GUIDED PRACTICE

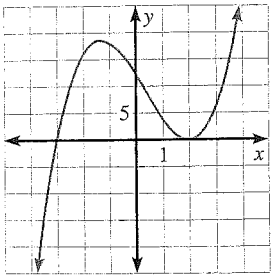
Vocabulary Check ✓

Concept Check ✓

1. State the fundamental theorem of algebra.

2. Two zeros of $f(x) = x^3 - 6x^2 - 16x + 96$ are 4 and -4. Explain why the third zero must also be a real number.

3. The graph of $f(x) = x^3 - x^2 - 8x + 12$ is shown at the right. How many real zeros does the function have? How many imaginary zeros does the function have? Explain your reasoning.



Ex. 3

Skill Check ✓

Find all the zeros of the polynomial function.

4. $f(x) = x^3 - x^2 - 2x$

5. $f(x) = x^4 + x^2 - 12$

6. $f(x) = x^3 + 5x^2 - 9x - 45$

7. $f(x) = x^4 - x^3 + 2x^2 - 4x - 8$

Write a polynomial function of least degree that has real coefficients, the given zeros, and a leading coefficient of 1.

8. 3, 0, -2

9. 1, 1, i, $-i$

10. 5, $2 + 3i$

11. 1, -1, 2, -2, 3

12. 3, -2, $-1 + i$

13. $4i$, $4i$

14. **GROCERY STORE REVENUE** For the 25 years that a grocery store has been open, its annual revenue R (in millions of dollars) can be modeled by

$$R = \frac{1}{10{,}000}(-t^4 + 12t^3 - 77t^2 + 600t + 13{,}650)$$

where t is the number of years the store has been open. In what year(s) was the revenue \$1.5 million?

PRACTICE AND APPLICATIONS

STUDENT HELP

Extra Practice to help you master skills is on p. 948.

CHECKING ZEROS **Decide whether the given x-value is a zero of the function.**

15. $f(x) = x^3 - x^2 + 4x - 4$, $x = 1$

16. $f(x) = x^3 + 3x^2 - 5x + 8$, $x = 4$

17. $f(x) = x^4 - x^2 - 3x + 3$, $x = 0$

18. $f(x) = x^3 + 5x^2 + x + 5$, $x = -5$

19. $f(x) = x^3 - 4x^2 + 16x - 64$, $x = 4i$

20. $f(x) = x^3 - 3x^2 + x - 3$, $x = -i$

FINDING ZEROS **Find all the zeros of the polynomial function.**

21. $f(x) = x^4 + 5x^3 + 5x^2 - 5x - 6$

22. $f(x) = x^4 + 4x^3 - 6x^2 - 36x - 27$

23. $f(x) = x^3 - 4x^2 + 3x$

24. $f(x) = x^3 + 5x^2 - 4x - 20$

25. $f(x) = x^4 + 7x^3 - x^2 - 67x - 60$

26. $f(x) = x^4 - 5x^2 - 36$

27. $f(x) = x^3 - x^2 + 49x - 49$

28. $f(x) = x^3 - x^2 + 25x - 25$

29. $f(x) = x^4 + 6x^3 + 14x^2 + 54x + 45$

30. $f(x) = x^3 + 3x^2 + 25x + 75$

31. $f(x) = x^4 - x^3 - 5x^2 - x - 6$

32. $f(x) = x^4 + x^3 + 2x^2 + 4x - 8$

33. $f(x) = 2x^4 - 7x^3 - 27x^2 + 63x + 81$

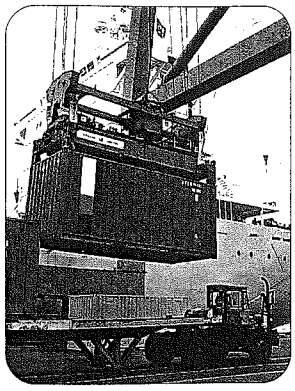
34. $f(x) = 2x^4 - x^3 - 42x^2 + 16x + 160$

STUDENT HELP

HOMEWORK HELP

Example 1: Exs. 21–54
Example 2: Exs. 21–34
Example 3: Exs. 35–46
Example 4: Exs. 47–54
Example 5: Exs. 55–59

FOCUS ON APPLICATIONS



REAL LIFE **UNITED STATES EXPORTS** The United States exports more than any other country in the world. It also imports more than any other country.

WRITING POLYNOMIAL FUNCTIONS **Write a polynomial function of least degree that has real coefficients, the given zeros, and a leading coefficient of 1.**

35. 2, 1, 4 **36.** 1, −4, 5 **37.** −6, 3, 5

38. −5, 2, −2 **39.** −2, −4, −7 **40.** 8, $-i$, i

41. $3i$, $-3i$, 5 **42.** 2, −2, $-6i$ **43.** i, $-3i$, $3i$

44. $3 - i$, $5i$ **45.** 4, 4, $2 + i$ **46.** −2, −2, 3, $-4i$

FINDING ZEROS **Use a graphing calculator to graph the polynomial function. Then use the *Zero* (or *Root*) feature of the calculator to find the real zeros of the function.**

47. $f(x) = x^3 - x^2 - 5x + 3$ **48.** $f(x) = 2x^3 - x^2 - 3x - 1$

49. $f(x) = x^3 - 2x^2 + x + 1$ **50.** $f(x) = x^4 - 2x - 1$

51. $f(x) = x^4 - x^3 - 4x^2 - 3x - 2$ **52.** $f(x) = x^4 - x^3 - 3x^2 - x + 1$

53. $f(x) = x^4 + 3x^2 - 2$ **54.** $f(x) = x^4 - x^3 - 20x^2 + 10x + 27$

GRAPHING MODELS **In Exercises 55–59, you may find it helpful to graph the model on a graphing calculator.**

55. **UNITED STATES EXPORTS** For 1980 through 1996, the total exports E (in billions of dollars) of the United States can be modeled by

$$E = -0.131t^3 + 5.033t^2 - 23.2t + 233$$

where t is the number of years since 1980. In what year were the total exports about \$312.76 billion? ▶ Source: U.S. Bureau of the Census

56. **EDUCATION DONATIONS** For 1983 through 1995, the amount of private donations D (in millions of dollars) allocated to education can be modeled by

$$D = 1.78t^3 - 6.02t^2 + 752t + 6701$$

where t is the number of years since 1983. In what year was \$14.3 billion of private donations allocated to education? ▶ Source: AAFRC Trust for Philanthropy

57. **SPORTS EQUIPMENT** For 1987 through 1996, the sales S (in millions of dollars) of gym shoes and sneakers can be modeled by

$$S = -0.982t^5 + 24.6t^4 - 211t^3 + 661t^2 - 318t + 1520$$

where t is the number of years since 1987. Were there any years in which sales were about \$2 billion? Explain. ▶ Source: National Sporting Goods Association

58. **TELEVISION** For 1990 through 2000, the actual and projected amount spent on television per person per year in the United States can be modeled by

$$S = -0.213t^3 + 3.96t^2 + 10.2t + 366$$

where S is the amount spent (in dollars) and t is the number of years since 1990. During which year was \$455 spent per person on television?
▶ Source: Veronis, Suhler & Associates, Inc.

59. **POPULATION** For 1890 through 1990, the American Indian, Eskimo, and Aleut population P (in thousands) can be modeled by the function

$$P = 0.00496t^3 - 0.432t^2 + 11.3t + 212$$

where t is the number of years since 1890. In what year did the population reach 722,000? **INTERNET** **DATA UPDATE** of *Statistical Abstract of the United States* data at www.mcdougallittell.com