- **Theorem on Slant Asymptotes** The rational function $F(x) = P(x)/Q(x)$, where $P(x)$ and $Q(x)$ have no common factors, has a slant asymptote if the degree of $P(x)$ is 1 greater than the degree of $Q(x)$. The equation of the asymptote can be determined by setting y equal to the quotient of $P(x)$ divided by $Q(x)$.

General Procedure for Graphing Rational Functions That Have No Common Factors

To graph a rational function F

1. Find the real zeros of the denominator. For each real zero a, the vertical line $x = a$ will be a vertical asymptote. Use the Theorem on Horizontal Asymptotes and the Theorem on Slant Asymptotes to determine whether F has a horizontal asymptote or a slant asymptote. Use dashed lines to graph all asymptotes.
2. Find the real zeros of the numerator. For each real zero c, plot $(c, 0)$. These are the x-intercepts. The y-intercept of the graph is the point $(0, F(0))$, provided $F(0)$ is a real number.
3. Use the tests for symmetry to determine whether the graph has symmetry with respect to the y-axis or with respect to the origin.
4. Find and plot additional points that lie in the intervals between and beyond the vertical asymptotes and the x-intercepts.
5. Determine the behavior of the graph near asymptotes.
6. Use all of the information obtained in steps 1 through 5 to sketch the graph.

See Examples 3 and 4, pages 313 and 315, and then try Exercises 60, 63, and 65, page 330.

General Procedure for Graphing Rational Functions That Have a Common Linear Factor

To graph a rational function F that has a numerator and a denominator with $(x - a)$ as a common factor

1. Reduce the rational function to simplest form. Then use the general procedure for graphing rational functions that have no common factors.
2. If the reduced rational function does not have $(x - a)$ as a factor of the denominator, then the graph produced in step 1 is the graph of F, provided you place an open circle on the graph at $x = a$. The height of the open circle can be determined by evaluating the reduced rational function at $x = a$.

   If $(x - a)$ is a factor of the denominator of the reduced rational function, then the graph produced in step 1 is the graph of F and it will have a vertical asymptote at $x = a$.

See Example 6, page 318, and then try Exercise 61, page 330.

Answer graphs to Exercises 21–26 and 59–66 are on pages AA14–AA15.

CHAPTER 3 REVIEW EXERCISES

In Exercises 1 and 2, use synthetic division to divide the first polynomial by the second.

1. $4x^3 - 11x^2 + 5x - 2, \quad x - 3$ $\quad 4x^2 + x + 8 + \dfrac{22}{x - 3}$ [3.1]
2. $x^4 + 9x^3 + 6x^2 - 65x - 63, \quad x + 7$ $\quad x^3 + 2x^2 - 8x - 9$ [3.1]

In Exercises 3 to 6, use the Remainder Theorem to find $P(c)$.

3. $P(x) = -2x^5 + 3x^3 - x^2 - 5x + 11, \quad c = 5$ $\quad -5914$ [3.1]
4. $P(x) = 3x^4 - 2x^3 - 11x^2 + 15x - 2, \quad c = -3$ $\quad 151$ [3.1]

5. $P(x) = 6x^4 - 12x^2 + 8x + 1, \quad c = -2$ 33 [3.1]

6. $P(x) = 5x^5 - 8x^4 + 2x^3 - 6x^2 - 9, \quad c = 3$ 558 [3.1]

In Exercises 7 to 10, use synthetic division to show that c is a zero of the given polynomial function.

The verifications in Exercises 7–10 use the concepts from Section 3.1.

7. $P(x) = x^3 + 2x^2 - 26x + 33, \quad c = 3$

8. $P(x) = 2x^4 + 8x^3 - 8x^2 - 31x + 4, \quad c = -4$

9. $P(x) = x^5 - x^4 - 2x^2 + x + 1, \quad c = 1$

10. $P(x) = 2x^3 + 3x^2 - 8x + 3, \quad c = \frac{1}{2}$

In Exercises 11 and 12, use the Factor Theorem to determine whether the given binomial is a factor of P.

