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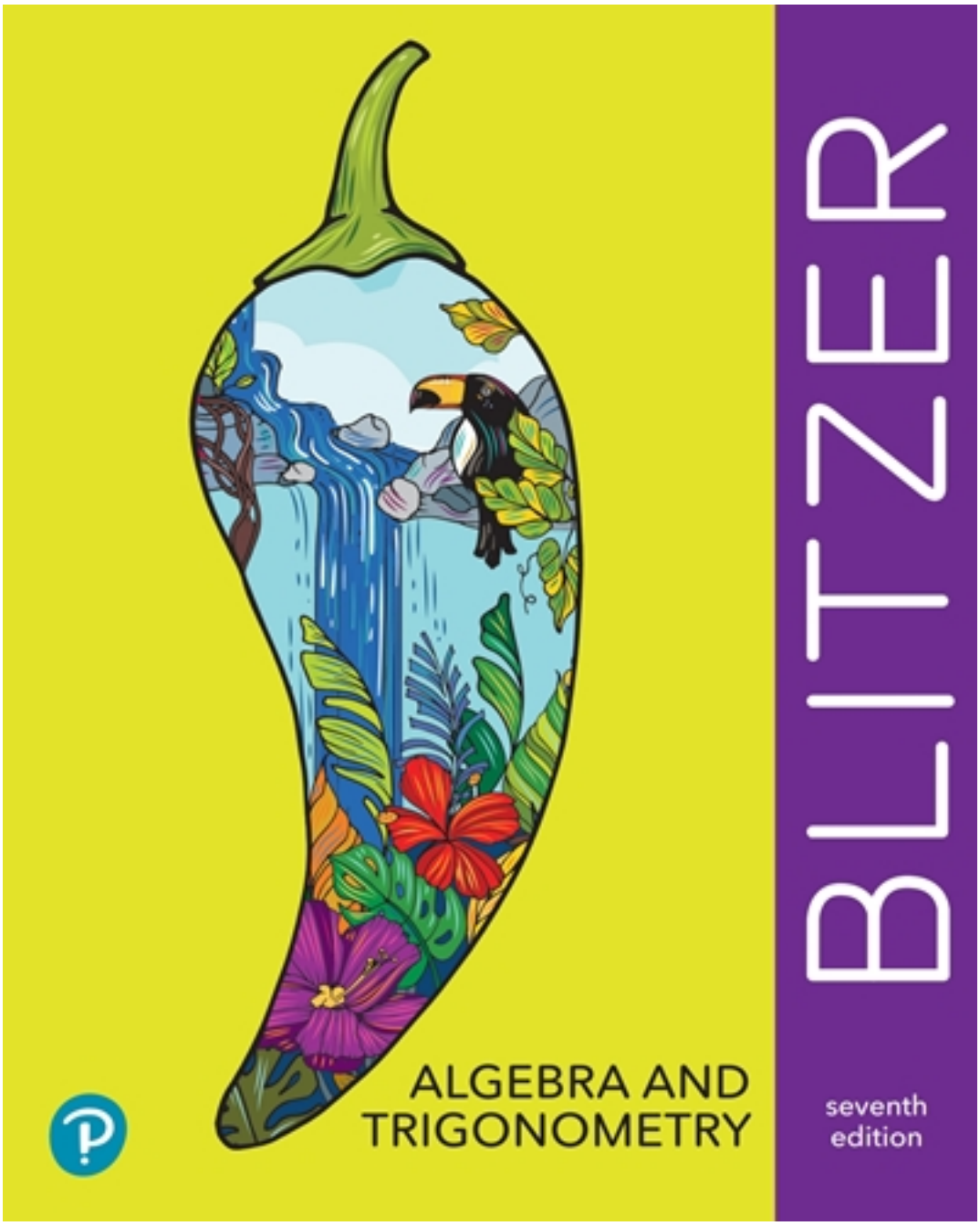


# Solutions

# INSTRUCTOR'S SOLUTIONS MANUAL

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# ALGEBRA AND TRIGONOMETRY

## SEVENTH EDITION

Robert Blitzer

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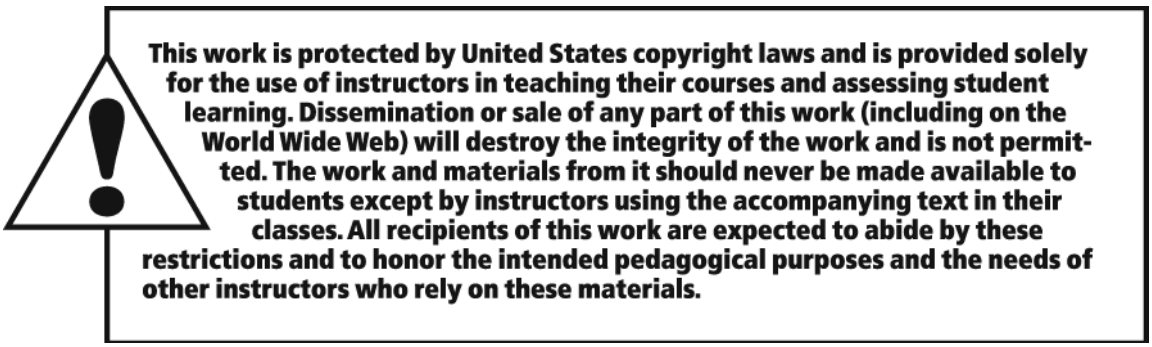
Pearson



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ISBN-13: 978-0-13-739397-8
ISBN-10: 0-13-739397-0

# TABLE OF CONTENTS for INSTRUCTOR SOLUTIONS

## *ALGEBRA AND TRIGONOMETRY 7E*

# 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.** $\left\{-9,\ -1.3,\ 0,\ 0.\overline{3},\ \frac{\pi}{2},\ \sqrt{9},\ \sqrt{10}\right\}$

**a.** Natural numbers: $\sqrt{9}$ because $\sqrt{9}=3$

**b.** Whole numbers: $0,\ \sqrt{9}$

**c.** Integers: $-9,\ 0,\ \sqrt{9}$

**d.** Rational numbers: $-9,\ -1.3,\ 0,\ 0.\overline{3},\ \sqrt{9}$

**e.** Irrational numbers: $\frac{\pi}{2},\ \sqrt{10}$

**f.** Real numbers: $-9,\ -1.3,\ 0,\ 0.\overline{3},\ \frac{\pi}{2},\ \sqrt{9},\ \sqrt{10}$

**6. a.** $\left|1-\sqrt{2}\right|$
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,
$\left|1-\sqrt{2}\right| = -\left(1-\sqrt{2}\right) = \sqrt{2}-1$

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

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

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

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

**17.** $C=\dfrac{5}{9}(50-32)=\dfrac{5}{9}(18)=10$
$50^\circ$F is equivalent to $10^\circ$C.

**18.** $C=\dfrac{5}{9}(F-32)=\dfrac{5}{9}(86-32)=\dfrac{5}{9}(54)=30$
$86^\circ$F is equivalent to $30^\circ$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 $\varnothing$.

**26.** $\{1,3,5,7\} \cap \{-5,-3,-1\} = \{\ \}$ or $\varnothing$

**27.** $\{a,b,c,d\} \cap \varnothing = \varnothing$

**28.** $\{w,y,z\} \cap \varnothing = \varnothing$

**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.** $\{a,e,i,o,u\} \cup \varnothing = \{a,e,i,o,u\}$

**34.** $\{e,m,p,t,y\} \cup \varnothing = \{e,m,p,t,y\}$

**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.** $\left|\sqrt{2} - 5\right| = 5 - \sqrt{2}$

**56.** $\left|\sqrt{5} - 13\right| = 13 - \sqrt{5}$

**57.** $\dfrac{-3}{|-3|} = \dfrac{-3}{3} = -1$

**58.** $\dfrac{-7}{|-7|} = \dfrac{-7}{7} = -1$

**59.** $\big||-3| - |-7|\big| = |3 - 7| = |-4| = 4$

**60.** $\big||-5| - |-13|\big| = |5 - 13| = |-8| = 8$

**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.** $\dfrac{y}{|y|} = \dfrac{-5}{|-5|} = \dfrac{-5}{5} = -1$

**66.** $\dfrac{|x|}{x} + \dfrac{|y|}{y} = \dfrac{|2|}{2} + \dfrac{|-5|}{-5} = \dfrac{2}{2} + \dfrac{5}{-5} = 1 + (-1) = 0$

**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.** $\dfrac{1}{x+3}(x+3) = 1; x \neq -3$,
inverse property of multiplication

