

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. $-1, 4, \frac{3 \pm \sqrt{13}}{2}$

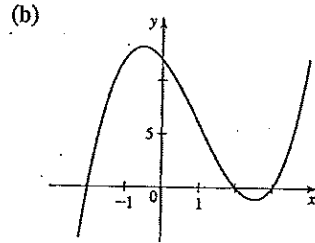
44. $-2, 1, \frac{-1 \pm \sqrt{5}}{2}$ 45. $3, \frac{1 \pm \sqrt{5}}{2}$

46. $-1, 2, 2 \pm \sqrt{2}$ 47. $\frac{1}{2}, \frac{1 \pm \sqrt{3}}{2}$

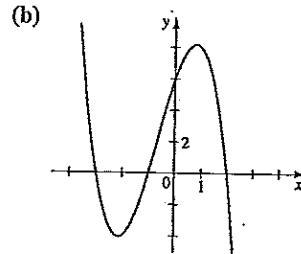
48. $-\frac{1}{3}, 1 \pm \sqrt{3}$ 49. $-1, -\frac{1}{2}, -3 \pm \sqrt{10}$

50. $\frac{1}{2}, 3, \frac{-2 \pm \sqrt{6}}{2}$

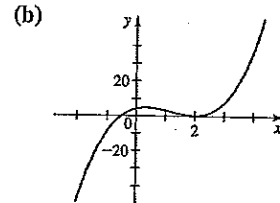
51. (a) $-2, 2, 3$



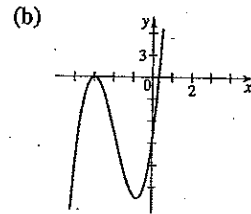
52. (a) $2, -1, -3$



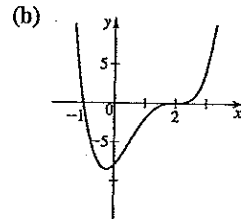
53. (a) $-\frac{1}{2}, 2$



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



55. (a) $-1, 2$

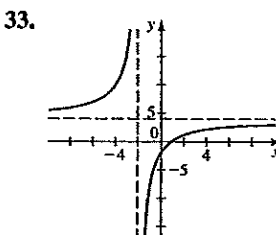
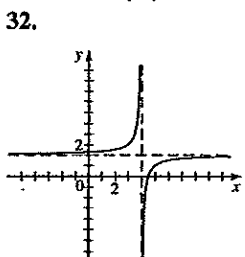
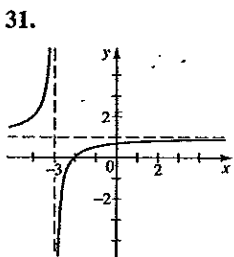
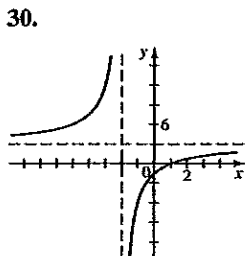
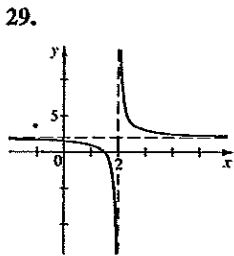
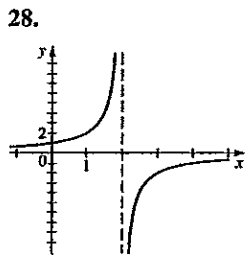
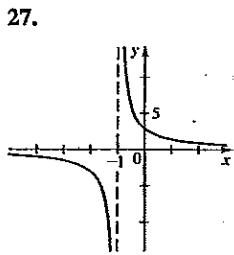
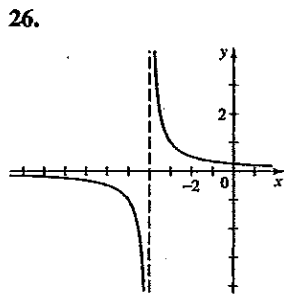
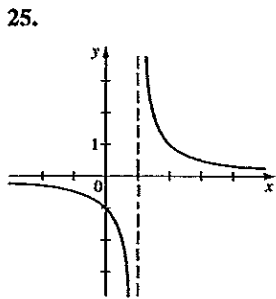


