Check Point 5 Use **Figure 2.41** on the previous page to find the average rate of change in the drug's concentration between 1 hour and 3 hours.

How Calculus Studies Change

Take a rapid sequence of still photographs of a moving scene and project them onto a screen at thirty shots a second or faster. Our eyes see the results as continuous motion. The small difference between one frame and the next cannot be detected by the human visual system. The idea of calculus likewise regards continuous motion as made up of a sequence of still configurations. Calculus masters the mystery of movement by "freezing the frame" of a continuous changing process, instant by instant. For example, **Figure 2.42** shows a male's changing height over intervals of time. Over the period of time from P to D, his average rate of growth is his change in height—that is, his height at time D minus his height at time P—divided by the change in time from P to D. This is the slope of secant line PD.

The secant lines PD, PC, PB, and PA shown in **Figure 2.42** have slopes that show average growth rates for successively shorter periods of time. Calculus makes these time frames so small that they approach a single point—that is, a single instant in time. This point is shown as point P in **Figure 2.42**. The slope of the line that touches the graph at P gives the male's growth rate at one instant in time, P.

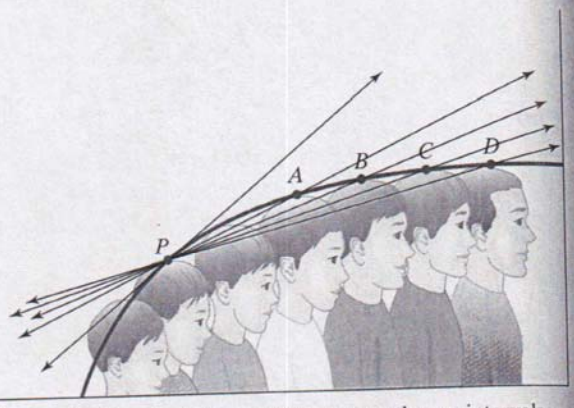


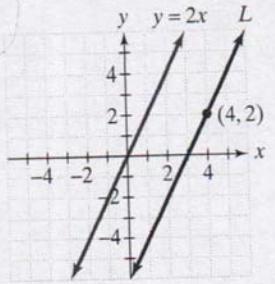
Figure 2.42 Analyzing continuous growth over intervals of time and at an instant in time

Exercise Set 2.4

Practice Exercises

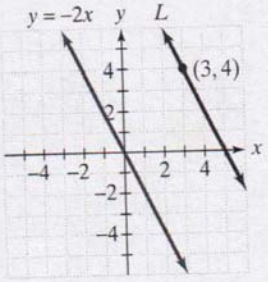
In Exercises 1–4, write an equation for line L in point-slope form and slope-intercept form.

1.



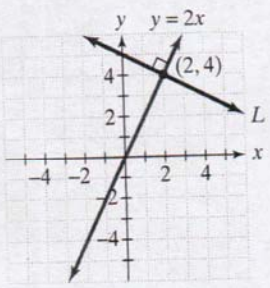
L is parallel to $y = 2x$.

2.



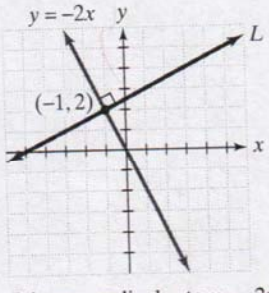
L is parallel to $y = -2x$.

3.



L is perpendicular to $y = 2x$.

4.



L is perpendicular to $y = -2x$.

In Exercises 5–8, use the given conditions to write an equation for each line in point-slope form and slope-intercept form.

5. Passing through $(-8, -10)$ and parallel to the line whose equation is $y = -4x + 3$

6. Passing through $(-2, -7)$ and parallel to the line whose equation is $y = -5x + 4$

7. Passing through $(2, -3)$ and perpendicular to the line whose equation is $y = \frac{1}{5}x + 6$

8. Passing through $(-4, 2)$ and perpendicular to the line whose equation is $y = \frac{1}{3}x + 7$

In Exercises 9–12, use the given conditions to write an equation for each line in point-slope form and general form.

9. Passing through $(-2, 2)$ and parallel to the line whose equation is $2x - 3y - 7 = 0$

10. Passing through $(-1, 3)$ and parallel to the line whose equation is $3x - 2y - 5 = 0$

11. Passing through $(4, -7)$ and perpendicular to the line whose equation is $x - 2y - 3 = 0$

12. Passing through $(5, -9)$ and perpendicular to the line whose equation is $x + 7y - 12 = 0$

In Exercises 13–18, find the average rate of change of the function from x_1 to x_2.

13. $f(x) = 3x$ from $x_1 = 0$ to $x_2 = 5$

14. $f(x) = 6x$ from $x_1 = 0$ to $x_2 = 4$
15. $f(x) = x^2 + 2x$ from $x_1 = 3$ to $x_2 = 5$
16. $f(x) = x^2 - 2x$ from $x_2 = 3$ to $x_2 = 6$
17. $f(x) = \sqrt{x}$ from $x_1 = 4$ to $x_2 = 9$
18. $f(x) = \sqrt{x}$ from $x_1 = 9$ to $x_2 = 16$

Practice Plus

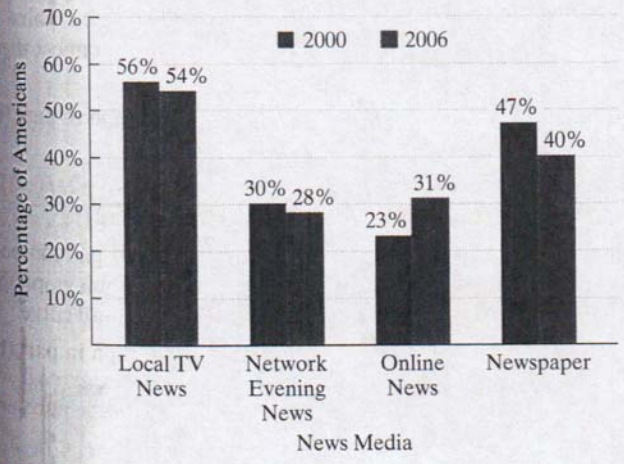
In Exercises 19–24, write an equation in slope-intercept form of a linear function f whose graph satisfies the given conditions.