**84.** $(x+4) + \big[-(x+4)\big] = 0$;
inverse property of addition

**85.** $\begin{aligned} 5(3x+4) - 4 &= 5 \cdot 3x + 5 \cdot 4 - 4 \\ &= 15x + 20 - 4 \\ &= 15x + 16 \end{aligned}$

**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.** $2(5x-1)+14x = 2\cdot 5x-2\cdot 1+14x$
$= 10x-2+14x$
$= 24x-2$

**89.** $7(3y-5)+2(4y+3)$
$= 7\cdot 3y-7\cdot 5+2\cdot 4y+2\cdot 3$
$= 21y-35+8y+6$
$= 29y-29$

**90.** $4(2y-6)+3(5y+10)$
$= 4\cdot 2y-4\cdot 6+3\cdot 5y+3\cdot 10$
$= 8y-24+15y+30$
$= 23y+6$

**91.** $5(3y-2)-(7y+2) = 15y-10-7y-2$
$= 8y-12$

**92.** $4(5y-3)-(6y+3) = 20y-12-6y-3$
$= 14y-15$

**93.** $7-4\left[3-(4y-5)\right] = 7-4[3-4y+5]$
$= 7-4[8-4y]$
$= 7-32+16y$
$= 16y-25$

**94.** $6-5[8-(2y-4)] = 6-5[8-2y+4]$
$= 6-5[12-2y]$
$= 6-60+10y$
$= 10y-54$

**95.** $18x^2+4-\left[6\left(x^2-2\right)+5\right]$
$= 18x^2+4-\left[6x^2-12+5\right]$
$= 18x^2+4-\left[6x^2-7\right]$
$= 18x^2+4-6x^2+7$
$= 18x^2-6x^2+4+7$
$= (18-6)x^2+11 = 12x^2+11$

**96.** $14x^2+5-\left[7\left(x^2-2\right)+4\right]$
$= 14x^2+5-\left[7x^2-14+4\right]$
$= 14x^2+5-\left[7x^2-10\right]$
$= 14x^2+5-7x^2+10$
$= 14x^2-7x^2+5+10$
$= (14-7)x^2+15$
$= 7x^2+15$

**97.** $-(-14x) = 14x$

**98.** $-(-17y) = 17y$

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

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

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

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

**103.** $|-6| \square |-3|$
$6 \square 3$
$6 > 3$
Since $6>3$, $|-6|>|-3|$.

**104.** $|-20| \square |-50|$
$20 \square 50$
$20 < 50$
Since $20<50$, $|-20|<|-50|$.

**105.** $\left|\frac{3}{5}\right| \square |-0.6|$
$|0.6| \square |-0.6|$
$0.6 \square 0.6$
$0.6 = 0.6$
Since $0.6=0.6$, $\left|\frac{3}{5}\right| = |-0.6|$.

**106.** $\left|\frac{5}{2}\right| \square |-2.5|$

$|2.5| \square |-2.5|$

$2.5 \square 2.5$

$2.5 = 2.5$

Since $2.5 = 2.5$, $\left|\frac{5}{2}\right| = |-2.5|$.

**107.** $\frac{30}{40} - \frac{3}{4} \square \frac{14}{15} \cdot \frac{15}{14}$

$\frac{30}{40} - \frac{30}{40} \square \frac{\cancel{14}}{\cancel{15}} \cdot \frac{\cancel{15}}{\cancel{14}}$

$0 \square 1$

$0 < 1$

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

**108.** $\frac{17}{18} \cdot \frac{18}{17} \square \frac{50}{60} - \frac{5}{6}$

$\frac{\cancel{17}}{\cancel{18}} \cdot \frac{\cancel{18}}{\cancel{17}} \square \frac{50}{60} - \frac{50}{60}$

$1 \square 0$

$1 > 0$

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

**109.** $\frac{8}{13} \div \frac{8}{13} \square |-1|$

$\frac{8}{13} \cdot \frac{13}{8} \square 1$

$1 \square 1$

$1 = 1$

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

**110.** $|-2| \square \frac{4}{17} \div \frac{4}{17}$

$2 \square \frac{4}{17} \cdot \frac{17}{4}$

$2 \square 1$

$2 > 1$

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

**111.** $8^2 - 16 \div 2^2 \cdot 4 - 3 = 64 - 16 \div 4 \cdot 4 - 3$

$= 64 - 4 \cdot 4 - 3$

$= 64 - 16 - 3$

$= 48 - 3$

$= 45$

**112.** $10^2 - 100 \div 5^2 \cdot 2 - 3 = 100 - 100 \div 25 \cdot 2 - 3$

$= 100 - 4 \cdot 2 - 3$

$= 100 - 8 - 3$

$= 92 - 3$

$= 89$

**113.** $\frac{5 \cdot 2 - 3^2}{[3^2 - (-2)]^2} = \frac{5 \cdot 2 - 9}{[9 - (-2)]^2}$

$= \frac{10 - 9}{[9 + 2]^2}$

$= \frac{10 - 9}{11^2}$

$= \frac{1}{121}$

**114.** $\frac{10 \div 2 + 3 \cdot 4}{(12 - 3 \cdot 2)^2} = \frac{5 + 12}{(12 - 6)^2}$

$= \frac{17}{6^2}$

$= \frac{17}{36}$

**115.** $8 - 3[-2(2 - 5) - 4(8 - 6)] = 8 - 3[-2(-3) - 4(2)]$

$= 8 - 3[6 - 8]$

$= 8 - 3[-2]$

$= 8 + 6$

$= 14$

**116.** $8 - 3[-2(5 - 7) - 5(4 - 2)] = 8 - 3[-2(-2) - 5(2)]$

$= 8 - 3[4 - 10]$

$= 8 - 3[-6]$

$= 8 + 18$

$= 26$

**117.** $\frac{2(-2) - 4(-3)}{5 - 8} = \frac{-4 + 12}{-3}$

$= \frac{8}{-3}$

$= -\frac{8}{3}$

**118.** $\dfrac{6(-4)-5(-3)}{9-10}=\dfrac{-24+15}{-1}$

$=\dfrac{-9}{-1}$

$=9$

**119.** $\dfrac{(5-6)^2-2|3-7|}{89-3\cdot 5^2}=\dfrac{(-1)^2-2|-4|}{89-3\cdot 25}$

$=\dfrac{1-2(4)}{89-75}$

$=\dfrac{1-8}{14}$

$=\dfrac{-7}{14}$

$=-\dfrac{1}{2}$

**120.** $\dfrac{12\div 3\cdot 5|2^2+3^2|}{7+3-6^2}=\dfrac{12\div 3\cdot 5|4+9|}{7+3-36}$

$=\dfrac{4\cdot 5|13|}{10-36}$

$=\dfrac{20(13)}{-26}$

$=\dfrac{260}{-26}$

$=-10$

**121.** $x-(x+4)=x-x-4=-4$

**122.** $x-(8-x)=x-8+x=2x-8$

**123.** $6(-5x)=-30x$

**124.** $10(-4x)=-40x$

**125.** $5x-2x=3x$

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

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

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

**129.** **a.** $H=\dfrac{7}{10}(220-a)$

$H=\dfrac{7}{10}(220-20)$

$=\dfrac{7}{10}(200)$

$=140$

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

**b.** $H=\dfrac{4}{5}(220-a)$

$H=\dfrac{4}{5}(220-20)$

$=\dfrac{4}{5}(200)$

$=160$

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

**130.** **a.** $H=\dfrac{1}{2}(220-a)$

$H=\dfrac{1}{2}(220-30)$

$=\dfrac{1}{2}(190)$

$=95$

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

**b.** $H=\dfrac{3}{5}(220-a)$

$H=\dfrac{3}{5}(220-30)$

$=\dfrac{3}{5}(190)$

$=114$

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

**131. a.** Model 1

$T = 975x + 13,547$

$= 975(18) + 13,547$

$= 31,097$

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

Model 2

$T = 32x^2 + 331x + 15,479$

$= 32(18)^2 + 331(18) + 15,479$

$= 31,805$

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

**b.** Model 2

$T = 32x^2 + 331x + 15,479$

$= 32(30)^2 + 331(30) + 15,479$

$= 54,209$

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

**132. a.** Model 1

$T = 975x + 13,547$

$= 975(10) + 13,547$

$= 23,297$

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

Model 2

$T = 32x^2 + 331x + 15,479$

$= 32(10)^2 + 331(10) + 15,479$

$= 21,989$

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

**b.** Model 2

$T = 32x^2 + 331x + 15,479$

$= 32(25)^2 + 331(25) + 15,479$

$= 43,754$

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

**133. a.** $0.015x + 0.0175(6000 - x)$

$= 0.015x + 105 - 0.0175x$

$= 105 - 0.0025x$

**b.** $0.015x + 0.0175(6000 - x)$

$= 0.015(4400) + 0.0175(6000 - 4400)$

$= 0.015(4400) + 0.0175(1600)$

$= 94$

$105 - 0.0025x$

$= 105 - 0.0025(4400)$

$= 94$

Both expressions determine the total interest is \$94

**c.** $105 - 0.0025x$

$= 105 - 0.0025(3000)$

$= 97.5$

The total interest is \$97.50

**134. a.** $0.06t + 0.5(50 - t)$

$= 0.06t + 25 - 0.5t$

$= 25 - 0.44t$

**b.** $0.06t + 0.5(50 - t)$

$= 0.06t + 0.5(50 - 20)$

$= 0.06(20) + 0.5(30)$

$= 16.2$

$25 - 0.44t$

$= 25 - 0.44(20)$

$= 16.2$

Both expressions determine the total distance is 16.2 miles.