11. $P(x) = x^3 - 11x^2 + 39x - 45, \quad (x - 5)$ Yes [3.1]

12. $P(x) = 2x^4 - 11x^3 + 11x^2 - 33x + 15, \quad (x + 2)$ No [3.1]

In Exercises 13 and 14, determine the far-left and the far-right behavior of the graph of the function.

13. $P(x) = -2x^3 - 5x^2 + 6x - 3$
Up to the far left, down to the far right [3.2]

14. $P(x) = -x^4 + 3x^3 - 2x^2 + x - 5$
Down to the far left, down to the far right [3.2]

In Exercises 15 and 16, use the maximum and minimum features of a graphing utility to estimate, to the nearest thousandth, the x and y coordinates of the points where P has a relative maximum or a relative minimum.

15. $P(x) = 2x^3 - x^2 - 3x + 1$ Relative maximum $y \approx 2.015$ at $x \approx -0.560$, relative minimum $y \approx -1.052$ at $x \approx 0.893$ [3.2]

16. $P(x) = x^4 - 2x^2 + x + 1$ Relative minimum $y \approx -1.056$ at $x \approx -1.107$, relative maximum $y \approx 1.130$ at $x \approx 0.270$, relative minimum $y \approx 0.927$ at $x \approx 0.838$ [3.2]

In Exercises 17 and 18, use the Intermediate Value Theorem to verify that P has a zero between a and b.

17. $P(x) = 3x^3 - 7x^2 - 3x + 7; a = 2, b = 3$ $P(2) < 0$ and $P(3) > 0$. The Intermediate Value Theorem implies that P has a zero between 2 and 3. [3.2]

18. $P(x) = 3x^4 - 5x^3 - 6x^2 - 10x - 24; a = -2, b = -1$ $P(-2) > 0$ and $P(-1) < 0$. The Intermediate Value Theorem implies that P has a zero between -2 and -1. [3.2]

In Exercises 19 and 20, determine the x-intercepts of the graph of P. For each x-intercept, use the Even and Odd Powers of $(x - c)$ Theorem to determine whether the graph of P crosses the x-axis or intersects but does not cross the x-axis.

19. $P(x) = (x + 3)(x - 5)^2$ Crosses the x-axis at $(-3,0)$, intersects but does not cross the x-axis at $(5,0)$ [3.2]

20. $P(x) = (x - 4)^4(x + 1)$ Intersects but does not cross the x-axis at $(4,0)$, crosses the x-axis at $(-1,0)$ [3.2]

In Exercises 21 to 26, graph the polynomial function.

21. $P(x) = x^3 - x$ [3.2]

22. $P(x) = -x^3 - x^2 + 8x + 12$ [3.2]

23. $P(x) = x^4 - 6$ [3.2]

24. $P(x) = x^5 - x$ [3.2]

25. $P(x) = x^4 - 10x^2 + 9$ [3.2]

26. $P(x) = x^5 - 5x^3$ [3.2]

In Exercises 27 to 32, use the Rational Zero Theorem to list all possible rational zeros for each polynomial function.

27. $P(x) = x^3 - 7x - 6$ $\pm 1, \pm 2, \pm 3, \pm 6$ [3.3]

28. $P(x) = 2x^3 + 3x^2 - 29x - 30$
$\pm 1, \pm 2, \pm 3, \pm 5, \pm 6, \pm 10, \pm 15, \pm 30, \pm\frac{1}{2}, \pm\frac{3}{2}, \pm\frac{5}{2}, \pm\frac{15}{2}$ [3.3]

29. $P(x) = 3x^3 - 20x^2 + 23x + 10$
$\pm\frac{1}{3}, \pm\frac{2}{3}, \pm\frac{5}{3}, \pm\frac{10}{3}, \pm 1, \pm 2, \pm 5, \pm 10$ [3.3]