14. $(2x - 3i)(2x + 3i); \pm \frac{3}{2}i(1)$
 15. $[x - (-1 + i)][x - (-1 - i)]; -1 + i(1), -1 - i(1)$
 16. $(x - 4 - i)(x - 4 + i); 4 + i(1), 4 - i(1)$
 17. $x(x - 2i)(x + 2i); 0(1), 2i(1), -2i(1)$
 18. $x(x - \frac{1}{2} - \frac{1}{2}i\sqrt{3})(x - \frac{1}{2} + \frac{1}{2}i\sqrt{3}); 0(1), \frac{1}{2} \pm \frac{1}{2}i\sqrt{3}(1)$
 19. $(x - 1)(x + 1)(x - i)(x + i); 1(1), -1(1), i(1), -i(1)$
 20. $(x - 5)(x + 5)(x - 5i)(x + 5i); \pm 5(1), \pm 5i(1)$
 21. $16(x - \frac{3}{2})(x + \frac{3}{2})(x - \frac{3}{2}i)(x + \frac{3}{2}i);$
 $\frac{3}{2}(1), -\frac{3}{2}(1), \frac{3}{2}i(1), -\frac{3}{2}i(1)$
 22. $(x - 4)(x + 2 - 2i\sqrt{3})(x + 2 + 2i\sqrt{3});$
 $4(1), -2 \pm 2i\sqrt{3}(1)$
 23. $(x + 1)(x - 3i)(x + 3i); -1(1), 3i(1), -3i(1)$
 24. $(x - 3)(x + 3)(x - \frac{3}{2} - \frac{3}{2}i\sqrt{3})(x - \frac{3}{2} + \frac{3}{2}i\sqrt{3}) \times$
 $(x + \frac{3}{2} - \frac{3}{2}i\sqrt{3})(x + \frac{3}{2} + \frac{3}{2}i\sqrt{3}); \pm 3(1),$
 $\frac{3}{2} \pm \frac{3}{2}i\sqrt{3}(1), -\frac{3}{2} \pm \frac{3}{2}i\sqrt{3}(1)$
 25. $(x - i)^2(x + i)^2; i(2), -i(2)$
 26. $(x - i\sqrt{5})^2(x + i\sqrt{5})^2; \pm i\sqrt{5}(2)$
 27. $(x - 1)(x + 1)(x - 2i)(x + 2i); 1(1), -1(1),$
 $2i(1), -2i(1)$
 28. $x^3(x - i\sqrt{7})(x + i\sqrt{7}); 0(3), \pm i\sqrt{7}(1)$
 29. $x(x - i\sqrt{3})^2(x + i\sqrt{3})^2; 0(1), i\sqrt{3}(2), -i\sqrt{3}(2)$
 30. $(x + 2)^2(x - 1 - i\sqrt{3})^2(x - 1 + i\sqrt{3})^2;$
 $-2(2), 1 \pm i\sqrt{3}(2)$
 31. $P(x) = x^2 - 2x + 2$
 32. $x^2 - 2x + 3$ 33. $Q(x) = x^3 - 3x^2 + 4x - 12$
 34. $x^3 + x$ 35. $P(x) = x^3 - 2x^2 + x - 2$
 36. $x^3 + x^2 - 4x + 6$
 37. $R(x) = x^4 - 4x^3 + 10x^2 - 12x + 5$
 38. $x^4 + 13x^2 + 36$
 39. $T(x) = 6x^4 - 12x^3 + 18x^2 - 12x + 12$
 40. $4x^5 + 6x^4 + 4x^3 + 4x^2 - 2$ 41. $-2, \pm 2i$
 42. $3, 2 \pm i$ 43. $1, \frac{1 \pm i\sqrt{3}}{2}$ 44. $-3, -2 \pm i\sqrt{2}$
 45. $2, \frac{1 \pm i\sqrt{3}}{2}$ 46. $2, -1 \pm i\sqrt{2}$ 47. $-\frac{3}{2}, -1 \pm i\sqrt{2}$
 48. $3, \frac{1}{2} \pm \frac{1}{2}i\sqrt{5}$ 49. $-2, 1, \pm 3i$ 50. $3, -1, \pm i$
 51. $1, \pm 2i, \pm i\sqrt{3}$ 52. $-2, \pm i, 1 \pm i\sqrt{3}$
 53. 3 (multiplicity 2), $\pm 2i$ 54. $-1, 1 \pm i$
 55. $-\frac{1}{2}$ (multiplicity 2), $\pm i$ 56. $-\frac{1}{2}, 1, -\frac{1}{2} \pm \frac{1}{2}i$
 57. 1 (multiplicity 3), $\pm 3i$ 58. $2, \pm i$
 59. (a) $(x - 5)(x^2 + 4)$ (b) $(x - 5)(x - 2i)(x + 2i)$
 60. (a) $(x - 2)(x^2 + 2x + 2)$
 (b) $(x - 2)(x + 1 - i)(x + 1 + i)$
 61. (a) $(x - 1)(x + 1)(x^2 + 9)$
 (b) $(x - 1)(x + 1)(x - 3i)(x + 3i)$