**c.** $25 - 0.44t$

$= 25 - 0.44(25)$

$= 14$

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.** $-\dfrac{3.14}{2}=-1.57$

$-\dfrac{\pi}{2}\approx -1.571$

$-1.57 > -1.571$

$-\dfrac{3.14}{2} > -\dfrac{\pi}{2}$

**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.** $\dfrac{b^7}{b^3}=\dfrac{b\cdot b\cdot b\cdot b\cdot b\cdot b\cdot b}{b\cdot b\cdot b}=b^4$

**b.** $\dfrac{b^8}{b^2}=\dfrac{b\cdot b\cdot b\cdot b\cdot b\cdot b\cdot b\cdot b}{b\cdot b}=b^6$

**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.** $3^3\cdot 3^2=3^{3+2}=3^5$ or 243

**b.** $\left(4x^3y^4\right)\left(10x^2y^6\right)=4\cdot 10\cdot x^3\cdot x^2\cdot y^4\cdot y^6$

$=40x^{3+2}\cdot y^{4+6}$

$=40x^5y^{10}$

**2.** **a.** $\dfrac{(-3)^6}{(-3)^3}=(-3)^3=-27$

**b.** $\dfrac{27x^{14}y^8}{3x^3y^5}=\dfrac{27}{3}\cdot\dfrac{x^{14}}{x^3}\cdot\dfrac{y^8}{y^5}=9x^{14-3}y^{8-5}=9x^{11}y^3$

**3.** **a.** $5^{-2}=\dfrac{1}{5^2}=\dfrac{1}{25}$

**b.** $(-3)^{-3}=\dfrac{1}{(-3)^3}=\dfrac{1}{-27}=-\dfrac{1}{27}$

**c.** $\dfrac{1}{4^{-2}}=\dfrac{1}{\frac{1}{4^2}}=1\cdot\dfrac{4^2}{1}=4^2=16$

**d.** $3x^{-6}y^4=3\cdot\dfrac{1}{x^6}\cdot y^4=\dfrac{3y^4}{x^6}$

**4.** **a.** $\left(3^3\right)^2=3^{3\cdot 2}=3^6$ or 729

**b.** $\left(y^7\right)^{-2}=y^{7(-2)}=y^{-14}=\dfrac{1}{y^{14}}$

**c.** $\left(b^{-3}\right)^{-4}=b^{-3(-4)}=b^{12}$

**5.** $(-4x)^3 = (-4)^3(x)^3 = -64x^3$

**6.** **a.** $\left(-\frac{2}{y}\right)^5 = \frac{(-2)^5}{y^5} = \frac{-32}{y^5}$

**b.** $\left(\frac{x^5}{3}\right)^3 = \frac{\left(x^5\right)^3}{3^3} = \frac{x^{15}}{27}$

**7.** **a.** $\left(2x^3y^6\right)^4 = (2)^4\left(x^3\right)^4\left(y^6\right)^4 = 16x^{12}y^{24}$

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

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

**8.** **a.** $-2.6\times10^9 = -2,600,000,000$

**b.** $3.017\times10^{-6} = 0.000003017$

**9.** **a.** $5,210,000,000 = 5.21\times10^9$

**b.** $-0.00000006893 = -6.893\times10^{-8}$

**10.** $410\times10^7 = \left(4.1\times10^2\right)\times10^7$
$= 4.1\times\left(10^2\times10^7\right)$
$= 4.1\times10^9$

**11** **a.** $\left(7.1\times10^5\right)\left(5\times10^{-7}\right)$
$= 7.1\cdot5\times10^5\cdot10^{-7}$
$= 35.5\times10^{-2}$
$= \left(3.55\times10^1\right)\times10^{-2}$
$= 3.55\times\left(10^1\times10^{-2}\right)$
$= 3.55\times10^{-1}$

**b.** $\frac{1.2\times10^6}{3\times10^{-3}} = \frac{1.2}{3}\cdot\frac{10^6}{10^{-3}}$
$= 0.4\times10^{6-(-3)}$
$= 0.4\times10^9$
$= 4\times10^8$

**12.** $\frac{13,500,000,000,000}{309,000,000} = \frac{1.35\times10^{13}}{3.09\times10^8} = \frac{1.35}{3.09}\cdot\frac{10^{13}}{10^8}$
$= 0.44\times10^5$
$= 44,000$

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

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

**3.** $(-2)^6 = (-2)(-2)(-2)(-2)(-2)(-2) = 64$

**4.** $(-2)^4 = (-2)(-2)(-2)(-2) = 16$

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

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

**7.** $(-3)^0 = 1$

**8.** $(-9)^0 = 1$

**9.** $-3^0 = -1$

**10.** $-9^0 = -1$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

**43.** $(-3x^2y^5)^2 = (-3)^2(x^2)^2 \cdot (y^5)^2$
$= 9x^{2\cdot 2}y^{5\cdot 2}$
$= 9x^4y^{10}$

**44.** $(-3x^4y^6)^3 = (-3)^3(x^4)^3(y^6)^3$
$= -27x^{4\cdot 3}y^{6\cdot 3}$
$= -27x^{12}y^{18}$

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

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

**47.** $(-9x^3y)(-2x^6y^4) = (-9)(-2)x^3x^6yy^4$
$= 18x^{3+6}y^{1+4}$
$= 18x^9y^5$

**48.** $(-5x^4y)(-6x^7y^{11}) = (-5)(-6)x^4x^7yy^{11}$
$= 30x^{4+7}y^{1+11}$
$= 30x^{11}y^{12}$

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

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

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

**52.** $\frac{35a^{14}b^6}{-7a^7b^3} = \left(\frac{35}{-7}\right)\left(\frac{a^{14}}{a^7}\right)\left(\frac{b^6}{b^3}\right)$
$= -5a^{14-7}b^{6-3}$
$= -5a^7b^3$

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

**54.** $\frac{20b^{10}}{10b^{20}} = \left(\frac{20}{10}\right)\left(\frac{b^{10}}{b^{20}}\right)$
$= 2b^{10-20}$
$= 2b^{-10}$
$= \frac{2}{b^{10}}$

**55.** $(4x^3)^{-2} = (4^{-2})(x^3)^{-2}$
$= 4^{-2}x^{-6}$
$= \frac{1}{4^2x^6}$
$= \frac{1}{16x^6}$

**56.** $(10x^2)^{-3} = 10^{-3}x^{2\cdot(-3)}$
$= 10^{-3}x^{-6}$
$= \frac{1}{10^3x^6}$
$= \frac{1}{1000x^6}$

**57.** $\frac{24x^3 \cdot y^5}{32x^7y^{-9}} = \frac{3}{4}x^{3-7}y^{5-(-9)}$
$= \frac{3}{4}x^{-4}y^{14}$
$= \frac{3y^{14}}{4x^4}$

**58.** $\frac{10x^4y^9}{30x^{12}y^{-3}} = \frac{1}{3}x^{4-12}y^{9-(-3)}$
$= \frac{1}{3}x^{-8}y^{12}$
$= \frac{y^{12}}{3x^8}$

