^2$
72. $(7x+3y)(7x-3y) = (7x)^2 - (3y)^2 = 49x^2 - 9y^2$
73. $(x+y+3)(x+y-3) = (x+y)^2 - 3^2 = x^2 + 2xy + y^2 - 9$
74. $(x+y+5)(x+y-5) = (x+y)^2 - 5^2 = x^2 + 2xy + y^2 - 25$
75. $(3x+7-5y)(3x+7+5y) = (3x+7)^2 - (5y)^2 = 9x^2 + 42x + 49 - 25y^2$
76. $(5x+7y-2)(5x+7y+2) = (5x+7y)^2 - 2^2 = 25x^2 + 70xy + 49y^2 - 4$

$$77. [5y-(2x+3)][5y+(2x+3)] = (5y)^2 - (2x+3)^2 = 25y^2 - (4x^2 + 12x + 9) = 25y^2 - 4x^2 - 12x - 9$$

$$78. [8y+(7-3x)][8y-(7-3x)] = (8y)^2 - (7-3x)^2 = 64y^2 - (49 - 42x + 9x^2) = 64y^2 - 49 + 42x - 9x^2$$

$$79. (x+y+1)^2 = (x+y)^2 + 2(x+y)+1 = x^2 + 2xy + y^2 + 2x + 2y + 1$$

$$80. (x+y+2)^2 = (x+y)^2 + 2(x+y)(2) + 2^2 = x^2 + 2xy + y^2 + 4x + 4y + 4$$

$$81. (2x+y+1)^2 = (2x+y)^2 + 2(2x+y)+1 = 4x^2 + 4xy + y^2 + 4x + 2y + 1$$

$$82. (5x+1+6y)^2 = (5x+1)^2 + 2(5x+1)(6y) + (6y)^2 = 25x^2 + 10x + 60xy + 1 + 12y + 36y^2$$

$$\begin{aligned} 83. (3x+4y)^2 - (3x-4y)^2 &= [(3x)^2 + 2(3x)(4y) + (4y)^2] - [(3x)^2 - 2(3x)(4y) + (4y)^2] \\ &= (9x^2 + 24xy + 16y^2) - (9x^2 - 24xy + 16y^2) \\ &= 9x^2 + 24xy + 16y^2 - 9x^2 + 24xy - 16y^2 \\ &= 48xy \end{aligned}$$

$$\begin{aligned} 84. (5x+2y)^2 - (5x-2y)^2 &= [(5x)^2 + 2(5x)(2y) + (2y)^2] - [(5x)^2 - 2(5x)(2y) + (2y)^2] \\ &= (25x^2 + 20xy + 4y^2) - (25x^2 - 20xy + 4y^2) \\ &= 25x^2 + 20xy + 4y^2 - 25x^2 + 20xy - 4y^2 \\ &= 40xy \end{aligned}$$

$$\begin{aligned} 85. (5x-7)(3x-2) - (4x-5)(6x-1) \\ &= [15x^2 - 10x - 21x + 14] - [24x^2 - 4x - 30x + 5] \\ &= (15x^2 - 31x + 14) - (24x^2 - 34x + 5) \\ &= 15x^2 - 31x + 14 - 24x^2 + 34x - 5 \\ &= -9x^2 + 3x + 9 \end{aligned}$$

$$\begin{aligned} 86. (3x+5)(2x-9) - (7x-2)(x-1) \\ &= (6x^2 - 27x + 10x - 45) - (7x^2 - 7x - 2x + 2) \\ &= (6x^2 - 17x - 45) - (7x^2 - 9x + 2) \\ &= 6x^2 - 17x - 45 - 7x^2 + 9x - 2 \\ &= -x^2 - 8x - 47 \end{aligned}$$

$$\begin{aligned}
 87. \quad & (2x+5)(2x-5)(4x^2+25) \\
 &= \left[(2x)^2 - 5^2 \right] (4x^2+25) \\
 &= (4x^2-25)(4x^2+25) \\
 &= (4x^2)^2 - (25)^2 \\
 &= 16x^4 - 625
 \end{aligned}$$

$$\begin{aligned}
 88. \quad & (3x+4)(3x-4)(9x^2+16) \\
 &= \left[(3x)^2 - 4^2 \right] (9x^2+16) \\
 &= (9x^2-16)(9x^2+16) \\
 &= (9x^2)^2 - (16)^2 \\
 &= 81x^4 - 256
 \end{aligned}$$

$$\begin{aligned}
 89. \quad & \frac{(2x-7)^5}{(2x-7)^3} = (2x-7)^{5-3} \\
 &= (2x-7)^2 \\
 &= (2x)^2 - 2(2x)(7) + (7)^2 \\
 &= 4x^2 - 28x + 49
 \end{aligned}$$

$$\begin{aligned}
 90. \quad & \frac{(5x-3)^6}{(5x-3)^4} = (5x-3)^{6-4} \\
 &= (5x-3)^2 \\
 &= (5x)^2 - 2(5x)(3) + (3)^2 \\
 &= 25x^2 - 30x + 9
 \end{aligned}$$

$$\begin{aligned}
 91. \quad \text{a.} \quad & S = 0.2x^3 - 1.5x^2 + 3.4x + 25 + (0.1x^3 - 1.3x^2 + 3.3x + 5) \\
 & S = 0.2x^3 - 1.5x^2 + 3.4x + 25 + 0.1x^3 - 1.3x^2 + 3.3x + 5 \\
 & S = 0.3x^3 - 2.8x^2 + 6.7x + 30
 \end{aligned}$$

$$\begin{aligned}
 \text{b.} \quad & S = 0.3x^3 - 2.8x^2 + 6.7x + 30 \\
 & S = 0.3(5)^3 - 2.8(5)^2 + 6.7(5) + 30 \\
 & S = 31
 \end{aligned}$$

