## 2.8 EXERCISES

### PRACTICE

Use the various rules of differentiation to find the derivative for each of the functions in Exercises 1–10.

**1.** $y = x^3 - 7x$

**2.** $y = 4x^2 - 9x + 2$

**3.** $y = 0.3x^2 - 4x + 6$

**4.** $y = 120 + 8x - 0.2x^2$

**5.** $y = x^3 - 6x^2 + 5x + 2$

**6.** $y = \frac{1}{3}x^3 - \frac{1}{2}x^2 - 3x + 4$

**7.** $y = 2x^{\frac{3}{2}} + 4x^{\frac{1}{2}} - 5$

**8.** $y = 2x^{-\frac{2}{3}} + 3x^{\frac{1}{3}} + 7$

**9.** $f(t) = 2t^{-\frac{1}{2}} + t^{\frac{1}{2}} + t$

**10.** $f(x) = 3x^{-\frac{1}{3}} - 2x^{-\frac{1}{2}} + 1$

In Exercises 11–20, use algebraic techniques to rewrite each function as a sum or difference; then find the derivative.

**11.** $y = (x+1)(2x-3)$

**12.** $y = \sqrt{x}\left(2x^2 + x - 3\right)$

**13.** $f(v) = v^{\frac{3}{2}}\left(v^2 + 2v - 1\right)$

**14.** $f(v) = v^{\frac{1}{3}}\left(6 - 4v + v^2\right)$

**15.** $f(x) = \dfrac{x^4 + 5x^3}{x^2}$

**16.** $f(x) = \dfrac{6x^2 + 1}{x^3}$

**17.** $g(t) = \dfrac{t-2}{\sqrt{t}}$

**18.** $g(t) = \dfrac{t^2 + 3}{\sqrt[3]{t}}$

**19.** $g(x) = \dfrac{4x + 5x^{\frac{1}{2}} - 1}{\sqrt{x}}$

**20.** $g(x) = \dfrac{3\sqrt{x} + 4x - 2}{x^2}$

In Exercises 21–26, confirm your results with a graphing calculator.

**21.** Let $f(x) = x^3 + 2x - 4$.

**a.** Find the slope of the tangent line at $x = -1$.

**b.** Find the equation of the tangent line at $x = -1$.

**22.** Let $f(x) = 2x^3 - x^2 - 3x$.

**a.** Find the slope of the tangent line at $x = 2$.

**b.** Find the equation of the tangent line at $x = 2$.

**23.** Let $g(x) = x^2 + 6x + 5$.

**a.** Find the slopes of the tangent lines at $x = -1$, $x = -3$, and $x = -4$.

**b.** Find the equations of the tangent lines at $x = -1$, $x = -3$, and $x = -4$.

**c.** Sketch the graphs of the curve and the three tangent lines.

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**24.** Let $g(x) = x^2 - 8x + 12$.
- **a.** Find the slopes of the tangent lines at $x = 2$, $x = 4$, and $x = 5$.
- **b.** Find the equations of the tangent lines at $x = 2$, $x = 4$, and $x = 5$.
- **c.** Sketch the graphs of the curve and the three tangent lines.

**25.** Let $f(x) = 8 - x^2$.
- **a.** Find the slopes of the tangent lines at $x = -2$, $x = 0$, and $x = 1$.
- **b.** Find the equations of the tangent lines at $x = -2$, $x = 0$, and $x = 1$.
- **c.** Sketch the graphs of the curve and the three tangent lines.

**26.** Let $f(x) = 10 - 3x - x^2$.
- **a.** Find the slopes of the tangent lines at $x = -3$, $x = -2$, and $x = 0$.
- **b.** Find the equations of the tangent lines at $x = -3$, $x = -2$, and $x = 0$.
- **c.** Sketch the graphs of the curve and the three tangent lines.

## APPLICATIONS

**27. Velocity of a rocket:** A model rocket is fired vertically upward. The height after $t$ seconds is $s(t) = 192t - 16t^2$ feet.
- **a.** Find the velocity at $t = 0$ seconds.
- **b.** Find the velocity at $t = 4$ seconds.
- **c.** When will the velocity be zero?

**28. Velocity of a particle:** A particle moving in a straight line is at a distance of $s(t) = 2.5t^2 + 18t$ feet from its starting point after $t$ seconds, where $0 \le t \le 12$.
- **a.** Find the velocity at $t = 6$.
- **b.** Find the velocity at $t = 9$.

**29. Population:** A city's population $t$ years from now can be estimated from the formula $P(t) = 9000 + 500t - 72\sqrt{t}$.
- **a.** Find the rate at which the city is growing after 4 years.
- **b.** Find the rate at which the city is growing after 9 years.

**30. Cost:** The total cost of producing $x$ units of a product is given by $C(x) = 4000 + 25x - 0.2x^2$ dollars, where $0 \le x \le 50$.
- **a.** Find the rate of change in the cost when $x = 10$.
- **b.** Find the rate of change in the cost when $x = 30$.

**31. Fuel consumption:** When a factory operates from 6:00 a.m. to 6:00 p.m., its total fuel consumption varies according to the formula $f(t) = 0.9t^2 - 0.3t^{0.5} + 20$, where $t$ is the time in hours after 6:00 a.m. and $f(t)$ is number of barrels of fuel oil.
- **a.** How much fuel oil is consumed by noon?
- **b.** What is the rate of consumption of fuel at 10:00 a.m.?
- **c.** What is the average rate of consumption from 6:00 a.m. to 2:00 p.m.?