30. $P(x) = 2x^5 + 3x^2 - x - 5$ $\pm\frac{1}{2}, \pm\frac{5}{2}, \pm 1, \pm 5$ [3.3]

31. $P(x) = x^3 + x^2 - x - 1$ ± 1 [3.3]

32. $P(x) = 6x^5 + 3x - 2$ $\pm 1, \pm 2, \pm\frac{1}{6}, \pm\frac{1}{3}, \pm\frac{1}{2}, \pm\frac{2}{3}$ [3.3]

In Exercises 33 to 36, use Descartes' Rule of Signs to state the number of possible positive and negative real zeros of each polynomial function.

33. $P(x) = -2x^5 + 4x^3 + 5x^2 - 2x - 6$
Two or no positive zeros; three or one negative zeros [3.3]

34. $P(x) = 7x^3 + x^4 + 3x^2 - 8x + 15$
Two or no positive zeros; two or no negative zeros [3.3]

35. $P(x) = x^4 - x - 1$
One positive real zero, one negative real zero [3.3]

36. $P(x) = x^5 - 4x^4 + 2x^3 - x^2 + x - 8$
Five, three, or one positive real zeros; no negative real zeros [3.3]

In Exercises 37 to 42, find the zeros of the polynomial function.

37. $P(x) = 2x^3 - 7x^2 - 33x + 18$ $-3, \frac{1}{2}, 6$ [3.3]

38. $P(x) = 2x^4 - 5x^3 - 15x^2 + 40x - 42$ $-3, \frac{7}{2}, 1 - i, 1 + i$ [3.3]

39. $P(x) = 6x^4 + 35x^3 + 72x^2 + 60x + 16$
-2 (multiplicity 2), $-\frac{1}{2}, -\frac{4}{3}$ [3.3]

40. $P(x) = 2x^4 + 7x^3 + 5x^2 + 7x + 3$ $-\frac{1}{2}, -3, i, -i$ [3.4]

41. $P(x) = x^4 - 4x^3 + 6x^2 - 4x + 1$ 1 (multiplicity 4) [3.3]

42. $P(x) = 2x^3 - 7x^2 + 22x + 13$ $-\frac{1}{2}, 2 + 3i, 2 - 3i$ [3.4]

In Exercises 43 and 44, find all the zeros of P and write P as a product of its leading coefficient and its linear factors.

43. $P(x) = 2x^4 - 9x^3 + 22x^2 - 29x + 10$
$\frac{1}{2}, 2, 1 + 2i, 1 - 2i$; $P(x) = 2\left(x - \frac{1}{2}\right)(x - 2)(x - 1 - 2i)(x - 1 + 2i)$ [3.4]

44. $P(x) = x^4 - 6x^3 + 21x^2 - 46x + 30$
$1, 3, 1 + 3i, 1 - 3i$; $P(x) = 1(x - 1)(x - 3)(x - 1 - 3i)(x - 1 + 3i)$ [3.4]

In Exercises 45 and 46, use the given zero to find the remaining zeros of each polynomial function.

45. $P(x) = x^4 - 4x^3 + 6x^2 - 4x - 15;\quad 1 - 2i$
$-1, 3, 1 + 2i$ [3.4]

46. $P(x) = x^4 - x^3 - 17x^2 + 55x - 50;\quad 2 + i$
$-5, 2, 2 - i$ [3.4]

In Exercises 47 to 50, find the requested polynomial function.

47. Find a third-degree polynomial function with integer coefficients and zeros of 4, −3, and $\frac{1}{2}$.
$P(x) = 2x^3 - 3x^2 - 23x + 12$ [3.4]

48. Find a fourth-degree polynomial function with zeros of 2, −3, i, and $-i$. $P(x) = x^4 + x^3 - 5x^2 + x - 6$ [3.4]

49. Find a fourth-degree polynomial function with real coefficients that has zeros of 1, 2, and $5i$.
$P(x) = x^4 - 3x^3 + 27x^2 - 75x + 50$ [3.4]

50. Find a fourth-degree polynomial function with real coefficients that has −2 as a zero of multiplicity 2 and has $1 + 3i$ as a zero.
$P(x) = x^4 + 2x^3 + 6x^2 + 32x + 40$ [3.4]

In Exercises 51 and 52, determine the domain of the rational function.