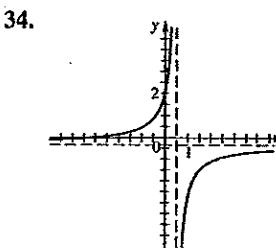
62. (a) $(x^2 + 4)^2$ (b) $(x - 2i)^2(x + 2i)^2$
 63. (a) $(x - 2)(x + 2)(x^2 - 2x + 4)(x^2 + 2x + 4)$
 (b) $(x - 2)(x + 2)[x - (1 + i\sqrt{3})][x - (1 - i\sqrt{3})] \times$
 $[x + (1 + i\sqrt{3})][x + (1 - i\sqrt{3})]$
 64. (a) $x(x - 2)(x + 2)(x^2 + 4)$
 (b) $x(x - 2)(x + 2)(x - 2i)(x + 2i)$
 65. (a) 4 real (b) 2 real, 2 imaginary (c) 4 imaginary
 66. (a) $\frac{1}{2} - 2i$ (b) $0, i$ (c) $-i$ (d) $-1 \pm i\sqrt{2}$
 68. (a) $x^4 - 2x^3 + 3x^2 - 2x + 2$
 (b) $x^2 - (1 + 2i)x - 1 + i$

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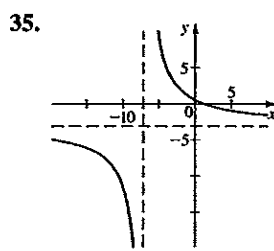
1. (a) $-3, -19, -199, -1999;$
 $5, 21, 201, 2001;$
 $1.2500, 1.0417, 1.0204, 1.0020;$
 $0.8333, 0.9615, 0.9804, 0.9980$
 (b) $r(x) \rightarrow -\infty$ as $x \rightarrow 2^-; r(x) \rightarrow \infty$ as $x \rightarrow 2^+$
 (c) Horizontal asymptote $y = 1$
 2. (a) $-14, -86, -896, -8996;$
 $22, 94, 904, 9004;$
 $5.1250, 4.1875, 4.0918, 4.0090;$
 $3.2500, 3.8269, 3.9118, 3.9910$
 (b) $r(x) \rightarrow -\infty$ as $x \rightarrow 2^-; r(x) \rightarrow \infty$ as $x \rightarrow 2^+$
 (c) Horizontal asymptote $y = 4$
 3. (a) $-22, -430, -40,300, -4,003,000;$
 $-10, -370, -39,700, -3,997,000;$
 $0.3125, 0.0608, 0.0302, 0.0030;$
 $-0.2778, -0.0592, -0.0298, -0.0030$
 (b) $r(x) \rightarrow -\infty$ as $x \rightarrow 2^-; r(x) \rightarrow -\infty$ as $x \rightarrow 2^+$
 (c) Horizontal asymptote $y = 0$
 4. (a) $31, 1183, 128,803, 12,988,003;$
 $79, 1423, 131,203, 13,012,003;$
 $4.7031, 3.2556, 3.1238, 3.0120;$
 $2.0903, 2.7740, 2.8836, 2.9880$
 (b) $r(x) \rightarrow \infty$ as $x \rightarrow 2^-; r(x) \rightarrow \infty$ as $x \rightarrow 2^+$
 (c) Horizontal asymptote $y = 3$
 5. x-intercept 1, y-intercept $-\frac{1}{4}$ 6. x-intercept 0, y-intercept 0
 7. x-intercepts $-1, 2$; y-intercept $\frac{1}{3}$ 8. no x-intercept,
 y-intercept $-\frac{1}{2}$ 9. x-intercepts $-3, 3$; no y-intercept
 10. x-intercept -2 , y-intercept 2 11. x-intercept 3,
 y-intercept 3, vertical $x = 2$; horizontal $y = 2$
 12. x-intercept 0, y-intercept 0, vertical $x = -1, x = 2$;
 horizontal $y = 0$ 13. x-intercepts $-1, 1$; y-intercept $\frac{1}{4}$;
 vertical $x = -2, x = 2$; horizontal $y = 1$
 14. x-intercepts $-2, 2$; y-intercept -6 ; horizontal $y = 2$
 15. Vertical $x = -2$; horizontal $y = 0$
 16. Vertical $x = 1$; horizontal $y = 2$
 17. Vertical $x = 3, x = -2$; horizontal $y = 1$
 18. Vertical $x = -1$; horizontal $y = 0$
 19. Horizontal $y = 0$
 20. Vertical $x = 3, x = 4$; horizontal $y = 1$
 21. Vertical $x = -6, x = 1$; horizontal $y = 0$
 22. Horizontal $y = 3$ 23. Vertical $x = 1$
 24. Vertical $x = 2, x = -2$



