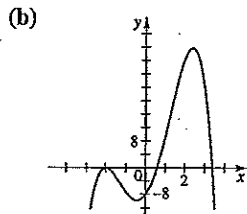
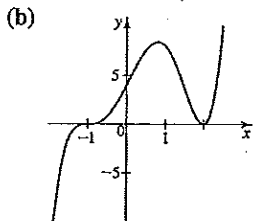


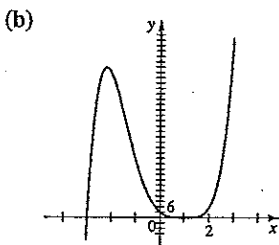
56. (a)  $-2, 2 \pm \sqrt{2}$



57. (a)  $-1, 2$



58. (a)  $-3, 1$



59. 1 positive, 2 or 0 negative; 3 or 1 real  
 60. 3 or 1 positive, no negative; 1 or 3 real  
 61. 1 positive, 1 negative; 2 real  
 62. No positive, 4, 2, or 0 negative; 0, 2, or 4 real  
 63. 2 or 0 positive, 0 negative; 3 or 1 real (since 0 is a zero but is neither positive nor negative) 64. 6, 4, 2, or 0 positive, no negative; 6, 4, 2, or 0 real 69. 3, -2 70. 3, -2  
 71. 3, -1 72. 1, -1 73.  $-2, \frac{1}{2}, \pm 1$   
 74.  $-2, -\frac{1}{2}, \frac{-5 \pm \sqrt{17}}{2}$   
 75.  $\pm \frac{1}{2}, \pm \sqrt{5}$  76.  $-1, 0, \frac{1}{2}, \frac{5}{3}$  77.  $-2, 1, 3, 4$   
 78.  $-2, \frac{3}{4}, 1, \frac{2 \pm \sqrt{2}}{2}$  83.  $-2, 2, 3$  84.  $-2, -1, 1, 2$   
 85.  $-\frac{3}{2}, -1, 1, 4$  86.  $-2$  87.  $-1.28, 1.53$  88. 3  
 89.  $-1.50$  90.  $-1.71, -1.20, -0.80$  93. 11.3 ft  
 94. 47 ft by 106 ft 95. (a) It began to snow again.  
 (b) No (c) Just before midnight on Saturday night  
 96. 5 cm by 10 cm by 30 cm or 3.49 cm by 13.03 cm by 33.03 cm  
 97. 2.76 m 98. (b) 1.45 ft by 1.34 ft or 2.31 ft by 0.53 ft  
 99. 88 in. (or 3.21 in.)

**Section 8.4 ■ page 289**

1. Real part 5, imaginary part  $-7$  2. Real part  $-6$ , imaginary part 4 3. Real part  $-\frac{2}{3}$ , imaginary part  $-\frac{5}{3}$  4. Real part 2, imaginary part  $\frac{7}{2}$  5. Real part 3, imaginary part 0 6. Real part  $-\frac{1}{2}$ , imaginary part 0 7. Real part 0, imaginary part  $-\frac{2}{3}$

