

153. Given  $\sqrt[n]{a}$ ,  $a$  is the radicand and  $n$  is the index.

157. (a) “Last digits:” 1 (Perfect square 81)  
 4 (Perfect square 64)  
 5 (Perfect square 25)  
 6 (Perfect square 36)  
 9 (Perfect square 49)  
 0 (Perfect square 100)

155. No.  $\sqrt{2}$  is an irrational number. Its decimal representation is a nonterminating, nonrepeating decimal.

- (b) Yes, 4,322,788,986 ends in a 6, but it is not a perfect square.

## Section 5.2 Simplifying Radical Expressions

$$1. \sqrt{20} = \sqrt{4 \cdot 5} = \sqrt{2^2 \cdot 5} = 2\sqrt{5}$$

$$3. \sqrt{50} = \sqrt{25 \cdot 2} = \sqrt{5^2 \cdot 2} = 5\sqrt{2}$$

$$5. \sqrt{96} = \sqrt{16 \cdot 6} = \sqrt{4^2 \cdot 6} = 4\sqrt{6}$$

$$7. \sqrt{216} = \sqrt{36 \cdot 6} = \sqrt{6^2 \cdot 6} = 6\sqrt{6}$$

$$9. \sqrt{1183} = \sqrt{169 \cdot 7} = \sqrt{13^2 \cdot 7} = 13\sqrt{7}$$

$$11. \sqrt{0.04} = \sqrt{4 \cdot 0.01} = \sqrt{4} \sqrt{0.01} = 2 \cdot 0.1 = 0.2$$

$$\begin{aligned} 13. \sqrt{0.0072} &= \sqrt{36 \cdot 2 \cdot 0.0001} \\ &= \sqrt{36} \cdot \sqrt{2} \cdot \sqrt{0.0001} \\ &= 6 \cdot 0.01\sqrt{2} \\ &= 0.06\sqrt{2} \end{aligned}$$

$$\begin{aligned} 15. \sqrt{2.42} &= \sqrt{121 \cdot 2 \cdot 0.01} \\ &= \sqrt{121} \cdot \sqrt{2} \cdot \sqrt{0.01} \\ &= 11 \cdot 0.1\sqrt{2} \\ &= 1.1\sqrt{2} \end{aligned}$$

$$17. \sqrt{\frac{15}{4}} = \frac{\sqrt{15}}{2}$$

$$19. \sqrt{\frac{13}{25}} = \frac{\sqrt{13}}{5}$$

$$\begin{aligned} 21. \sqrt{9x^5} &= \sqrt{3^2 x^4 \cdot x} \\ &= 3 \cdot x^2 \cdot \sqrt{x} \\ &= 3x^2\sqrt{x} \end{aligned}$$

$$23. \sqrt{48y^4} = \sqrt{16 \cdot 3 \cdot y^4} = 4y^2\sqrt{3}$$

$$25. \sqrt{117y^6} = \sqrt{9 \cdot 13 \cdot y^6} = 3|y^3|\sqrt{13}$$

$$27. \sqrt{120x^2y^3} = \sqrt{4 \cdot 30 \cdot x^2 \cdot y^2 \cdot y} = 2|x|y\sqrt{30y}$$

$$\begin{aligned} 29. \sqrt{192a^5b^7} &= \sqrt{64 \cdot 3 \cdot a^4 \cdot a \cdot b^6 \cdot b} \\ &= 8a^2b^3\sqrt{3ab} \end{aligned}$$

$$31. \sqrt[3]{48} = \sqrt[3]{16 \cdot 3} = \sqrt[3]{2^4 \cdot 3} = 2\sqrt[3]{3 \cdot 2} = 2\sqrt[3]{6}$$

$$\begin{aligned} 33. \sqrt[3]{112} &= \sqrt[3]{8 \cdot 14} \\ &= \sqrt[3]{8} \cdot \sqrt[3]{14} \\ &= 2\sqrt[3]{14} \end{aligned}$$