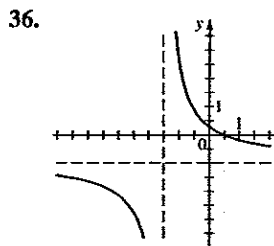
x-intercept 1
y-intercept -2
vertical $x = -2$
horizontal $y = 4$



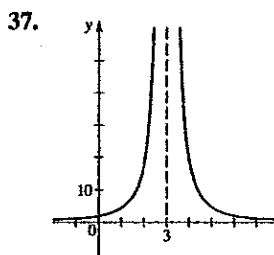
x-intercept -3
y-intercept 2
vertical $x = \frac{1}{2}$
horizontal $y = -\frac{1}{3}$



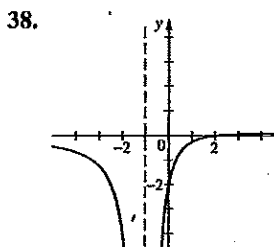
x-intercept $\frac{4}{3}$
y-intercept $\frac{4}{7}$
vertical $x = -7$
horizontal $y = -3$



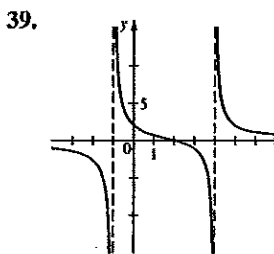
x-intercept $\frac{1}{2}$
y-intercept $\frac{1}{3}$
vertical $x = -\frac{3}{2}$
horizontal $y = -1$



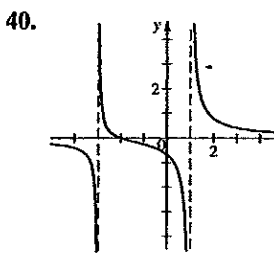
y-intercept 2
vertical $x = 3$
horizontal $y = 0$



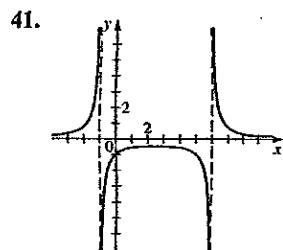
x-intercept 2
y-intercept -2
vertical $x = -1$
horizontal $y = 0$



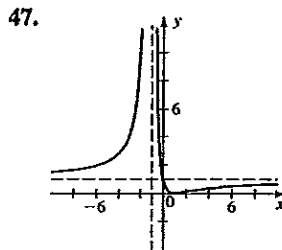
x-intercept 2
y-intercept -5
vertical $x = -1, x = 4$
horizontal $y = 0$



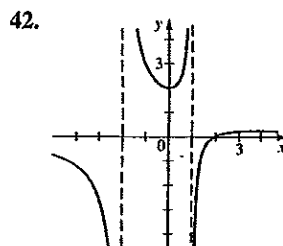
x-intercept -2
y-intercept $-\frac{2}{3}$
vertical $x = -3, x = 1$
horizontal $y = 0$