51. $F(x) = \dfrac{2x - 3}{x^2 - 25}$
All real numbers except −5 and 5 [3.4]

52. $F(x) = \dfrac{6x^2 - 5x - 4}{15x^2 - 24x + 15}$
All real numbers [3.4]

In Exercises 53 and 54, determine the vertical asymptotes for the graph of each rational function.

53. $f(x) = \dfrac{2x^2 + 3x - 5}{6x^2 - x - 35}$ $x = -\frac{7}{3},\ x = \frac{5}{2}$ [3.5]

54. $f(x) = \dfrac{3x - 17}{x^3 - 16x}$ $x = -4,\ x = 0,\ x = 4$ [3.5]

In Exercises 55 and 56, determine the horizontal asymptote for the graph of each rational function.

55. $f(x) = \dfrac{-2x^3 - 5x^2 + 4x + 1}{3x^4 - 2x^3 - 7x^2 + x - 3}$ $y = 0$ [3.5]

56. $f(x) = \dfrac{5x^2 - 2x + 3}{\frac{1}{3}x^2 + x + 4}$ $y = 15$ [3.5]

In Exercises 57 and 58, determine the slant asymptote for the graph of each rational function.

57. $f(x) = \dfrac{x^3 - 5x^2 + x + 12}{x^2 - 2x - 5}$ $y = x - 3$ [3.5]

58. $f(x) = \dfrac{-2x^4 - 3x^3 - 2x^2 + 5x + 3}{x^3 - 2x^2 - 5}$ $y = -2x - 7$ [3.5]

In Exercises 59 to 66, graph each rational function.

59. $f(x) = \dfrac{3x - 2}{x}$ [3.5]

60. $f(x) = \dfrac{x + 4}{x - 2}$ [3.5]

61. $f(x) = \dfrac{12x - 24}{x^2 - 4}$ [3.5]

62. $f(x) = \dfrac{4x^2}{x^2 + 1}$ [3.5]

63. $f(x) = \dfrac{2x^3 - 4x + 6}{x^2 - 4}$ [3.5]

64. $f(x) = \dfrac{x}{x^3 - 1}$ [3.5]

65. $f(x) = \dfrac{3x^2 - 6}{x^2 - 9}$ [3.5]

66. $f(x) = \dfrac{-x^3 + 6}{x^2}$ [3.5]

67. **Average Cost of Skateboards** The cost, in dollars, of producing x skateboards is given by

$$C(x) = 5.75x + 34{,}200$$

The average cost per skateboard is given by

$$\overline{C}(x) = \frac{C(x)}{x} = \frac{5.75x + 34{,}200}{x}$$

a. Find the average cost per skateboard, to the nearest cent, of producing 5000 and 50,000 skateboards. $12.59, $6.43

b. What is the equation of the horizontal asymptote of the graph of $\overline{C}$? Explain the significance of the horizontal asymptote as it relates to this application. $y = 5.75$. As the number of skateboards produced increases, the average cost per skateboard approaches $5.75. [3.5]

68. **Food Temperature** The temperature F, in degrees Fahrenheit, of a dessert placed in a freezer for t hours is given by the rational function

$$F(t) = \frac{60}{t^2 + 2t + 1},\ t \geq 0$$

a. Find the temperature of the dessert after it has been in the freezer for 1 hour. 15°F

b. What temperature will the dessert approach as $t \to \infty$? 0°F [3.5]

69. **Tuition and Fees** The following table shows the average cost for tuition and fees, paid per school year, by a United States college student attending a private four-year college.