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

**60.** $\left(\frac{3x^4}{y}\right)^{-3} = \left(\frac{y}{3x^4}\right)^3$

$= \frac{y^3}{3^3 x^{4\cdot 3}}$

$= \frac{y^3}{27x^{12}}$

**61.** $\left(\frac{-15a^4b^2}{5a^{10}b^{-3}}\right)^3 = \left(\frac{-3b^{2-(-3)}}{a^{10-4}}\right)^3$

$= \left(\frac{-3b^5}{a^6}\right)^3$

$= \frac{-27b^{15}}{a^{18}}$

**62.** $\left(\frac{-30a^{14}b^8}{10a^{17}b^{-2}}\right)^3 = \left(\frac{-3b^{8-(-2)}}{a^{17-14}}\right)^3$

$= \left(\frac{-3b^{10}}{a^3}\right)^3$

$= \frac{-27b^{30}}{a^9}$

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

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

**65.** $3.8\times10^2 = 380$

**66.** $9.2\times10^2 = 920$

**67.** $6\times10^{-4} = 0.0006$

**68.** $7\times10^{-5} = 0.00007$

**69.** $-7.16\times10^6 = -7{,}160{,}000$

**70.** $-8.17\times10^6 = -8{,}170{,}000$

**71.** $7.9\times10^{-1} = 0.79$

**72.** $6.8\times10^{-1} = 0.68$

**73.** $-4.15\times10^{-3} = -0.00415$

**74.** $-3.14\times10^{-3} = -0.00314$

**75.** $-6.00001\times10^{10} = -60{,}000{,}100{,}000$

**76.** $-7.00001\times10^{10} = -70{,}000{,}100{,}000$

**77.** $32{,}000 = 3.2\times10^4$

**78.** $64{,}000 = 6.4\times10^4$

**79.** $638{,}000{,}000{,}000{,}000{,}000$

$= 6.38\times10^{17}$

**80.** $579{,}000{,}000{,}000{,}000{,}000 = 5.79\times10^{17}$

**81.** $-5716 = -5.716\times10^3$

**82.** $-3829 = -3.829\times10^3$

**83.** $0.0027 = 2.7\times10^{-3}$

**84.** $0.0083 = 8.3\times10^{-3}$

**85.** $-0.00000000504 = -5.04\times10^{-9}$

**86.** $-0.00000000405 = -4.05\times10^{-9}$

**87.** $\left(3\times10^4\right)\left(2.1\times10^3\right) = (3\times2.1)\left(10^4\times10^3\right)$

$= 6.3\times10^{4+3} = 6.3\times10^7$

**88.** $\left(2\times10^4\right)\left(4.1\times10^3\right) = 8.2\times10^7$

**89.** $\left(1.6\times10^{15}\right)\left(4\times10^{-11}\right) = (1.6\times4)\left(10^{15}\times10^{-11}\right)$

$= 6.4\times10^{15+(-11)}$

$= 6.4\times10^4$

**90.** $\left(1.4\times10^{15}\right)\left(3\times10^{-11}\right) = (1.4\times3)\left(10^{15}\times10^{-11}\right)$

$= 4.2\times10^{15+(-11)}$

$= 4.2\times10^4$

**91.** $\left(6.1\times10^{-8}\right)\left(2\times10^{-4}\right) = (6.1\times2)\left(10^{-8}\times10^{-4}\right)$

$= 12.2\times10^{-8+(-4)}$

$= 12.2\times10^{-12}$

$= 1.22\times10^{-11}$

**92.** $\left(5.1\times10^{-8}\right)\left(3\times10^{-4}\right)=15.3\times10^{-12}$
$=1.53\times10^{-11}$

**93.** $\left(4.3\times10^{8}\right)\left(6.2\times10^{4}\right)$
$=(4.3\times6.2)\left(10^{8}\times10^{4}\right)$
$=26.66\times10^{8+4}$
$=26.66\times10^{12}$
$=2.666\times10^{13}\approx2.67\times10^{13}$

**94.** $\left(8.2\times10^{8}\right)\left(4.6\times10^{4}\right)$
$=37.72\times10^{8+4}=37.72\times10^{12}$
$=3.772\times10^{13}\approx3.77\times10^{13}$

**95.** $\dfrac{8.4\times10^{8}}{4\times10^{5}}=\dfrac{8.4}{4}\times\dfrac{10^{8}}{10^{5}}$
$=2.1\times10^{8-5}=2.1\times10^{3}$

**96.** $\dfrac{6.9\times10^{8}}{3\times10^{5}}=2.3\times10^{8-5}=2.3\times10^{3}$

**97.** $\dfrac{3.6\times10^{4}}{9\times10^{-2}}=\dfrac{3.6}{9}\times\dfrac{10^{4}}{10^{-2}}$
$=0.4\times10^{4-(-2)}$
$=0.4\times10^{6}=4\times10^{5}$

**98.** $\dfrac{1.2\times10^{4}}{2\times10^{-2}}=0.6\times10^{4-(-2)}=0.6\times10^{6}$
$=\left(6\times10^{-1}\right)\times10^{6}=6\times10^{5}$

**99.** $\dfrac{4.8\times10^{-2}}{2.4\times10^{6}}=\dfrac{4.8}{2.4}\times\dfrac{10^{-2}}{10^{6}}$
$=2\times10^{-2-6}=2\times10^{-8}$

**100.** $\dfrac{7.5\times10^{-2}}{2.5\times10^{6}}=3\times10^{-2-6}=3\times10^{-8}$

**101.** $\dfrac{2.4\times10^{-2}}{4.8\times10^{-6}}=\dfrac{2.4}{4.8}\times\dfrac{10^{-2}}{10^{-6}}$
$=0.5\times10^{-2-(-6)}$
$=0.5\times10^{4}=5\times10^{3}$

**102.** $\dfrac{1.5\times10^{-2}}{5\times10^{-6}}=0.5\times10^{-2-(-6)}$
$=0.5\times10^{4}=5\times10^{3}$

**103.** $\dfrac{480,000,000,000}{0.00012}=\dfrac{4.8\times10^{11}}{1.2\times10^{-4}}$
$=\dfrac{4.8}{1.2}\times\dfrac{10^{11}}{10^{-4}}$
$=4\times10^{11-(-4)}$
$=4\times10^{15}$

**104.** $\dfrac{282,000,000,000}{0.00141}=\dfrac{2.82\times10^{11}}{1.41\times10^{-3}}$
$=2\times10^{11-(-3)}$
$=2\times10^{14}$

**105.** $\dfrac{0.00072\times0.003}{0.00024}$
$=\dfrac{\left(7.2\times10^{-4}\right)\left(3\times10^{-3}\right)}{2.4\times10^{-4}}$
$=\dfrac{7.2\times3}{2.4}\times\dfrac{10^{-4}\cdot10^{-3}}{10^{-4}}=9\times10^{-3}$

**106.** $\dfrac{66000\times0.001}{0.003\times0.002}=\dfrac{\left(6.6\times10^{4}\right)\left(1\times10^{-3}\right)}{\left(3\times10^{-3}\right)\left(2\times10^{-3}\right)}$
$=\dfrac{6.6\times10^{1}}{6\times10^{-6}}=1.1\times10^{1-(-6)}$
$=1.1\times10^{7}$

**107.** $\dfrac{\left(x^{-2}y\right)^{-3}}{\left(x^{2}y^{-1}\right)^{3}}=\dfrac{x^{6}y^{-3}}{x^{6}y^{-3}}$
$=x^{6-6}y^{-3-(-3)}=x^{0}y^{0}=1$

**108.** $\dfrac{\left(xy^{-2}\right)^{-2}}{\left(x^{-2}y\right)^{-3}}=\dfrac{x^{-2}y^{4}}{x^{6}y^{-3}}$
$=x^{-2-6}y^{4-(-3)}=x^{-8}y^{7}=\dfrac{y^{7}}{x^{8}}$

**109.** $\left(2x^{-3}yz^{-6}\right)(2x)^{-5}=2x^{-3}yz^{-6}\cdot2^{-5}x^{\cdot-5}$
$=2^{-4}x^{-8}yz^{-6}=\dfrac{y}{2^{4}x^{8}z^{6}}=\dfrac{y}{16x^{8}z^{6}}$

**110.** $\left(3x^{-4}yz^{-7}\right)(3x)^{-3} = 3x^{-4}yz^{-7}\cdot 3^{-3}x^{\cdot -3}$

$= 3^{-2}x^{-7}yz^{-7} = \dfrac{y}{3^2x^7z^7} = \dfrac{y}{9x^7z^7}$

**111.** $\left(\dfrac{x^3y^4z^5}{x^{-3}y^{-4}z^{-5}}\right)^{-2} = \left(x^6y^8z^{10}\right)^{-2}$

$= x^{-12}y^{-16}z^{-20} = \dfrac{1}{x^{12}y^{16}z^{20}}$

**112.** $\left(\dfrac{x^4y^5z^6}{x^{-4}y^{-5}z^{-6}}\right)^{-4} = \left(x^8y^{10}z^{12}\right)^{-4}$

$= x^{-32}y^{-40}z^{-48} = \dfrac{1}{x^{32}y^{40}z^{48}}$

**113.** $\dfrac{\left(2^{-1}x^{-2}y^{-1}\right)^{-2}\left(2x^{-4}y^3\right)^{-2}\left(16x^{-3}y^3\right)^0}{\left(2x^{-3}y^{-5}\right)^2}$