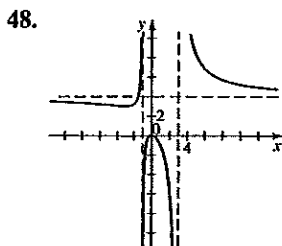
41. y-intercept -1
vertical $x = -1, x = 6$
horizontal $y = 0$



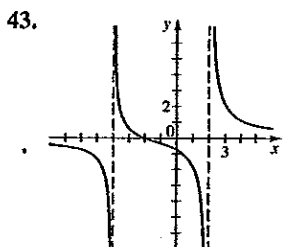
47. x-intercept 1
y-intercept 1
vertical $x = -1, x = 3$
horizontal $y = 1$



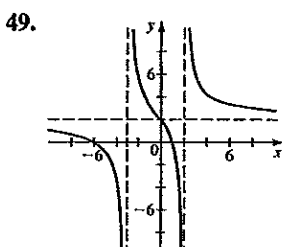
42. x-intercept 2
y-intercept 2
vertical $x = -2, x = 1$
horizontal $y = 0$



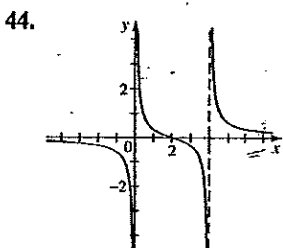
48. x-intercept 0
y-intercept 0
vertical $x = -1, x = 3$
horizontal $y = 4$



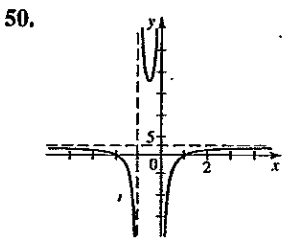
43. x-intercept -2
y-intercept $-\frac{3}{4}$
vertical $x = -4, x = 2$
horizontal $y = 0$



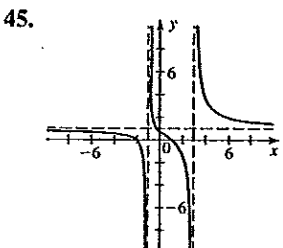
49. x-intercepts $-6, 1$
y-intercept 2
vertical $x = -3, x = 2$
horizontal $y = 2$



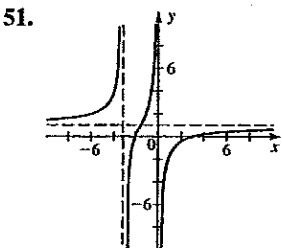
44. x-intercept 2
vertical $x = 0, x = 4$
horizontal $y = 0$



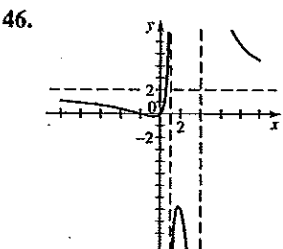
50. x-intercepts $1, -2$
vertical $x = -1, x = 0$
horizontal $y = 2$



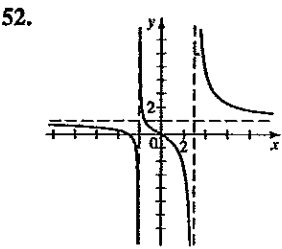
45. x-intercepts $-2, 1$
y-intercept $\frac{2}{3}$
vertical $x = -1, x = 3$
horizontal $y = 1$



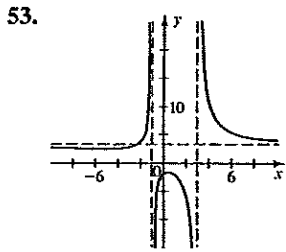
51. x-intercepts $-2, 3$
vertical $x = -3, x = 0$
horizontal $y = 1$



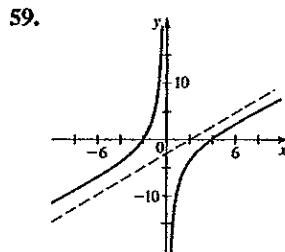
46. x-intercepts $0, -2$
y-intercept 0
vertical $x = 1, x = 4$
horizontal $y = 2$



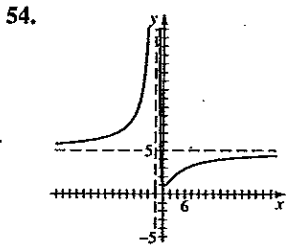
52. x-intercepts $0, -3$
y-intercept 0
vertical $x = -2, x = 3$
horizontal $y = 1$