8. Real part 0, imaginary part  $\sqrt{3}$  9. Real part  $\sqrt{3}$ , imaginary part 2 10. Real part 2, imaginary part  $-\sqrt{5}$   
 11.  $5 - i$  12.  $6 - i$  13.  $3 + 5i$  14.  $-2 - \frac{1}{2}i$   
 15.  $6 - i$  16. 1 17.  $2 - 2i$  18.  $-6 + 6i$   
 19.  $-19 + 4i$  20.  $-4 + 7i$  21.  $-\frac{1}{4} + \frac{1}{2}i$   
 22.  $-1.1 + 2.5i$  23.  $-4 + 8i$  24.  $2 + i$  25.  $30 + 10i$   
 26.  $8 + 2i$  27.  $-33 - 56i$  28.  $-\frac{2591}{9} + 18i$  29.  $27 - 8i$   
 30.  $1 + 17i$  31.  $-i$  32.  $\frac{1}{2} - \frac{1}{2}i$  33.  $\frac{8}{5} + \frac{1}{5}i$   
 34.  $\frac{11}{25} - \frac{23}{25}i$  35.  $-5 + 12i$  36.  $4 + 3i$  37.  $-4 + 2i$   
 38.  $\frac{2}{15} + \frac{3}{15}i$  39.  $2 - \frac{4}{3}i$  40.  $\frac{1}{3} + \frac{1}{3}i$  41.  $-i$  42.  $3 + i$   
 43.  $-i$  44. 16 45. 1 46.  $-1$  47.  $5i$  48.  $\frac{3}{2}i$   
 49.  $-6$  50.  $3i$  51.  $(3 + \sqrt{5}) + (3 - \sqrt{5})i$  52.  $-i$   
 53. 2 54.  $-\sqrt{2} - 4\sqrt{6}i$  55.  $-i\sqrt{2}$  56.  $-\frac{7}{2}$  57.  $\pm 3i$   
 58.  $\pm \frac{2}{3}i$  59.  $2 \pm i$  60.  $-1 \pm i$  61.  $-\frac{1}{2} \pm \frac{\sqrt{3}}{2}i$   
 62.  $\frac{3}{2} \pm \frac{\sqrt{3}}{2}i$  63.  $\frac{1}{2} \pm \frac{1}{2}i$  64.  $\frac{1}{2} \pm \frac{\sqrt{5}}{2}i$  65.  $-\frac{3}{2} \pm \frac{\sqrt{3}}{2}i$   
 66.  $-2 \pm 2\sqrt{2}i$  67.  $\frac{-6 \pm \sqrt{6}i}{6}$  68.  $2 \pm \frac{\sqrt{3}}{2}i$   
 69.  $1 \pm 3i$  70.  $-\frac{1}{4} \pm \frac{\sqrt{15}}{4}i$

**Section 8.5 ■ page 298**

1. (a)  $0, \pm 2i$  (b)  $x^2(x - 2i)(x + 2i)$  2. (a)  $0, \pm 3i$   
 (b)  $x^3(x - 3i)(x + 3i)$  3. (a)  $0, 1 \pm i$   
 (b)  $x(x - 1 - i)(x - 1 + i)$  4. (a)  $0, -\frac{1}{2} \pm \frac{1}{2}i\sqrt{3}$   
 (b)  $x(x + \frac{1}{2} - \frac{1}{2}i\sqrt{3})(x + \frac{1}{2} + \frac{1}{2}i\sqrt{3})$  5. (a)  $\pm i$   
 (b)  $(x - i)^2(x + i)^2$  6. (a)  $\pm \sqrt{2}, \pm i$   
 (b)  $(x - \sqrt{2})(x + \sqrt{2})(x - i)(x + i)$   
 7. (a)  $\pm 2, \pm 2i$  (b)  $(x - 2)(x + 2)(x - 2i)(x + 2i)$   
 8. (a)  $\pm i\sqrt{3}$  (b)  $(x - i\sqrt{3})^2(x + i\sqrt{3})^2$   
 9. (a)  $-2, 1 \pm i\sqrt{3}$   
 (b)  $(x + 2)(x - 1 - i\sqrt{3})(x - 1 + i\sqrt{3})$   
 10. (a)  $2, -1 \pm i\sqrt{3}$   
 (b)  $(x - 2)(x + 1 - i\sqrt{3})(x + 1 + i\sqrt{3})$   
 11. (a)  $\pm 1, \frac{1}{2} \pm \frac{1}{2}i\sqrt{3}, -\frac{1}{2} \pm \frac{1}{2}i\sqrt{3}$   
 (b)  $(x - 1)(x + 1)(x - \frac{1}{2} - \frac{1}{2}i\sqrt{3})(x - \frac{1}{2} + \frac{1}{2}i\sqrt{3}) \times$   
 $(x + \frac{1}{2} - \frac{1}{2}i\sqrt{3})(x + \frac{1}{2} + \frac{1}{2}i\sqrt{3})$   
 12. (a)  $-1, 2, -1 \pm i\sqrt{3}, \frac{1}{2} \pm \frac{1}{2}i\sqrt{3}$   
 (b)  $(x + 1)(x - 2)(x + 1 - i\sqrt{3})(x + 1 + i\sqrt{3}) \times$   
 $(x - \frac{1}{2} - \frac{1}{2}i\sqrt{3})(x - \frac{1}{2} + \frac{1}{2}i\sqrt{3})$