19. The graph of f passes through $(-1, 5)$ and is perpendicular to the line whose equation is $x = 6$.
20. The graph of f passes through $(-2, 6)$ and is perpendicular to the line whose equation is $x = -4$.
21. The graph of f passes through $(-6, 4)$ and is perpendicular to the line that has an x-intercept of 2 and a y-intercept of -4.
22. The graph of f passes through $(-5, 6)$ and is perpendicular to the line that has an x-intercept of 3 and a y-intercept of -9.
23. The graph of f is perpendicular to the line whose equation is $3x - 2y - 4 = 0$ and has the same y-intercept as this line.
24. The graph of f is perpendicular to the line whose equation is $4x - y - 6 = 0$ and has the same y-intercept as this line.

Application Exercises

The bar graph shows that as online news has grown, traditional news media have slipped.

Percentage of Americans Who Regularly Use Various News Media



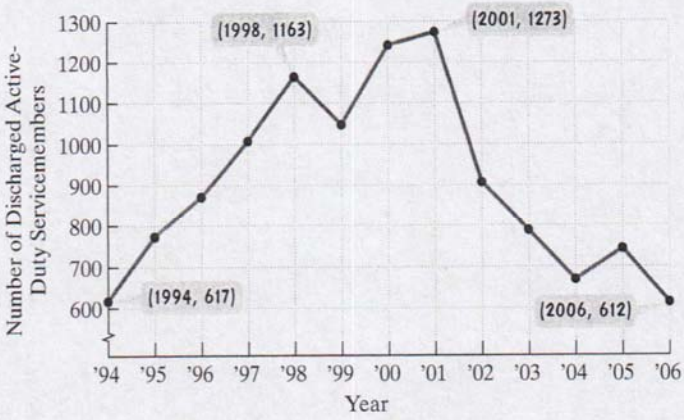
Source: Pew Research Center

In Exercises 25–26, find a linear function in slope-intercept form that models the given description. Each function should model the percentage of Americans, $P(x)$, who regularly used the news outlet x years after 2000.

25. In 2000, 47% of Americans regularly used newspapers for getting news and this has decreased at an average rate of approximately 1.2% per year since then.
26. In 2000, 23% of Americans regularly used online news for getting news and this has increased at an average rate of approximately 1.3% per year since then.

The stated intent of the 1994 "don't ask, don't tell" policy was to reduce the number of discharges of gay men and lesbians from the military. Nearly 12,000 active-duty gay servicemembers have been dismissed under the policy. The line graph shows the number of discharges under "don't ask, don't tell" from 1994 through 2006. Use the data displayed by the graph to solve Exercises 27–28.

Number of Active-Duty Gay Servicemembers Discharged from the Military for Homosexuality

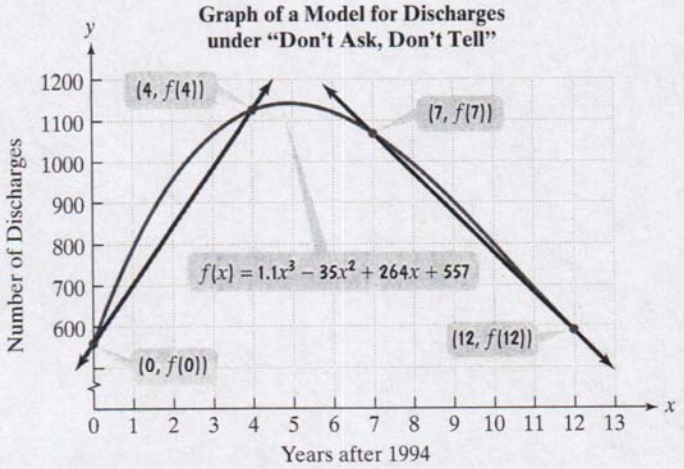


Source: General Accountability Office

27. Find the average rate of change, rounded to the nearest whole number, from 1994 through 1998. Describe what this means.
28. Find the average rate of change, rounded to the nearest whole number, from 2001 through 2006. Describe what this means.

The function $f(x) = 1.1x^3 - 35x^2 + 264x + 557$ models the number of discharges, $f(x)$, under "don't ask, don't tell" x years after 1994. Use this model and its graph, shown on the domain $[0, 12]$ to solve Exercises 29–30.

Graph of a Model for Discharges under "Don't Ask, Don't Tell"



29. **a.** Find the slope of the secant line, rounded to the nearest whole number, from $x_1 = 0$ to $x_2 = 4$.
    b. Does the slope from part (a) underestimate or overestimate the average yearly increase that you determined in Exercise 27? By how much?
30. **a.** Find the slope of the secant line, rounded to the nearest whole number, from $x_1 = 7$ to $x_2 = 12$.
    b. Does the slope from part (b) underestimate or overestimate the average yearly decrease that you determined in Exercise 28? By how much?