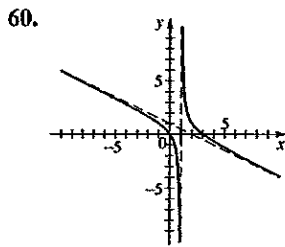
53. y-intercept -2
vertical $x = -1, x = 3$
horizontal $y = 3$



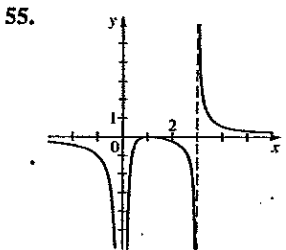
59. slant $y = x - 2$
vertical $x = 0$



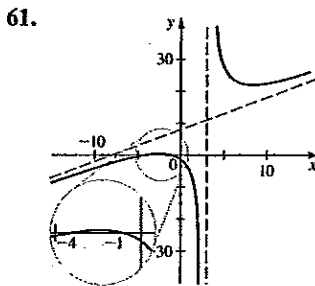
54. y-intercept $\frac{5}{4}$
vertical $x = -2$
horizontal $y = 5$



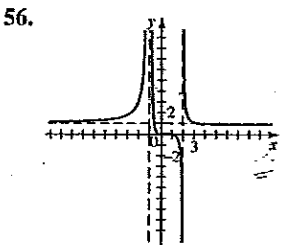
60. slant $y = -\frac{1}{2}x + 1$
vertical $x = 1$



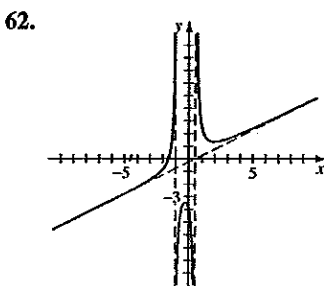
55. x-intercept 1
vertical $x = 0, x = 3$
horizontal $y = 0$



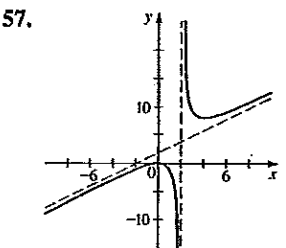
61. slant $y = x + 8$
vertical $x = 3$



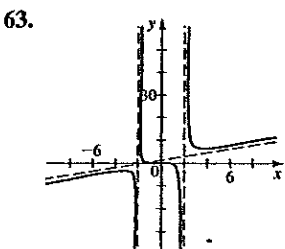
56. x-intercepts $0, 1$
y-intercept 0
vertical $x = -1, x = 2$
horizontal $y = 1$



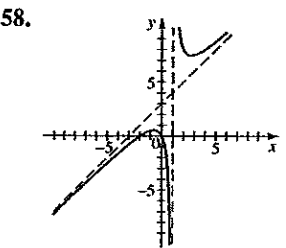
62. slant $y = \frac{1}{2}x - \frac{1}{4}$
vertical $x = -1, x = \frac{1}{2}$



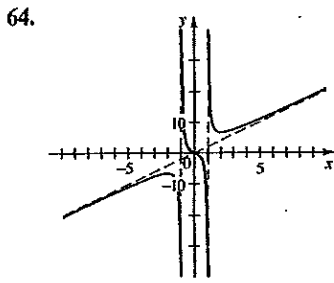
57. slant $y = x + 2$
vertical $x = 2$



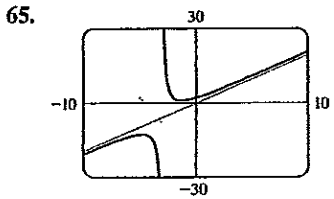
63. slant $y = x + 1$
vertical $x = 2, x = -2$