$= \dfrac{\left(2^2x^2y^2\right)\left(2^{-2}x^8y^{-6}\right)(1)}{\left(2^2x^{-6}y^{-10}\right)}$

$= \dfrac{x^{18}y^6}{4}$

**114.** $\dfrac{\left(2^{-1}x^{-3}y^{-1}\right)^{-2}\left(2x^{-6}y^4\right)^{-2}\left(9x^3y^{-3}\right)^0}{\left(2x^{-4}y^{-6}\right)^2}$

$= \dfrac{\left(2^2x^6y^2\right)\left(2^{-2}x^{12}y^{-8}\right)(1)}{\left(2^2x^{-8}y^{-12}\right)}$

$= \dfrac{x^{26}y^6}{4}$

**115.** **a.** $5.19\times10^{11}$

**b.** $4.8\times10^7$

**c.** $\dfrac{5.19\times10^{11}}{4.8\times10^7} = \dfrac{5.19}{4.8}\times\dfrac{10^{11}}{10^7}$

$\approx 1.0813\times10^4$

$\approx 10{,}813$

$10,813 yearly per person

**d.** $\dfrac{10{,}813}{12} \approx 901$

$901 monthly per person

**116.** **a.** $3.3\times10^{10}$

**b.** $2.57\times10^7$

**c.** $\dfrac{3.3\times10^{10}}{2.57\times10^7} = \dfrac{3.3}{2.57}\times\dfrac{10^{10}}{10^7}$

$\approx 1.284\times10^3$

$\approx 1284$

$1284 yearly per person

**d.** $\dfrac{1284}{12} = 107$

$107 monthly per person

**117.** Medicaid

$\dfrac{1.98\times10^{11}}{5.34\times10^7} = \dfrac{1.98}{5.34}\times\dfrac{10^{11}}{10^7}$

$\approx 0.3708\times10^4$

$\approx 3708$

Medicare

$\dfrac{2.94\times10^{11}}{4.23\times10^7} = \dfrac{2.94}{4.23}\times\dfrac{10^{11}}{10^7}$

$\approx 0.6950\times10^4$

$\approx 6950$

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

**118.** **a.** $2.55\times10^{13}$

**b.** $2.54\times10^{11}$

**c.** $\dfrac{2.55\times10^{13}}{2.54\times10^{11}} = \dfrac{2.55}{2.54}\times\dfrac{10^{13}}{10^{11}}$

$\approx 1.00\times10^2$

$\approx 100$

approximately 100 years

**119.** **a.** $2.55\times10^{13}$

**b.** $6\times10^4$

**c.** $\dfrac{2.55\times10^{13}}{6\times10^4} = \dfrac{2.55}{6}\times\dfrac{10^{13}}{10^4}$

$= 0.425\times10^9$

$= 425{,}000{,}000$

425,000,000 Americans

**120. a.** $9.84\times10^{11}$

**b.** $3.2\times10^{7}$

**c.** $\dfrac{9.84\times10^{11}}{3.2\times10^{7}}=\dfrac{9.84}{3.2}\times\dfrac{10^{11}}{10^{7}}$

$=3.075\times10^{4}$

$=30,750$

30,750 years

**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: $4.6\times10^{12}$ 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: $(-2)^4\neq2^{-4}$ because $16\neq\dfrac{1}{16}$.

**136.** false; Changes to make the statement true will vary.
A sample change is: $5^2\cdot5^{-2}=2^5\cdot2^{-5}$.

**137.** false; Changes to make the statement true will vary.
A sample change is: $534.7\neq5347$.

**138.** false; Changes to make the statement true will vary.
A sample change is:
$\dfrac{8\times10^{30}}{2\times10^{-5}}=4\times10^{30-(-5)}=4\times10^{35}$.

**139.** false; Changes to make the statement true will vary.
A sample change is:
$(7\times10^5)+(2\times10^{-3})=700,000.002$.

**140.** true

**141.** The doctor has gathered:

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

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

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

$b^A=b^Cb^D$

$A=C+D$

**143.** $\dfrac{70\text{ bts}}{\cancel{\text{min}}}\cdot\dfrac{60\,\cancel{\text{min}}}{\cancel{\text{hr}}}\cdot\dfrac{24\,\cancel{\text{hrs}}}{\cancel{\text{day}}}\cdot\dfrac{365\,\cancel{\text{days}}}{\cancel{\text{yr}}}\cdot80\,\cancel{\text{yrs}}$

$=70\cdot60\cdot24\cdot365\cdot80$ beats

$=2943360000$ beats

$=2.94336\times10^9$ beats

$\approx2.94\times10^9$ beats

The heartbeats approximately $2.94\times10^9$ times over a lifetime of 80 years.

**144.** Answers will vary.

**145. a.** $\sqrt{16}\cdot\sqrt{4}=4\cdot2=8$

**b.** $\sqrt{16\cdot4}=\sqrt{64}=8$

**c.** $\sqrt{16}\cdot\sqrt{4}=\sqrt{16\cdot4}$

**146. a.** $\sqrt{300}\approx17.32$

**b.** $10\sqrt{3}\approx17.32$

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

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

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

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

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

**b.**
$$\begin{aligned}\sqrt{5x} \cdot \sqrt{10x} &= \sqrt{5x \cdot 10x} \\ &= \sqrt{50x^2} \\ &= \sqrt{25 \cdot 2x^2} \\ &= \sqrt{25x^2} \cdot \sqrt{2} \\ &= 5x\sqrt{2}\end{aligned}$$

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

**b.**
$$\begin{aligned}\frac{\sqrt{150x^3}}{\sqrt{2x}} &= \sqrt{\frac{150x^3}{2x}} \\ &= \sqrt{75x^2} \\ &= \sqrt{25x^2} \cdot \sqrt{3} \\ &= 5x\sqrt{3}\end{aligned}$$

**4. a.**
$$\begin{aligned}8\sqrt{13} + 9\sqrt{13} &= (8+9)\sqrt{3} \\ &= 17\sqrt{13}\end{aligned}$$

**b.**
$$\begin{aligned}&\sqrt{17x} - 20\sqrt{17x} \\ &= 1\sqrt{17x} - 20\sqrt{17x} \\ &= (1-20)\sqrt{17x} \\ &= -19\sqrt{17x}\end{aligned}$$

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

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

**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.** $3\sqrt[3]{81} - 4\sqrt[3]{3}$
$= 3\sqrt[3]{27 \cdot 3} - 4\sqrt[3]{3}$
$= 3 \cdot 3\sqrt[3]{3} - 4\sqrt[3]{3}$
$= 9\sqrt[3]{3} - 4\sqrt[3]{3}$
$= (9-4)\sqrt[3]{3}$
$= 5\sqrt[3]{3}$

**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.** $27^{\frac{4}{3}} = \left(\sqrt[3]{27}\right)^4 = (3)^4 = 81$

**b.** $4^{\frac{3}{2}} = \left(\sqrt{4}\right)^3 = (2)^3 = 8$

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

**12.** **a.** $\left(2x^{4/3}\right)\left(5x^{8/3}\right)$
$= 2 \cdot 5x^{4/3} \cdot x^{8/3}$
$= 10x^{(4/3)+(8/3)}$
$= 10x^{12/3}$
$= 10x^4$

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

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

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

**30.** $\dfrac{\sqrt{24x^4}}{\sqrt{3x}} = \sqrt{\dfrac{24x^4}{3x}}$
$= \sqrt{8x^3}$
$= \sqrt{4x^2}\cdot\sqrt{2x}$
$= 2x\sqrt{2x}$

**31.** $\dfrac{\sqrt{200x^3}}{\sqrt{10x^{-1}}} = \sqrt{\dfrac{200x^3}{10x^{-1}}}$
$= \sqrt{20x^{3-(-1)}}$
$= \sqrt{20x^4}$
$= \sqrt{4\cdot 5x^4}$
$= 2x^2\sqrt{5}$

**32.** $\dfrac{\sqrt{500x^3}}{\sqrt{10x^{-1}}} = \sqrt{\dfrac{500x^3}{10x^{-1}}} = \sqrt{50x^{3-(-1)}}$
$= \sqrt{50x^4} = \sqrt{25\cdot 2x^4} = 5x^2\sqrt{2}$