In answers 13–30, the factored form is given first, then the zeros are listed with the multiplicity of each in parentheses.  
 13.  $(x - 5i)(x + 5i); \pm 5i(1)$

14.  $(2x - 3i)(x - (-1 - i))$   
 15.  $[x - (-1 - i)](x - (-1 + i))$   
 16.  $(x - 4 - i)(x - 4 + i)$   
 17.  $x(x - 2i)(x + 2i)$   
 18.  $x(x - \frac{1}{2} - \frac{1}{2}i\sqrt{3})(x - \frac{1}{2} + \frac{1}{2}i\sqrt{3})$   
 19.  $(x - 1)(x - 2)$   
 20.  $(x - 5)(x - 2)$   
 21.  $16(x - \frac{3}{2})(x - \frac{1}{2})$   
 22.  $(x - 4)(x - 1)$   
 23.  $(x + 1)(x - 2)$   
 24.  $(x - 3)(x - 1)$   
 25.  $(x - i)^2(x + i)^2$   
 26.  $(x - i\sqrt{5})(x + i\sqrt{5})$   
 27.  $(x - 1)(x - 2)$   
 28.  $x^3(x - i\sqrt{3})(x + i\sqrt{3})$   
 29.  $x(x - i\sqrt{3})(x + i\sqrt{3})$   
 30.  $(x + 2)^2(x - 2)$   
 31.  $P(x) = x^2 - 2x + 2$   
 32.  $x^2 - 2x + 2$   
 33.  $x^3 + x$  35.  $x^3 + x^2 - 2x$   
 36.  $x^3 + x^2 - 2x$   
 37.  $R(x) = x^4 - 13x^2 + 6$   
 38.  $x^4 + 13x^2 - 6$   
 39.  $T(x) = 6x^4 - 4x^5 + 6x^4$   
 40.  $4x^5 + 6x^4 - 2(2), 1 \pm i\sqrt{2}$   
 41.  $P(x) = x^2 - 2x + 2$   
 42.  $3, 2 \pm i$  4.  $\frac{1 \pm i\sqrt{2}}{2}$   
 45.  $2, \frac{1 \pm i\sqrt{2}}{2}$   
 48.  $3, \frac{1}{2} \pm \frac{1}{2}i\sqrt{3}$   
 51.  $1, \pm 2i, \pm i$   
 53. 3 (multiplicity 3)  
 55.  $-\frac{1}{2}$  (multiplicity 3)  
 57. 1 (multiplicity 3)  
 59. (a)  $(x - 5)^2$   
 (b)  $(x - 2)(x - 1)$   
 61. (a)  $(x - 1)^2$   
 (b)  $(x - 1)(x - 2)$

6.  $(x^2 - 2)(2x^3 + 4x^2 + 8) + (-x + 13)$   
 7.  $x + 1 + \frac{-11}{x + 3}$  8.  $x^2 + 4x + 22 + \frac{93}{x - 4}$   
 9.  $2x - \frac{1}{2} + \frac{-15}{2x - 1}$  10.  $2x^2 + 3x + \frac{5}{3x - 4}$   
 11.  $2x^2 - x + 1 + \frac{4x - 4}{x^2 + 4}$  12.  $x^3 - x + 1 + \frac{-x + 2}{x^2 + x - 1}$

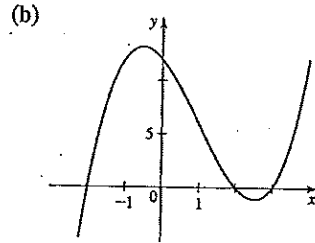
In answers 13-36, the first polynomial given is the quotient and the second is the remainder.