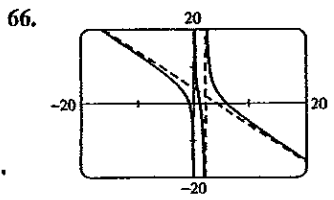
58. slant $y = x + 3$
vertical $x = 1$



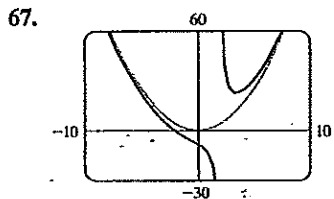
slant $y = 2x$
vertical $x = -1, x = 1$



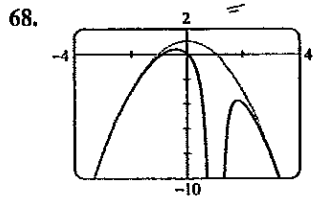
vertical $x = -3$



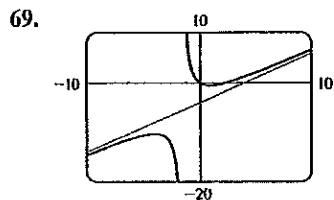
vertical $x = 0, x = 2$



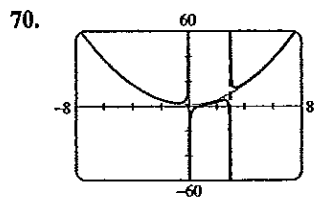
vertical $x = 2$



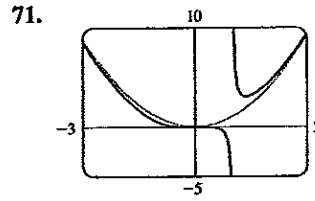
vertical $x = 1$



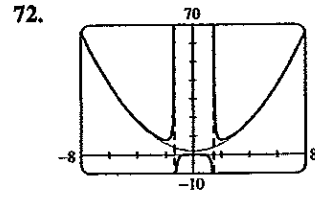
vertical $x = -1.5$
 x -intercepts $0, 2.5$
 y -intercept 0 , local maximum $(-3.9, -10.4)$
local minimum $(0.9, -0.6)$
end behavior: $y = x - 4$



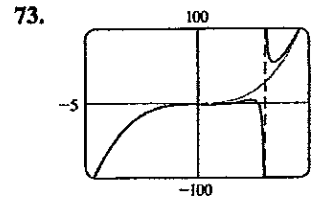
vertical $x = 0, x = 3$
 x -intercept 0.82 , local maximum $(2.56, 4.88)$
local minima $(-0.80, 2.63)$
 $(3.38, 14.76)$
end behavior $y = x^2 + 1$



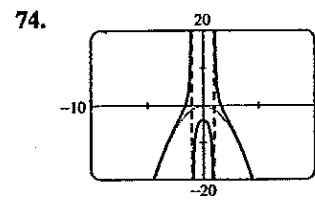
vertical $x = 1$
 x -intercept 0
 y -intercept 0
local minimum $(1.4, 3.1)$
end behavior: $y = x^2$



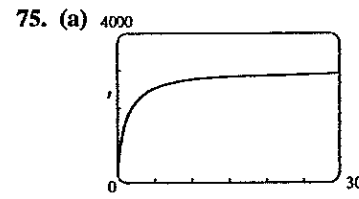
vertical $x = -1.41, x = 1.41$
 x -intercept 0
 y -intercept 0
local maximum $(0, 0)$
local minima $(-2, 8), (2, 8)$
end behavior $y = x^2 + 2$



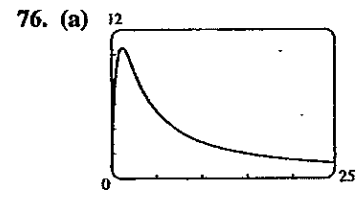
vertical $x = 3$
 x -intercepts $1.6, 2.7$
 y -intercept -2
local maxima $(-0.4, -1.8), (2.4, 3.8)$,
local minima $(0.6, -2.3), (3.4, 54.3)$
end behavior $y = x^3$



vertical $x = -1, x = 1$
 x -intercepts $-1.6, 1.6$
 y -intercept -4
local maximum $(0, -4)$
end behavior $y = -x^2$

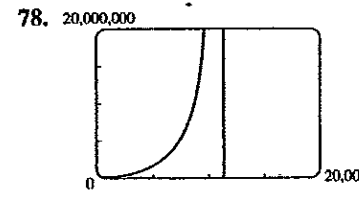


(b) It levels off at 3000.

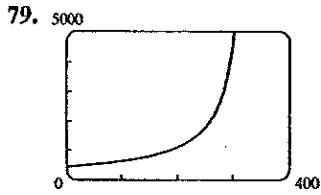


(b) It decreases to 0.