**32. Population:** The population of bacteria in a lab experiment for BIOL 403 at Nevada Tech is given by $f(x) = 2.2x^{1.5} - 0.7x + 2$, where $x$ is the time in hours after 2:00 p.m. and $f(x)$ is population in suitable units.
- **a.** What is the population at 2:00 p.m.?
- **b.** The lab is over at 4:00 p.m. What is the new population of bacteria?
- **c.** What is the average rate of change of bacteria from 2:00 p.m. to 4:00 p.m.?
- **d.** What is the instantaneous rate of change of bacteria at 3:00 p.m.?

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**33. Electrical charge:** The electrical charge on a new cell phone declines according to the formula $C(t) = 15 - 0.1t^2 - 0.5t$, where $t$ is the time in hours following a full charge and $C(t)$ is a measure of the charge.

**a.** To the nearest hour, how long does it take for the charge to be fully depleted?

**b.** What is the instantaneous rate of change, in charge units per hour, at $t = 4$?

**c.** What is the average rate of change from $t = 0$ to $t = 4$?

**34. Spreading a rumor:** The number of college students at Salis Technical College who have not heard a new rumor is approximated by the formula $N(x) = 300(1 - 0.004x^2)$, where $x$ is the number of days following the start of a new rumor.

**a.** How many days does it take for 90 percent of the students to hear the rumor?

**b.** What is the instantaneous rate of change in students after one day? Interpret the meaning of this number.

**c.** Why is the slope negative in this exercise?

**35. Birth rate:** The fertility decline in many countries can be modeled by a quadratic equation. In China, from the late 1960s to the present, the number of births per woman has declined according to the formula $f(x) = 0.00675x^2 - 0.3215x + 5.585$, where $x$ is the number of years after 1969. (**Source:** Nancy E. Riley, "China's Population: New Trends and Challenges," *Population Bulletin*, Vol. 20, No. 2, June 2004.)

**a.** What was the number of births per woman in 1969?

**b.** What was the number of births per woman in 1999?

**c.** What was the rate of change of this fertility rate in 1979?

**36. Birth rate:** In China, from 1964 to the present, the death rate has remained nearly constant at approximately 8 deaths per 1000 people. The yearly birth rate, in births per 1000 people, has declined in most years according to the formula $f(x) = -0.00191x^3 + 0.134x^2 - 3.16x + 44.5$, where $x$ is the number of years since 1964. (**Source:** Nancy E. Riley, "China's Population: New Trends and Challenges," *Population Bulletin*, Vol. 20, No. 2, June 2004.)

**a.** What number is $f(30)$ and what does it represent?

**b.** What number is $f'(30)$ and what does it represent?

**c.** In what year, according to the model, did the number of new births equal the number of deaths?

**37. Population growth:** The percentage of older persons in China (age 60 and over) has grown since the 1950s according to the formula $f(x) = 0.003727x^2 - 0.105x + 7.063$, where $x$ is the number of years since 1953. (**Source:** Nancy E. Riley, "China's Population: New Trends and Challenges," *Population Bulletin*, Vol. 20, No. 2, June 2004.)

**a.** What was the percentage of older persons in China in 1953?

**b.** What is the percentage of older persons projected to be in the year 2025?

**c.** At what rate was the percentage changing in 2000?

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**38. Population growth:** The population in billions of people in the lesser developed countries has varied according to the formula $P(x) = \frac{4.953}{10^4}x^2 - 0.007352x + 1.7748$, where $x$ is the number of years since 1900. (**Source:** Population Reference Bureau, "Transition's in World Population," *Population Bulletin*, Vol. 59, No. 1, 5, March 2004.)

**a.** What was the population in 1950?

**b.** At what rate was the population changing in 1950?

**c.** What population was projected for 2020 in these countries?

**39. Death rate:** The death rate in Mexico has varied since 1920 according to the formula $M(x) = -\frac{2.076}{10^4}x^3 + 0.033x^2 - 1.785x + 43.07$, where $x$ is the number of years since 1920. (**Source:** Population Reference Bureau, "Transition's in World Population," *Population Bulletin*, Vol. 59, No. 1, 5, March 2004.)

**a.** What was the death rate in 1950?

**b.** At what rate was the death rate changing in 1950?

**c.** What was the death rate in 2000?

**d.** In what year did the formula predict that no one would die?

**40. Birth rate:** The function $f(x) = 0.00375x^2 - 0.2355x + 5.595$ gives the average number of births per woman in Thailand where $x$ denotes the number of years since 1970. (**Source:** Lori Ashford, "World Population Highlights 2004," BRIDGE Population Reference Bureau, August 2004.)

**a.** What number is $f(10)$ and what does it represent?

**b.** What number is $f'(10)$ and what does it represent?

**41. Birth rate:** In Argentina, from 1970 to 2000, the average number of births per woman was given by the function $f(x) = -0.001x^2 + 0.014x + 3.14$, where $x$ is the number of years after 1970. (**Source:** Lori Ashford, "World Population Highlights 2004," BRIDGE Population Reference Bureau, August 2004.)

**a.** What number is $f(30)$ and what does it represent?

**b.** What number is $f'(30)$ and what does it represent?

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