13.  $x - 2, -16$  14.  $x^2 + x, 6$  15.  $2x^2 - 1, -2$   
 16.  $\frac{1}{3}x^2 + \frac{1}{3}x + \frac{2}{3}, -1$  17.  $x + 2, 8x - 1$   
 18.  $3x^2 - 8x - 1, 5x - 2$  19.  $3x + 1, 7x - 5$   
 20.  $3, 20x + 5$  21.  $x^4 + 1, 0$   
 22.  $\frac{1}{2}x^3 - x^2 - \frac{5}{2}x - \frac{7}{4}, \frac{19}{2}x + 1$  23.  $x - 2, -2$   
 24.  $x - 4, 0$  25.  $3x + 23, 138$  26.  $4x - 20, 97$   
 27.  $x^2 + 2, -3$  28.  $3x^2 + 3x + 6, 31$   
 29.  $x^2 - 3x + 1, -1$  30.  $x^3 + x^2 + 3x + 5, 12$   
 31.  $x^4 + x^3 + 4x^2 + 4x + 4, -2$  32.  $x^2 - 6x + 9, 0$   
 33.  $2x^2 + 4x, 1$  34.  $6x^3 + 6x^2 + x + \frac{1}{3}, \frac{7}{9}$   
 35.  $x^2 + 3x + 9, 0$  36.  $x^3 - 2x^2 + 4x - 8, 0$  37.  $-3$   
 38.  $6$  39.  $12$  40.  $2$  41.  $-7$  42.  $20$  43.  $-483$   
 44.  $-273$  45.  $2159$  46.  $100$  47.  $\frac{1}{3}$  48.  $\frac{49}{64}$   
 49.  $-8.279$  50. (a)  $1$  (b)  $1$  55.  $-1 \pm \sqrt{6}$   
 56.  $-1, 3$  57.  $x^3 - 3x^2 - x + 3$   
 58.  $x^4 - 4x^3 - 4x^2 + 16x$  59.  $x^4 - 8x^3 + 14x^2 + 8x - 15$   
 60.  $x^5 - 5x^3 + 4x$  61.  $-\frac{3}{2}x^3 + 3x^2 + \frac{15}{2}x - 9$   
 62.  $2x^4 - 5x^3 + 5x - 2$  63.  $(x + 1)(x - 1)(x - 2)$   
 64.  $(x + 1)(x - 2)^2$  65.  $(x + 2)^2(x - 1)^2$   
 66.  $(x + 2)(x + 1)(x - 1)^2$