77. (a) 2.50 mg/L (b) It decreases to 0. (c) 16.61 h

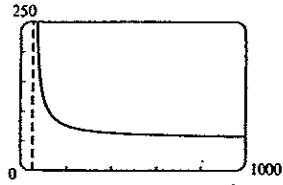


The vertical asymptote represents the escape velocity from the earth's gravitational pull.



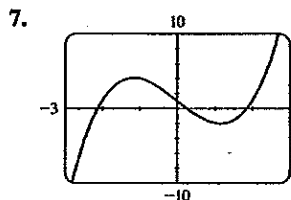
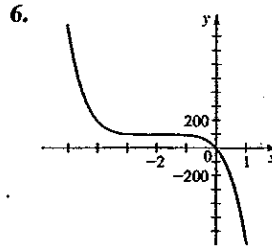
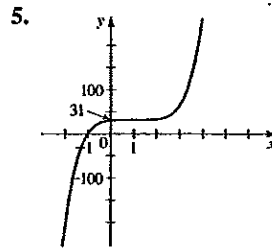
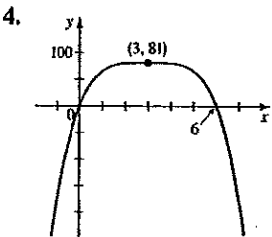
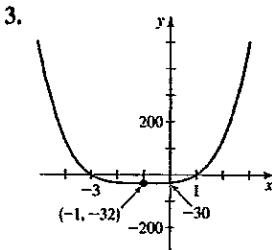
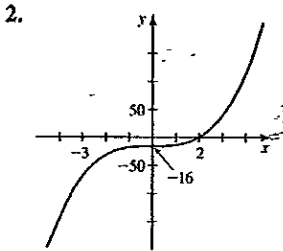
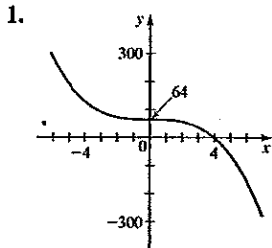
If the speed of the train approaches the speed of sound, then the pitch increases indefinitely (a sonic boom).

80. (a) $y = \frac{55x}{x - 55}$

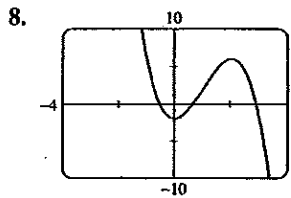


(b) y approaches 55 mm (c) y approaches ∞

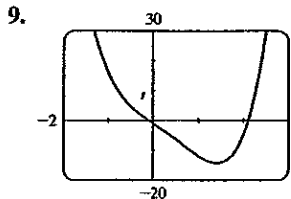
Chapter 8 Review



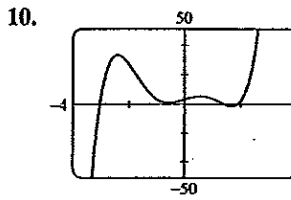
x -intercepts $-2.1, 0.3, 1.9$
 y -intercept 1
 local maximum $(-1.2, 4.1)$
 local minimum $(1.2, -2.1)$
 $y \rightarrow \infty$ as $x \rightarrow \infty$
 $y \rightarrow -\infty$ as $x \rightarrow -\infty$



x -intercepts $-0.5, 0.7, \text{ and } 2.9$
 y -intercept -2
 local maximum $(2, 6)$
 local minimum $(0, -2)$
 $y \rightarrow \infty$ as $x \rightarrow -\infty$ and
 $y \rightarrow -\infty$ as $x \rightarrow \infty$



x -intercepts $-0.1, 0, \text{ and } 2.1$
 y -intercept -1
 local minimum $(1.4, -14.5)$
 $y \rightarrow \infty$ as $x \rightarrow \infty$
 $y \rightarrow \infty$ as $x \rightarrow -\infty$



x -intercepts $-3.0, 1.3, \text{ and } 1.9$
 y -intercept 3
 local maxima $(-2.4, 33.2)$ and
 $(0.5, 5.0)$
 local minima $(-0.6, 0.6)$ and
 $(1.6, -1.6)$
 $y \rightarrow -\infty$ as $x \rightarrow -\infty$ and
 $y \rightarrow \infty$ as $x \rightarrow \infty$

11. (a) $S = 13.8x(100 - x^2)$ (b) $0 \leq x \leq 10$
 (c) 6000 (d) 5.8 in.