Average Tuition/Fees at U.S. Private Four-Year Colleges

School Year	Tuition/Fees (in dollars)	School Year	Tuition/Fees (in dollars)
2003–04	17,763	2007–08	21,427
2004–05	18,604	2008–09	22,036
2005–06	19,292	2009–10	21,908
2006–07	20,517	2010–11	22,771

Source: The World Almanac and Book of Facts 2013, p. 419.

a. Find a quartic regression function that models the data. Use $x = 3$ to represent 2003–04, $x = 4$ to represent 2004–05, . . . , and $x = 10$ to represent 2010–11.
$P(x) \approx 10.03219697x^4 - 269.4280303x^3 + 2526.142045x^2 - 8907.912879x + 28{,}276.91667$

b. Use the quartic regression function to estimate the average cost of tuition and fees for the 2013–14 ($x = 13$) school year. Round to the nearest hundred dollars.
\$34,000 [3.2]

70. **Physiology** One of Poiseuille's laws states that the resistance R encountered by blood flowing through a blood vessel is given by

$$R(r) = C\frac{L}{r^4}$$

where C is a positive constant determined by the viscosity of the blood, L is the length of the blood vessel, and r is its radius.

a. Explain the meaning of $R(r) \to \infty$ as $r \to 0$.
As the radius of the blood vessel approaches 0, the resistance increases.

b. Explain the meaning of $R(r) \to 0$ as $r \to \infty$.
As the radius of the blood vessel gets larger, the resistance approaches 0. [3.5]

Answer graphs to Exercises 15–17 are on page AA15.

CHAPTER 3 TEST

1. Use synthetic division to divide

$$(3x^3 + 5x^2 + 4x - 1) \div (x + 2)$$
$3x^2 - x + 6 - \dfrac{13}{x+2}$ [3.1]

2. Use the Remainder Theorem to find $P(-2)$ if

$$P(x) = -3x^3 + 7x^2 + 2x - 5$$ 43 [3.1]

3. Use the Factor Theorem to show that $x - 1$ is a factor of

$$x^4 - 4x^3 + 7x^2 - 6x + 2$$
The verification for Exercise 3 uses the concepts from Section 3.1.

4. Determine the far-left and far-right behavior of the graph of

$$P(x) = x^5 - 3x^4 + 4x^3 - x^2 - 2x + 1$$
Down to the far left and up to the far right [3.2]

5. Find the real zeros of $P(x) = 3x^3 + 7x^2 - 6x$. $0, \frac{2}{3}, -3$ [3.2]

6. Use the Intermediate Value Theorem to verify that

$$P(x) = 2x^3 - 3x^2 - x + 1$$

has a zero between 1 and 2. $P(1) < 0$, $P(2) > 0$. Therefore, by the Intermediate Value Theorem, the polynomial function P has a zero between 1 and 2. [3.2]

7. Find the zeros of

$$P(x) = (x^2 - 4)^2(2x - 3)(x + 1)^3$$

and state the multiplicity of each. 2 (multiplicity 2), -2 (multiplicity 2), $\frac{3}{2}$ (multiplicity 1), -1 (multiplicity 3) [3.3]

8. Use the Rational Zero Theorem to list the possible rational zeros of $\pm 1, \pm 3, \pm\frac{1}{2}, \pm\frac{3}{2}, \pm\frac{1}{3}, \pm\frac{1}{6}$ [3.3]

$$P(x) = 6x^3 - 3x^2 + 2x - 3$$

9. Use Descartes' Rule of Signs to state the number of possible positive and negative real zeros of

$$P(x) = x^4 - 5x^3 + 12x^2 - 23x - 15$$
Three or one positive zeros; one negative zero [3.3]

10. Find the zeros of $P(x) = 2x^4 - 15x^3 + 41x^2 - 47x + 15$.
$\frac{1}{2}, 3, 2 - i, 2 + i$ [3.3]

11. Given that $2 + 3i$ is a zero of

$$P(x) = 6x^4 - 5x^3 + 12x^2 + 207x + 130$$

find the remaining zeros. $2 - 3i, -\frac{2}{3}, -\frac{5}{2}$ [3.4]