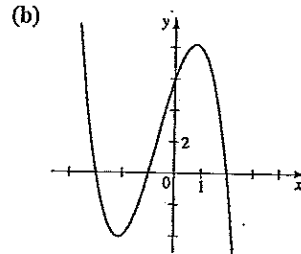
**Section 3.3 ■ page 279**

1.  $\pm 1, \pm 3$  2.  $\pm 1, \pm 2, \pm 4, \pm 8$  3.  $\pm 1, \pm 2, \pm 4, \pm 8, \pm \frac{1}{2}$   
 4.  $\pm 1, \pm 2, \pm 3, \pm 4, \pm 6, \pm 12, \pm \frac{1}{2}, \pm \frac{3}{2}, \pm \frac{1}{3}, \pm \frac{2}{3}, \pm \frac{4}{3}, \pm \frac{1}{6}$   
 5.  $\pm 1, \pm 7, \pm \frac{1}{2}, \pm \frac{7}{2}, \pm \frac{1}{4}, \pm \frac{7}{4}$   
 6.  $\pm 1, \pm 2, \pm 4, \pm 8, \pm \frac{1}{2}, \pm \frac{1}{3}, \pm \frac{2}{3}, \pm \frac{4}{3}, \pm \frac{8}{3}, \pm \frac{1}{4}, \pm \frac{1}{6}, \pm \frac{1}{12}$   
 7. (a)  $\pm 1, \pm \frac{1}{5}$  (b)  $-1, 1, \frac{1}{5}$  8. (a)  $\pm 1, \pm 2, \pm \frac{1}{3}, \pm \frac{2}{3}$   
 (b)  $-1, \frac{2}{3}$  9. (a)  $\pm 1, \pm 3, \pm \frac{1}{2}, \pm \frac{3}{2}$  (b)  $-\frac{1}{2}, 1, 3$   
 10. (a)  $\pm 1, \pm \frac{1}{2}, \pm \frac{1}{4}$  (b)  $\frac{1}{4}, 1$  11.  $-2, 1$  12.  $1, 2, 4$   
 13.  $-1, 2$  14.  $-3, 2$  15.  $2$  16.  $-3, 2$  17.  $-1, 2, 3$   
 18.  $-2, 1, 5$  19.  $-1$  20.  $3$  21.  $\pm 1, \pm 2$  22.  $-2, 1, 2$   
 23.  $1, -1, -2, -4$  24.  $-3, 2, 5$  25.  $\pm 2, \pm \frac{3}{2}$   
 26.  $-1, 2$  27.  $-2$  28.  $-2, \frac{1}{2}$  29.  $-1, -\frac{1}{2}, \frac{1}{2}$   
 30.  $-1, 1, \frac{3}{2}$  31.  $-\frac{3}{2}, \frac{1}{2}, 1$  32.  $-1, -\frac{3}{4}, \frac{1}{2}$   
 33.  $-\frac{5}{2}, -1, \frac{3}{2}$  34.  $-2, -\frac{1}{3}, \frac{1}{2}$  35.  $-1, \frac{1}{2}, 2$   
 36.  $-1, -\frac{1}{3}, \frac{1}{2}, 2$  37.  $-3, -2, 1, 3$  38.  $-2, -1, 2, 3$   
 39.  $-1, -\frac{1}{3}, 2, 5$  40.  $-3, 2, \frac{1}{2}$  41.  $-2, -1 \pm \sqrt{2}$   
 42.  $3, 1 \pm \sqrt{5}$  43.  $-1, 4, \frac{3 \pm \sqrt{13}}{2}$

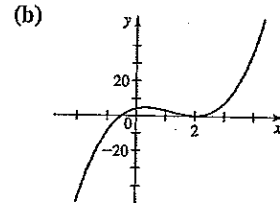
44.  $-2, 1, \frac{-1 \pm \sqrt{5}}{2}$  45.  $3, \frac{1 \pm \sqrt{5}}{2}$   
 46.  $-1, 2, 2 \pm \sqrt{2}$  47.  $\frac{1}{2}, \frac{1 \pm \sqrt{3}}{2}$   
 48.  $-\frac{1}{3}, 1 \pm \sqrt{3}$  49.  $-1, -\frac{1}{2}, -3 \pm \sqrt{10}$   
 50.  $\frac{1}{2}, 3, \frac{-2 \pm \sqrt{6}}{2}$   
 51. (a)  $-2, 2, 3$



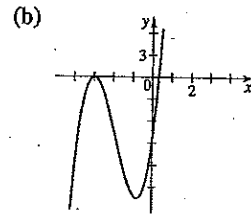
52. (a)  $2, -1, -3$



53. (a)  $-\frac{1}{2}, 2$



54. (a)  $-3, \frac{1}{3}$



55. (a)  $-1, 2$