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

**37.** $\sqrt{8}+3\sqrt{2} = \sqrt{4\cdot 2}+3\sqrt{2}$
$= 2\sqrt{2}+3\sqrt{2}$
$= (2+3)\sqrt{2}$
$= 5\sqrt{2}$

**38.** $\sqrt{20}+6\sqrt{5} = \sqrt{4\cdot 5}+6\sqrt{5}$
$= 2\sqrt{5}+6\sqrt{5}$
$= (2+6)\sqrt{5}$
$= 8\sqrt{5}$

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

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

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

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

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

**44.** $3\sqrt{54}-2\sqrt{24}-\sqrt{96}+4\sqrt{63}$
$= 3\sqrt{9\cdot 6}-2\sqrt{4\cdot 6}-\sqrt{16\cdot 6}+4\sqrt{9\cdot 7}$
$= 3\cdot 3\sqrt{6}-2\cdot 2\sqrt{6}-4\sqrt{6}+4\cdot 3\sqrt{7}$
$= 9\sqrt{6}-4\sqrt{6}-4\sqrt{6}+12\sqrt{7}$
$= \sqrt{6}+12\sqrt{7}$

**45.** $\dfrac{1}{\sqrt{7}} = \dfrac{1}{\sqrt{7}}\cdot\dfrac{\sqrt{7}}{\sqrt{7}} = \dfrac{\sqrt{7}}{7}$

**46.** $\dfrac{2}{\sqrt{10}} = \dfrac{2}{\sqrt{10}}\cdot\dfrac{\sqrt{10}}{\sqrt{10}} = \dfrac{2\sqrt{10}}{10} = \dfrac{\sqrt{10}}{5}$

**47.** $\dfrac{\sqrt{2}}{\sqrt{5}} = \dfrac{\sqrt{2}}{\sqrt{5}}\cdot\dfrac{\sqrt{5}}{\sqrt{5}} = \dfrac{\sqrt{10}}{5}$

**48.** $\dfrac{\sqrt{7}}{\sqrt{3}} = \dfrac{\sqrt{7}}{\sqrt{3}}\cdot\dfrac{\sqrt{3}}{\sqrt{3}} = \dfrac{\sqrt{21}}{3}$

**49.** $$\frac{13}{3+\sqrt{11}} = \frac{13}{3+\sqrt{11}} \cdot \frac{3-\sqrt{11}}{3-\sqrt{11}}$$
$$= \frac{13(3-\sqrt{11})}{3^2-(\sqrt{11})^2}$$
$$= \frac{13(3-\sqrt{11})}{9-11}$$
$$= \frac{13(3-\sqrt{11})}{-2}$$

**50.** $$\frac{3}{3+\sqrt{7}} = \frac{3}{3+\sqrt{7}} \cdot \frac{3-\sqrt{7}}{3-\sqrt{7}}$$
$$= \frac{3(3-\sqrt{7})}{3^2-(\sqrt{7})^2}$$
$$= \frac{3(3-\sqrt{7})}{9-7}$$
$$= \frac{3(3-\sqrt{7})}{2}$$

**51.** $$\frac{7}{\sqrt{5}-2} = \frac{7}{\sqrt{5}-2} \cdot \frac{\sqrt{5}+2}{\sqrt{5}+2}$$
$$= \frac{7(\sqrt{5}+2)}{(\sqrt{5})^2-2^2}$$
$$= \frac{7(\sqrt{5}+2)}{5-4}$$
$$= 7(\sqrt{5}+2)$$

**52.** $$\frac{5}{\sqrt{3}-1} = \frac{5}{\sqrt{3}-1} \cdot \frac{\sqrt{3}+1}{\sqrt{3}+1}$$
$$= \frac{5(\sqrt{3}+1)}{(\sqrt{3})^2-1^2}$$
$$= \frac{5(\sqrt{3}+1)}{3-1}$$
$$= \frac{5(\sqrt{3}+1)}{2}$$

**53.** $$\frac{6}{\sqrt{5}+\sqrt{3}} = \frac{6}{\sqrt{5}+\sqrt{3}} \cdot \frac{\sqrt{5}-\sqrt{3}}{\sqrt{5}-\sqrt{3}}$$
$$= \frac{6(\sqrt{5}-\sqrt{3})}{(\sqrt{5})^2-(\sqrt{3})^2}$$
$$= \frac{6(\sqrt{5}-\sqrt{3})}{5-3}$$
$$= \frac{6(\sqrt{5}-\sqrt{3})}{2}$$
$$= 3(\sqrt{5}-\sqrt{3})$$

**54.** $$\frac{11}{\sqrt{7}-\sqrt{3}} = \frac{11}{\sqrt{7}-\sqrt{3}} \cdot \frac{\sqrt{7}+\sqrt{3}}{\sqrt{7}+\sqrt{3}}$$
$$= \frac{11(\sqrt{7}+\sqrt{3})}{(\sqrt{7})^2-(\sqrt{3})^2}$$
$$= \frac{11(\sqrt{7}+\sqrt{3})}{7-3}$$
$$= \frac{11(\sqrt{7}+\sqrt{3})}{4}$$

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

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

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

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

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

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

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

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

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

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

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

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

**93.** $\frac{20x^{1/2}}{5x^{1/4}} = \left(\frac{20}{5}\right)\left(\frac{x^{1/2}}{x^{1/4}}\right)$
$= 4 \cdot x^{1/2-1/4}$
$= 4x^{1/4}$

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

**95.** $\left(x^{2/3}\right)^3 = x^{2/3 \cdot 3} = x^2$

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

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

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

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

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

**100.** $\dfrac{\left(2y^{1/5}\right)^4}{y^{3/10}} = \dfrac{2^4\left(y^{1/5}\right)^4}{y^{3/10}}$

$= \dfrac{16y^{4/5}}{y^{3/10}} = 16y^{4/5-3/10} = 16y^{1/2}$

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

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

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

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

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

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

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

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

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

**110.** $\sqrt[3]{\sqrt{\sqrt{169}+\sqrt{9}}+\sqrt{\sqrt[3]{1000}+\sqrt[3]{216}}}$

$= \sqrt[3]{\sqrt{13+3}+\sqrt{10+6}}$

$= \sqrt[3]{\sqrt{16}+\sqrt{16}}$

$= \sqrt[3]{4+4} = \sqrt[3]{8}$

$= 2$

**111.** $\left(49x^{-2}y^4\right)^{-1/2}\left(xy^{1/2}\right)$

$= (49)^{-1/2}\left(x^{-2}\right)^{-1/2}\left(y^4\right)^{-1/2}\left(xy^{1/2}\right)$

$= \dfrac{1}{49^{1/2}}x^{(-2)(-1/2)}y^{(4)(-1/2)}\left(xy^{1/2}\right)$

$= \dfrac{1}{7}x^1y^{-2}\cdot xy^{1/2} = \dfrac{1}{7}x^{1+1}y^{-2+(1/2)}$

$= \dfrac{1}{7}x^2y^{-3/2} = \dfrac{x^2}{7y^{3/2}}$

**112.** $\left(8x^{-6}y^3\right)^{1/3}\left(x^{5/6}y^{-1/3}\right)^6$

$= 8^{1/3}x^{(-6)(1/3)}y^{(3)(1/3)}x^{(5/6)(6)}y^{(-1/3)(6)}$

$= 2x^{-2}y^1x^5y^{-2} = 2x^{-2+5}y^{1+(-2)}$

$= 2x^3y^{-1} = \dfrac{2x^3}{y}$

**113.** $\left(\dfrac{x^{-5/4}y^{1/3}}{x^{-3/4}}\right)^{-6} = \left(x^{(-5/4)-(-3/4)}y^{1/3}\right)^{-6}$

$= \left(x^{-2/4}y^{1/3}\right)^{-6} = x^{(-2/4)(-6)}y^{(1/3)(-6)}$

$= x^3y^{-2} = \dfrac{x^3}{y^2}$

**114.** $\left(\dfrac{x^{1/2}y^{-7/4}}{y^{-5/4}}\right)^{-4} = \left(x^{1/2}y^{(-7/4)-(-5/4)}\right)^{-4}$

$= \left(x^{1/2}y^{-2/4}\right)^{-4} = x^{(1/2)(-4)}y^{(-2/4)(-4)}$

$= x^{-2}y^2 = \dfrac{y^2}{x^2}$

**115. a.** $P = \dfrac{x\left(13+\sqrt{x}\right)}{5\sqrt{x}}$

$= \dfrac{25\left(13+\sqrt{25}\right)}{5\sqrt{25}}$

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

$= 18$

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

**b.** $P = \dfrac{x\left(13+\sqrt{x}\right)}{5\sqrt{x}}$

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

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

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

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

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

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

$= 18$

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.** $\dfrac{2}{\sqrt{5}-1} \cdot \dfrac{\sqrt{5}+1}{\sqrt{5}+1} = \dfrac{2(\sqrt{5}+1)}{5-1}$

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

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

$\approx 1.62$

About 1.62 to 1.