$$\begin{aligned} 35. \sqrt[3]{40x^5} &= \sqrt[3]{8 \cdot 5 \cdot x^3 \cdot x^2} \\ &= 2x\sqrt[3]{5x^2} \end{aligned}$$

$$\begin{aligned} 37. \sqrt[4]{324y^6} &= \sqrt[4]{81 \cdot 4 \cdot y^4 \cdot y^2} \\ &= 3|y|\sqrt[4]{4y^2} \\ &= 3|y|\sqrt[4]{2^2y^2} \\ &= 3|y|\sqrt{2y} \end{aligned}$$

$$39. \sqrt[3]{x^4y^3} = \sqrt[3]{x^3 \cdot x \cdot y^3} = xy\sqrt[3]{x}$$

$$\begin{aligned} 41. \sqrt[4]{3x^4y^2} &= \sqrt[4]{x^4} \cdot \sqrt[4]{3y^2} \\ &= |x|\sqrt[4]{3y^2} \end{aligned}$$

$$43. \sqrt[5]{32x^5y^6} = \sqrt[5]{2^5 \cdot x^5 \cdot y^5 \cdot y} = 2xy\sqrt[5]{y}$$

45.  $\sqrt[3]{\frac{35}{64}} = \frac{\sqrt[3]{35}}{4}$

47.  $\sqrt[5]{\frac{15}{243}} = \frac{\sqrt[5]{15}}{3}$

49.  $\sqrt[5]{\frac{32x^2}{y^5}} = \sqrt[5]{\frac{2^5x^2}{y^5}}$   
 $= \frac{2}{y}\sqrt[5]{x^2}$

51.  $\sqrt[3]{\frac{54a^4}{b^9}} = \sqrt[3]{\frac{3^3 \cdot 2 \cdot a^3 \cdot a}{b^9}} = \frac{3a}{b^3}\sqrt[3]{2a}$

53.  $\sqrt{\frac{32a^4}{b^2}} = \frac{\sqrt{16 \cdot 2 \cdot a^4}}{\sqrt{b^2}} = \frac{4a^2\sqrt{2}}{|b|}$

55.  $\sqrt[4]{(3x^2)^4} = 3x^2$

57.  $\sqrt{\frac{1}{3}} = \frac{1}{\sqrt{3}} \cdot \frac{\sqrt{3}}{\sqrt{3}} = \frac{\sqrt{3}}{3}$

59.  $\frac{1}{\sqrt{7}} = \frac{1}{\sqrt{7}} \cdot \frac{\sqrt{7}}{\sqrt{7}} = \frac{\sqrt{7}}{7}$

61.  $\frac{12}{\sqrt{3}} = \frac{12}{\sqrt{3}} \cdot \frac{\sqrt{3}}{\sqrt{3}} = \frac{12\sqrt{3}}{3} = 4\sqrt{3}$

63.  $\sqrt[4]{\frac{5}{4}} = \frac{\sqrt[4]{5}}{\sqrt[4]{2^2}} \cdot \frac{\sqrt[4]{2^2}}{\sqrt[4]{2^2}} = \frac{\sqrt[4]{5 \cdot 2^2}}{\sqrt[4]{2^4}} = \frac{\sqrt[4]{20}}{2}$

65.  $\frac{6}{\sqrt[3]{32}} = \frac{6}{\sqrt[3]{2^3 \cdot 2^2}} = \frac{6}{2\sqrt[3]{2^2}} \cdot \frac{\sqrt[3]{2}}{\sqrt[3]{2}} = \frac{6\sqrt[3]{2}}{2\sqrt[3]{2^3}} = \frac{6\sqrt[3]{2}}{4} = \frac{3\sqrt[3]{2}}{2}$

67.  $\frac{1}{\sqrt{y}} = \frac{1}{\sqrt{y}} \cdot \frac{\sqrt{y}}{\sqrt{y}} = \frac{\sqrt{y}}{\sqrt{y^2}} = \frac{\sqrt{y}}{y}$

69.  $\sqrt{\frac{4}{x}} = \frac{\sqrt{4}}{\sqrt{x}} = \frac{2}{\sqrt{x}} \cdot \frac{\sqrt{x}}{\sqrt{x}} = \frac{2\sqrt{x}}{x}$