12. Find all the zeros of

$$P(x) = x^5 - 6x^4 + 14x^3 - 14x^2 + 5x$$
0, 1 (multiplicity 2), $2 + i$, $2 - i$ [3.4]

13. Find a polynomial function of smallest degree that has integer coefficients and zeros $3 - 2i$, 2, and $-\frac{1}{2}$.
$P(x) = 2x^4 - 15x^3 + 42x^2 - 27x - 26$ [3.4]

14. Find the vertical asymptotes and the horizontal asymptotes of the graph of

$$f(x) = \frac{3x^2 - 2x + 1}{x^2 - 5x + 6}$$
Vertical asymptotes: $x = 3$, $x = 2$; horizontal asymptote: $y = 3$ [3.5]

15. Graph: $P(x) = x^3 - 6x^2 + 9x + 1$

16. Graph: $f(x) = \dfrac{x^2 - 1}{x^2 - 2x - 3}$

17. Graph: $f(x) = \dfrac{2x^2 + 2x + 1}{x + 1}$

18. **Weight of a Great White Shark** The following table shows the estimated weights of great white sharks of various lengths.

Estimated Weight of Great White Sharks

Length (in feet, x)	Weight (in pounds)	Length (in feet, x)	Weight (in pounds)
7	256	11	1031
8	386	12	1348
9	555	13	1726
10	768	14	2169

Source: National Oceanic and Atmospheric Administration.

a. Find the cubic regression function that models the data.
$P(x) = 0.8863636364x^3 - 1.831168831x^2 + 7.721861472x - 12.36363636$

b. What is the coefficient of determination for this cubic regression? 0.9999999546

c. What does the coefficient of determination indicate concerning how well the cubic regression function models the data?
The cubic regression function provides a very good model of the data.

d. Use the cubic regression function to estimate the weight of a great white shark that has a length of 12.5 feet and the weight of a great white shark that has a length of 15 feet. Round to the nearest pound. 1529 pounds; 2683 pounds [3.2]

19. **Typing Speed** The rational function

$$w(t) = \frac{70t + 120}{t + 40}, \; t \geq 0$$

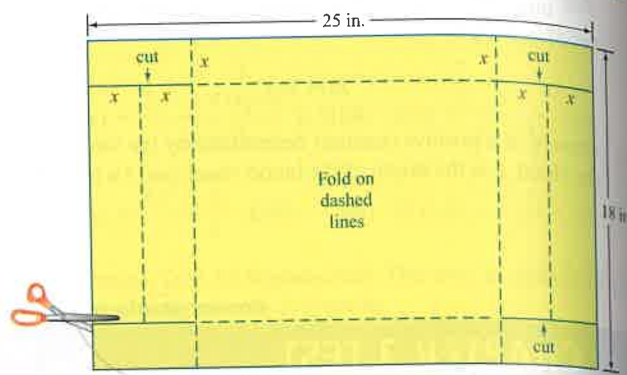
models Rene's typing speed, in words per minute, after t hours of typing lessons.

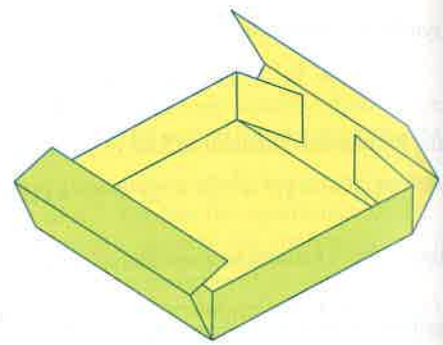
a. Find $w(1)$, $w(10)$, and $w(20)$. Round to the nearest word per minute. 5 words/min, 16 words/min, 25 words/min

b. How many hours of typing lessons will be needed before Rene can expect to type at 60 words per minute? 228 h

c. What will Rene's typing speed approach as $t \to \infty$?
70 words/min [3.5]