The model gives a score of 31 for the group in the 45-54 age range which is the same as the score displayed by the bar graph.

$$92. \quad \text{a.} \quad S = 0.1x^3 - 1.2x^2 + 2.4x + 17 + (0.2x^3 - 1.6x^2 + 4.3x + 13)$$

$$S = 0.1x^3 - 1.2x^2 + 2.4x + 17 + 0.2x^3 - 1.6x^2 + 4.3x + 13$$

$$S = 0.3x^3 - 2.8x^2 + 6.7x + 30$$

$$\text{b.} \quad S = 0.3x^3 - 2.8x^2 + 6.7x + 30$$

$$S = 0.3(6)^3 - 2.8(6)^2 + 6.7(6) + 30$$

$$S = 34.2$$

The model gives a score of 34.2 for the group in the 55-64 age range. This overestimates the score shown on the bar graph by 0.2.

$$\begin{aligned} 93. \quad x(8-2x)(10-2x) &= x(80-36x+4x^2) \\ &= 80x-36x^2+4x^3 \\ &= 4x^3-36x^2+80x \end{aligned}$$

$$\begin{aligned} 94. \quad x(8-2x)(5-2x) &= x(40-26x+4x^2) \\ &= 40x-26x^2+4x^3 \\ &= 4x^3-26x^2+40x \end{aligned}$$

$$\begin{aligned} 95. \quad (x+9)(x+3) - (x+5)(x+1) \\ &= x^2 + 12x + 27 - (x^2 + 6x + 5) \\ &= x^2 + 12x + 27 - x^2 - 6x - 5 \\ &= 6x + 22 \end{aligned}$$

$$\begin{aligned} 96. \quad (x+4)(x+3) - (x+2)(x+1) \\ &= x^2 + 7x + 12 - (x^2 + 3x + 2) \\ &= x^2 + 7x + 12 - x^2 - 3x - 2 \\ &= 4x + 10 \end{aligned}$$

97. – 102. Answers will vary.

103. makes sense

104. does not make sense; Explanations will vary. Sample explanation: FOIL is used to multiply two binomials.

105. makes sense

106. makes sense, although answers may vary

$$\begin{aligned} 107. \quad (x+3)(x-1) + ((x+3)-x)(x-(x-1)) \\ &= (x+3)(x-1) + 3(x-x+1) \\ &= x^2 - x + 3x - 3 + 3 \\ &= x^2 + 2x \end{aligned}$$

$$\begin{aligned} 108. \quad (2x-1)x(x+3) - x(x-2)x \\ &= (2x^2 + 5x - 3)(x+2) - x^2(x-2) \\ &= 2x^3 + 5x^2 - 3x - x^3 + 2x^2 \\ &= x^3 + 7x^2 - 3x \end{aligned}$$

$$\begin{aligned}
 109. & (x+5)(2x+1)(x+2) - 3 \cdot x(x+5) \\
 &= (2x^2 + 11x + 5)(x+2) - 3x^2 - 15x \\
 &= 2x^3 + 15x^2 + 27x + 10 - 3x^2 - 15x \\
 &= 2x^3 + 12x^2 + 12x + 10
 \end{aligned}$$

$$\begin{aligned}
 110. & (y^n + 2)(y^n - 2) - (y^n - 3)^2 \\
 &= y^{2n} - 4 - (y^{2n} - 6y^n + 9) \\
 &= y^{2n} - 4 - y^{2n} + 6y^n - 9 \\
 &= 6y^n - 13
 \end{aligned}$$

$$111. (x+3)(x+\boxed{4}) = x^2 + 7x + 12$$

$$112. (x-\boxed{2})(x-12) = x^2 - 14x + 24$$

$$113. (4x+1)(2x-\boxed{3}) = 8x^2 - 10x - 3$$

Section P.5

Check Point Exercises

$$\begin{aligned}
 1. \quad \text{a.} \quad & 10x^3 - 4x^2 \\
 &= 2x^2(5x) - 2x^2(2) \\
 &= 2x^2(5x - 2)
 \end{aligned}$$

$$\begin{aligned}
 \text{b.} \quad & 2x(x-7) + 3(x-7) \\
 &= (x-7)(2x+3)
 \end{aligned}$$

$$\begin{aligned}
 2. \quad & x^3 + 5x^2 - 2x - 10 \\
 &= (x^3 + 5x^2) - (2x + 10) \\
 &= x^2(x+5) - 2(x+5) \\
 &= (x+5)(x^2 - 2)
 \end{aligned}$$

$$\begin{aligned}
 3. \quad & \text{Find two numbers whose product is 40 and whose sum is 13. The required integers are 8 and 5. Thus,} \\
 & x^2 + 13x + 40 = (x+8)(x+5) \text{ or } (x+5)(x+8).
 \end{aligned}$$

$$\begin{aligned}
 4. \quad & \text{Find two numbers whose product is } -14 \text{ and whose sum is } -5. \text{ The required integers are } -7 \text{ and } 2. \text{ Thus,} \\
 & x^2 - 5x - 14 = (x-7)(x+2) \text{ or } (x+2)(x-7).
 \end{aligned}$$

$$5. \text{ Find two First terms whose product is } 6x^2.$$

$$6x^2 + 19x - 7 = (6x \quad)(x \quad)$$

$$6x^2 + 19x - 7 = (3x \quad)(2x \quad)$$

Find two Last terms whose product is -7 .

The possible factors are $1(-7)$ and $-1(7)$.

Try various combinations of these factors to find the factorization in which the sum of the Outside and Inside products is $19x$.