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

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

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

$= R_f\sqrt{0.19}$

$\approx 0.44R_f$

$R_a = 0.44R_f$

$44 = 0.44R_f$

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

$100 = R_f$

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: $7^{1/2}\cdot 7^{1/2} = 7^1 = 7$.

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

**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: $\dfrac{\sqrt{20}}{8} = \dfrac{\sqrt{5}}{4}$.

**137.** $\left(5+\sqrt{\boxed{3}}\right)\left(5-\sqrt{\boxed{3}}\right) = 22$

$$25 - \boxed{3} = 22$$

$$\boxed{3} = 3$$

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

**139.**

$$\begin{aligned}&\sqrt{13+\sqrt{2}+\frac{7}{3+\sqrt{2}}} \\ &= \sqrt{13+\sqrt{2}+\frac{7}{3+\sqrt{2}}\cdot\frac{3-\sqrt{2}}{3-\sqrt{2}}} \\ &= \sqrt{13+\sqrt{2}+\frac{21-7\sqrt{2}}{9-2}} \\ &= \sqrt{13+\sqrt{2}+\frac{21-7\sqrt{2}}{7}} \\ &= \sqrt{13+\sqrt{2}+3-\sqrt{2}} \\ &= \sqrt{16} \\ &= 4\end{aligned}$$

**140. a.** $3^{\frac{1}{2}} \boxed{>} 3^{\frac{1}{3}}$

Calculator Check: $1.7321 > 1.4422$

**b.** $\sqrt{7}+\sqrt{18} \boxed{>} \sqrt{7+18}$

Calculator Check: $6.8884 > 5$

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

$=\dfrac{ab}{a^2+ab+b^2}+\left(\dfrac{\cancel{(c-d)}\cancel{(a-b)}}{\cancel{(c-d)}\cancel{(a+b)}}\cdot\dfrac{\cancel{(a+b)}\left(a^2-ab+b^2\right)}{\cancel{(a-b)}\left(a^2+ab+b^2\right)}\right)=\dfrac{ab}{a^2+ab+b^2}+\dfrac{a^2-ab+b^2}{a^2+ab+b^2}$

$=\dfrac{ab+a^2-ab+b^2}{a^2+ab+b^2}=\dfrac{a^2+b^2}{a^2+ab+b^2}$

Her son is 8 years old.

**b.** Son's portion:

$$\frac{8^{-\frac{4}{3}}+2^{-2}}{16^{-\frac{3}{4}}+2^{-1}}=\frac{\dfrac{1}{\left(\sqrt[3]{8}\right)^4}+\dfrac{1}{2^2}}{\dfrac{1}{\left(\sqrt[4]{16}\right)^3}+\dfrac{1}{2}}$$

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

$$=\frac{\dfrac{1}{16}+\dfrac{1}{4}}{\dfrac{1}{8}+\dfrac{1}{2}}$$

$$=\frac{\dfrac{5}{16}}{\dfrac{5}{8}}$$

$$=\frac{8}{16}$$

$$=\frac{1}{2}$$

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.** $(13x^2-9x^2-7x+1)-(-7x^3+2x^2-5x+9)$

$=(13x^3-9x^2-7x+1)+(7x^3-2x^2+5x-9)$

$=(13x^3+7x^3)+(-9x^2-2x^2)+(-7x+5x)+(1-9)$

$=20x^3-11x^2-2x-8$

**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.** Use the special-product formula shown.

$(A+B)(A-B)=A^2-B^2$

$(7x+8)(7x-8)=(7x)^2-(8)^2$

$=49x^2-64$

**b.** Use the special-product formula shown.

$(A+B)(A-B)=A^2-B^2$

$(2y^3-5)(2y^3+5)=(2y^3+5)(2y^3-5)$

$=(2y^3)^2-(5)^2$

$=4y^6-25$

**5. a.** Use the special-product formula shown.

$(A+B)^2=A^2+2AB+B^2$

$(x+10)^2=x^2+2(x)(10)+10^2$

$=x^2+20x+100$

**b.** Use the special-product formula shown.

$(A+B)^2=A^2+2AB+B^2$

$(5x+4)^2=(5x)^2+2(5x)(4)+4^2$

$=25x^2+40x+16$

**6.** **a.** Use the special-product formula shown.

$$(A-B)^2 = A^2 - 2AB + B^2$$
$$(x-9)^2 = x^2 - 2(x)(9) + 9^2$$
$$= x^2 - 18x + 81$$

**b.** Use the special-product formula shown.

$$(A-B)^2 = A^2 - 2AB + B^2$$
$$(7x-3)^2 = (7x)^2 - 2(7x)(3) + 3^2$$
$$= 49x^2 - 42x + 9$$

**7.**
$$(x^3 - 4x^2y + 5xy^2 - y^3) - (x^3 - 6x^2y + y^3)$$
$$= (x^3 - 4x^2y + 5xy^2 - y^3) + (-x^3 + 6x^2y - y^3)$$
$$= (x^3 - x^3) + (-4x^2y + 6x^2y) + (5xy^2) + (-y^3 - y^3)$$
$$= 2x^2y + 5xy^2 - 2y^3$$

**8.** **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.**
$$(2x+4y)^2 = (2x)^2 + 2(2x)(4y) + (4y)^2$$
$$= 4x^2 + 16xy + 16y^2$$

**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.** $(x+5)\left(x^2-5x+25\right)=x(x^2)-x(5x)+x(25)+5(x^2)-5(5x)+5(25)$
$=x^3-5x^2+25x+5x^2-25x+125)$
$=x^3+125$

**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.** $\left(8x^3+3\right)\left(x^2-5\right)=\left(8x^3\right)\left(x^2\right)+\left(8x^3\right)(-5)+(3)\left(x^2\right)+(3)(-5)=8x^5-40x^3+3x^2-15$

**30.** $\left(7x^3+5\right)\left(x^2-2\right)=\left(7x^3\right)\left(x^2\right)+\left(7x^3\right)(-2)+(5)\left(x^2\right)+(5)(-2)=7x^5-14x^3+5x^2-10$

**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.** $\left(1-y^5\right)\left(1+y^5\right)=(1)^2-\left(y^5\right)^2=1-y^{10}$

**40.** $\left(2-y^5\right)\left(2+y^5\right)=(2)^2-\left(y^5\right)^2=4-y^{10}$

**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.** $(x-3)^3 = x^3 - 3 \cdot x^3 \cdot 3 + 3 \cdot x \cdot 3^2 - 3^3 = x^3 - 9x^2 + 27x - 27$

**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.**
$$\begin{aligned}(5x^2y - 3xy) + (2x^2y - xy) &= (5x^2y + 2x^2y) + (-3xy - xy) \\ &= (5+2)x^2y + (-3-1)xy \\ &= 7x^2y - 4xy \text{ is of degree 3.}\end{aligned}$$

**60.**
$$\begin{aligned}(-2x^2y + xy) + (4x^2y + 7xy) &= (-2x^2y + 4x^2y) + (xy + 7xy) \\ &= (-2+4)x^2y + (1+7)xy \\ &= 2x^2y + 8xy \text{ is of degree 3.}\end{aligned}$$

**61.**
$$\begin{aligned}(4x^2y + 8xy + 11) + (-2x^2y + 5xy + 2) &= (4x^2y - 2x^2y) + (8xy + 5xy) + (11+2) \\ &= (4-2)x^2y + (8+5)xy + 13 \\ &= 2x^2y + 13xy + 13 \text{ is of degree 3.}\end{aligned}$$

**62.**
$$\begin{aligned}(7x^4y^2 - 5x^2y^2 + 3xy) + (-18x^4y^2 - 6x^2y^2 - xy) &= (7x^4y^2 - 18x^4y^2) + (-5x^2y^2 - 6x^2y^2) + (3xy - xy) \\ &= (7-18)x^4y^2 + (-5-6)x^2y^2 + (3-1)xy \\ &= -11x^4y^2 - 11x^2y^2 + 2xy \text{ is of degree 6.}\end{aligned}$$

**63.**
$$\begin{aligned}(x^3 + 7xy - 5y^2) - (6x^3 - xy + 4y^2) &= (x^3 + 7xy - 5y^2) \\ &= (x^3 - 6x^3) + (7xy + xy) + (-5y^2 - 4y^2) \\ &= (1-6)x^3 + (7+1)xy + (-5-4)y^2 \\ &= -5x^3 + 8xy - 9y^2 \text{ is of degree 3.}\end{aligned}$$

**64.** $(x^4 - 7xy - 5y^3) - (6x^4 - 3xy + 4y^3) = (x^4 - 7xy - 5y^3) + (-6x^4 + 3xy - 4y^3)$
$= (x^4 - 6x^4) + (-7xy + 3xy) + (-5y^3 - 4y^3)$
$= (1-6)x^4 + (-7+3)xy + (-5-4)y^3$
$= -5x^4 - 4xy - 9y^3$ is of degree 4.