71.  $\frac{1}{\sqrt{2x}} = \frac{1}{\sqrt{2x}} \cdot \frac{\sqrt{2x}}{\sqrt{2x}} = \frac{\sqrt{2x}}{2x}$

73.  $\frac{6}{\sqrt{3b^3}} = \frac{6}{b\sqrt{3b}} \cdot \frac{\sqrt{3b}}{\sqrt{3b}} = \frac{6\sqrt{3b}}{3b^2} = \frac{2\sqrt{3b}}{b^2}$

75.  $\sqrt[3]{\frac{2x}{3y}} = \frac{\sqrt[3]{2x}}{\sqrt[3]{3y}} \cdot \frac{\sqrt[3]{3^2y^2}}{\sqrt[3]{3^2y^2}} = \frac{\sqrt[3]{2x \cdot 3^2y^2}}{\sqrt[3]{3^3y^3}} = \frac{\sqrt[3]{18xy^2}}{3y}$

77.  $\frac{a^3}{\sqrt[3]{ab^2}} = \frac{a^3}{\sqrt[3]{ab^2}} \cdot \frac{\sqrt[3]{a^2b}}{\sqrt[3]{a^2b}} = \frac{a^3\sqrt[3]{a^2b}}{\sqrt[3]{a^3b^3}} = \frac{a^3\sqrt[3]{a^2b}}{ab} = \frac{a^2\sqrt[3]{a^2b}}{b}$

79.  $3\sqrt{2} - \sqrt{2} = 2\sqrt{2}$

81.  $12\sqrt{8} - 3\sqrt[3]{8} = 12\sqrt{4 \cdot 2} - 3 \cdot 2 = 24\sqrt{2} - 6$

83.  $\sqrt[4]{3} - 5\sqrt[4]{7} - 12\sqrt[4]{3} = -11\sqrt[4]{3} - 5\sqrt[4]{7}$

85.  $2\sqrt[3]{54} + 12\sqrt[3]{16} = 2\sqrt[3]{27 \cdot 2} + 12\sqrt[3]{8 \cdot 2}$   
 $= 6\sqrt[3]{2} + 24\sqrt[3]{2} = 30\sqrt[3]{2}$

87.  $5\sqrt{9x} - 3\sqrt{x} = 15\sqrt{x} - 3\sqrt{x} = 12\sqrt{x}$

89.  $\sqrt{25y} + \sqrt{64y} = 5\sqrt{y} + 8\sqrt{y} = 13\sqrt{y}$

91.  $10\sqrt[3]{z} - \sqrt[3]{z^4} = 10\sqrt[3]{z} - \sqrt[3]{z^3 \cdot z} = 10\sqrt[3]{z} - z\sqrt[3]{z}$   
 $= (10 - z)\sqrt[3]{z}$

93.  $\sqrt{5} - \frac{3}{\sqrt{5}} = \sqrt{5} - \left(\frac{3}{\sqrt{5}} \cdot \frac{\sqrt{5}}{\sqrt{5}}\right) = \sqrt{5} - \frac{3\sqrt{5}}{5}$   
 $= \left(1 - \frac{3}{5}\right)\sqrt{5}$   
 $= \frac{2}{5}\sqrt{5}$

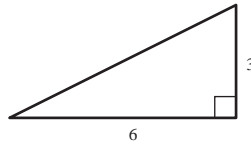
95.  $\sqrt{20} - \sqrt{\frac{1}{5}} = \sqrt{4 \cdot 5} - \sqrt{\frac{1}{5}} \cdot \frac{\sqrt{5}}{\sqrt{5}} = 2\sqrt{5} - \frac{\sqrt{5}}{5}$   
 $= \left(2 - \frac{1}{5}\right)\sqrt{5}$   
 $= \frac{9}{5}\sqrt{5}$