20. **Maximizing Volume** You are to construct an open box from a rectangular sheet of cardboard that measures 18 inches by 25 inches. To assemble the box, you make the four cuts shown in the figure below and then fold on the dashed lines. What value of x (to the nearest 0.01 inch) will produce a box with maximum volume? What is the maximum volume (to the nearest 0.1 cubic inch)? 2.42 in., 487.9 in.^{3} [3.2]





CUMULATIVE REVIEW EXERCISES

1. Write $\frac{3 + 4i}{1 - 2i}$ in $a + bi$ form. $-1 + 2i$ [P.6]

2. Use the quadratic formula to solve $x^2 - x - 1 = 0$. $\frac{1 \pm \sqrt{5}}{2}$ [1.3]

3. Solve: $\sqrt{2x + 5} - \sqrt{x - 1} = 2$ 2, 10 [1.4]

4. Solve: $|x - 3| \leq 11$ $\{x \mid -8 \leq x \leq 14\}$ [1.5]

5. Find the distance between the points (2, 5) and (7, −11). $\sqrt{281}$ [2.1]

6. Explain how to use the graph of $y = x^2$ to produce the graph of $y = (x - 2)^2 + 4$.
Shift the graph of $y = x^2$ to the right 2 units and up 4 units. [2.5]

7. Find the difference quotient for the function $P(x) = x^2 - 2x - 3$. $2x + h - 2$ [2.6]

8. Given $f(x) = 2x^2 + 5x - 3$ and $g(x) = 4x - 7$, find $(f \circ g)(x)$. $32x^2 - 92x + 60$ [2.6]

9. Given $f(x) = x^3 - 2x + 7$ and $g(x) = x^2 - 3x - 4$, find $(f - g)(x)$. $x^3 - x^2 + x + 11$ [2.6]

10. Use synthetic division to divide $(4x^4 - 2x^2 - 4x - 5)$ by $(x + 2)$. $4x^3 - 8x^2 + 14x - 32 + \frac{59}{x + 2}$ [3.1]

11. Use the Remainder Theorem to find $P(3)$ for the polynomial function $P(x) = 2x^4 - 3x^2 + 4x - 6$. 141 [3.1]

12. Determine the far-right behavior of the graph the of polynomial function $P(x) = -3x^4 - x^2 + 7x - 6$. The graph goes down. [3.2]

13. Determine the relative maximum of the polynomial function $P(x) = -3x^3 - x^2 + 4x - 1$. Round to the nearest ten-thousandth. 0.3997 [3.2]

14. Use the Rational Zero Theorem to list all possible rational zeros of $P(x) = 3x^4 - 4x^3 - 11x^2 + 16x - 4$. $\pm 1, \pm 2, \pm 4, \pm\frac{1}{3}, \pm\frac{2}{3}, \pm\frac{4}{3}$ [3.3]

15. Use Descartes' Rule of Signs to state the number of possible positive and negative real zeros of

$$P(x) = x^3 + x^2 + 2x + 4$$

No positive real zeros, three or one negative real zeros [3.3]

16. Find all zeros of $P(x) = x^3 + x + 10$. $-2, 1 + 2i, 1 - 2i$ [3.4]

17. Find a polynomial function of smallest degree that has real coefficients and -2 and $3 + i$ as zeros. $P(x) = x^3 - 4x^2 - 2x + 20$ [3.4]

18. Write $P(x) = x^3 - 2x^2 + 9x - 18$ as a product of linear factors. $(x - 2)(x + 3i)(x - 3i)$ [3.4]

19. Determine the vertical and horizontal asymptotes of the graph of $F(x) = \frac{4x^2}{x^2 + x - 6}$.
Vertical asymptotes: $x = -3$, $x = 2$; horizontal asymptote: $y = 4$ [3.5]

20. Find the equation of the slant asymptote for the graph of $F(x) = \frac{x^3 + 4x^2 + 1}{x^2 + 4}$. $y = x + 4$ [3.5]