**65.** $(3x^4y^2 + 5x^3y - 3y) - (2x^4y^2 - 3x^3y - 4y + 6x) = (3x^4y^2 + 5x^3y - 3y) + (-2x^4y^2 + 3x^3y + 4y - 6x)$
$= (3x^4y^2 - 2x^4y^2) + (5x^3y + 3x^3y) + (-3y + 4y) - 6x$
$= (3-2)x^4y^2 + (5+3)x^3y + (-3+4)y - 6x$
$= x^4y^2 + 8x^3y + y - 6x$ is of degree 6.

**66.** $(5x^4y^2 + 6x^3y - 7y) - (3x^4y^2 - 5x^3y - 6y + 8x) = (5x^4y^2 + 6x^3y - 7y) + (-3x^4y^2 + 5x^3y + 6y - 8x)$
$= (5x^4y^2 - 3x^4y^2) + (6x^3y + 5x^3y) + (-7y + 6y) - 8x$
$= (5-3)x^4y^2 + (6+5)x^3y + (-7+6)y - 8x$
$= 2x^4y^2 + 11x^3y - y - 8x$ is of degree 6.

**67.** $(x+5y)(7x+3y) = x(7x) + x(3y) + (5y)(7x) + (5y)(3y)$
$= 7x^2 + 3xy + 35xy + 15y^2$
$= 7x^2 + 38xy + 15y^2$

**68.** $(x+9y)(6x+7y) = x(6x) + x(7y) + (9y)(6x) + (9y)(7y)$
$= 6x^2 + 7xy + 54xy + 63y^2$
$= 6x^2 + 61xy + 63y^2$

**69.** $(x-3y)(2x+7y) = x(2x) + x(7y) + (-3y)(2x) + (-3y)(7y)$
$= 2x^2 + 7xy - 6xy - 21y^2$
$= 2x^2 + xy - 21y^2$

**70.** $(3x-y)(2x+5y) = (3x)(2x) + (3x)(5y) + (-y)(2x) + (-y)(5y)$
$= 6x^2 + 15xy - 2xy - 5y^2$
$= 6x^2 + 13xy - 5y^2$

**71.** $(3xy-1)(5xy+2) = (3xy)(5xy) + (3xy)(2) + (-1)(5xy) + (-1)(2)$
$= 15x^2y^2 + 6xy - 5xy - 2$
$= 15x^2y^2 + xy - 2$

**72.** $(7x^2y+1)(2x^2y-3) = (7x^2y)(2x^2y) + (7x^2y)(-3) + (1)2x^2y + (1)(-3)$
$= 14x^4y^2 - 21x^2y + 2x^2y - 3$
$= 14x^4y^2 - 19x^2y - 3$

**73.** $(7x+5y)^2 = (7x)^2 + 2(7x)(5y) + (5y)^2 = 49x^2 + 70xy + 25y^2$

**74.** $(9x+7y)^2 = (9x)^2 + 2(9x)(7y) + (7y)^2 = 81x^2 + 126xy + 49y^2$

**75.** $(x^2y^2-3)^2=(x^2y^2)^2-2(x^2y^2)(3)+3^2=x^4y^4-6x^2y^2+9$

**76.** $(x^2y^2-5)^2=(x^2y^2)^2-2(x^2y^2)(5)+5^2=x^4y^4-10x^2y^2+25$

**77.** $$\begin{aligned}(x-y)(x^2+xy+y^2)&=x(x^2)+x(xy)+x(y^2)+(-y)(x^2)+(-y)(xy)+(-y)(y^2)\\&=x^3+x^2y+xy^2-x^2y-xy^2-y^3\\&=x^3-y^3\end{aligned}$$

**78.** $$\begin{aligned}(x+y)(x^2-xy+y^2)&=x(x^2)+x(-xy)+x(y^2)+y(x^2)+y(-xy)+y(y^2)\\&=x^3-x^2y+xy^2+x^2y-xy^2+y^3\\&=x^3+y^3\end{aligned}$$

**79.** $(3x+5y)(3x-5y)=(3x)^2-(5y)^2=9x^2-25y^2$

**80.** $(7x+3y)(7x-3y)=(7x)^2-(3y)^2=49x^2-9y^2$

**81.** $\left(7xy^2-10y\right)\left(7xy^2+10y\right)=\left(7xy^2\right)^2-\left(10y\right)^2=49x^2y^4-100y^2$

**82.** $\left(3xy^2-4y\right)\left(3xy^2+4y\right)=\left(3xy^2\right)^2-\left(4y\right)^2=9x^2y^4-16y^2$

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

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

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

**86.** $(3x+5)(2x-9)-(7x-2)(x-1)$

$=\left(6x^2-27x+10x-45\right)-\left(7x^2-7x-2x+2\right)$

$=\left(6x^2-17x-45\right)-\left(7x^2-9x+2\right)$

$=6x^2-17x-45-7x^2+9x-2$

$=-x^2-8x-47$

**87.** $(2x+5)(2x-5)\left(4x^2+25\right)$

$=\left[(2x)^2-5^2\right]\left(4x^2+25\right)$

$=\left(4x^2-25\right)\left(4x^2+25\right)$

$=\left(4x^2\right)^2-(25)^2$

$=16x^4-625$

**88.** $(3x+4)(3x-4)\left(9x^2+16\right)$

$=\left[(3x)^2-4^2\right]\left(9x^2+16\right)$

$=\left(9x^2-16\right)\left(9x^2+16\right)$

$=\left(9x^2\right)^2-(16)^2$

$=81x^4-256$

**89.** $\dfrac{(2x-7)^5}{(2x-7)^3}=(2x-7)^{5-3}$

$=(2x-7)^2$

$=(2x)^2-2(2x)(7)+(7)^2$

$=4x^2-28x+49$

**90.** $\dfrac{(5x-3)^6}{(5x-3)^4}=(5x-3)^{6-4}$

$=(5x-3)^2$

$=(5x)^2-2(5x)(3)+(3)^2$

$=25x^2-30x+9$

**91.** **a.** $S=0.2x^3-1.5x^2+3.4x+25+\left(0.1x^3-1.3x^2+3.3x+5\right)$

$S=0.2x^3-1.5x^2+3.4x+25+0.1x^3-1.3x^2+3.3x+5$

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

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

$S = 0.3(5)^3 - 2.8(5)^2 + 6.7(5) + 30$

$S = 31$

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. a.** $S = 0.1x^3 - 1.2x^2 + 2.4x + 17 + \left(0.2x^3 - 1.6x^2 + 4.3x + 13\right)$

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

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

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

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

$S = 34.2$

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.

**93.** $x(8-2x)(10-2x) = x\left(80 - 36x + 4x^2\right)$

$= 80x - 36x^2 + 4x^3$

$= 4x^3 - 36x^2 + 80x$

**94.** $x(8-2x)(5-2x) = x\left(40 - 26x + 4x^2\right)$

$= 40x - 26x^2 + 4x^3$

$= 4x^3 - 26x^2 + 40x$

**95.** $(x+9)(x+3) - (x+5)(x+1)$

$= x^2 + 12x + 27 - \left(x^2 + 6x + 5\right)$

$= x^2 + 12x + 27 - x^2 - 6x - 5$

$= 6x + 22$

**96.** $(x+4)(x+3) - (x+2)(x+1)$

$= x^2 + 7x + 12 - \left(x^2 + 3x + 2\right)$

$= x^2 + 7x + 12 - x^2 - 3x - 2$

$= 4x + 10$

**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

**107.** false; Changes to make the statement true will vary. A sample change is: $(3x^3 + 2)(3x^3 - 2) = 9x^6 - 4$