97.  $\sqrt{2x} - \frac{3}{\sqrt{2x}} = \sqrt{2x} - \left(\frac{3}{\sqrt{2x}} \cdot \frac{\sqrt{2x}}{\sqrt{2x}}\right) = \sqrt{2x} - \frac{3\sqrt{2x}}{2x}$   
 $= \frac{2x\sqrt{2x}}{2x} - \frac{3\sqrt{2x}}{2x}$   
 $= \frac{2x\sqrt{2x} - 3\sqrt{2x}}{2x}$   
 $= \frac{\sqrt{2x}(2x - 3)}{2x}$

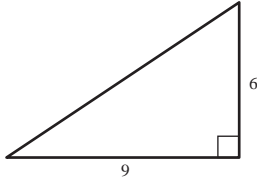
99.  $\sqrt{7} + \sqrt{18} > \sqrt{7+18}$

101.  $5 > \sqrt{3^2 + 2^2}$

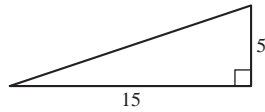
$$\begin{aligned} 103. c &= \sqrt{a^2 + b^2} \\ &= \sqrt{6^2 + 3^2} \\ &= \sqrt{36 + 9} = \sqrt{45} = \sqrt{9 \cdot 5} = 3\sqrt{5} \end{aligned}$$



$$\begin{aligned} 105. c &= \sqrt{a^2 + b^2} \\ &= \sqrt{9^2 + 6^2} \\ &= \sqrt{81 + 36} \\ &= \sqrt{117} \\ &= 3\sqrt{13} \end{aligned}$$



$$\begin{aligned} 107. (a) c &= \sqrt{a^2 + b^2} \\ c &= \sqrt{(15)^2 + (5)^2} \\ c &= \sqrt{225 + 25} \\ c &= \sqrt{250} \\ c &= \sqrt{25 \cdot 10} \\ c &= 5\sqrt{10} \end{aligned}$$



(b) Area of roof = 2 · Length · Width

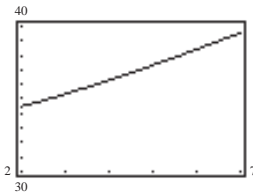
$$A = 2 \cdot 40 \cdot 5\sqrt{10}$$

$$A = 400\sqrt{10}$$

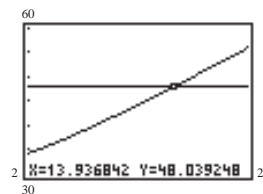
Thus, the total area of the roof is  $400\sqrt{10} \approx 1264.9$  square feet.

$$109. f = \frac{1}{100} \sqrt{\frac{400 \times 10^6}{5}} \approx 8.9443 \times 10^1 \approx 89.443 \approx 89.44 \text{ cycles per second}$$

111. (a)



(b)



The average salary will reach \$48,000 after 14 years so  $1990 + 14 = 2004$ .

$$113. \left(\frac{5}{\sqrt{3}}\right)^2 = \frac{5}{\sqrt{3}} \cdot \frac{5}{\sqrt{3}} = \frac{25}{3}$$

No. When you rationalize the denominator, the value of the number is not changed.

$$\frac{5}{\sqrt{3}} = \frac{5}{\sqrt{3}} \cdot \frac{\sqrt{3}}{\sqrt{3}} = \frac{5\sqrt{3}}{3} \neq \frac{25}{3}$$

$$115. \text{ Example: } \sqrt{6} \cdot \sqrt{15} = \sqrt{6 \cdot 15} = \sqrt{3 \cdot 2 \cdot 3 \cdot 5} = 3\sqrt{10}$$

117.  $\sqrt{2} + \sqrt{18}$  is not in simplest form because  $\sqrt{18}$  can be simplified to  $3\sqrt{2}$  and then added to  $\sqrt{2}$ .

$$\sqrt{2} + \sqrt{18} = \sqrt{2} + 3\sqrt{2} = 4\sqrt{2}$$

119.  $\sqrt{x^2} \neq x$  for all negative values of  $x$ .

$$\text{Example: } \sqrt{(-8)^2} = \sqrt{64} = 8$$