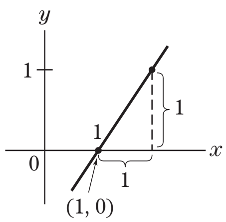
CHAPTER 1

Exercises 1.1, page 63

1. $m = -7, b = 3$ **2.** $m = \frac{3}{5}, b = \frac{1}{5}$ **3.** $m = \frac{1}{2}, b = \frac{3}{2}$ **4.** $m = 0, b = 6$ **5.** $m = \frac{1}{7}, b = -5$ **6.** $m = -\frac{4}{9}, b = -\frac{1}{9}$
7. $y - 1 = -(x - 7)$ **8.** $y + 2 = 2(x - 1)$ **9.** $y - 1 = \frac{1}{2}(x - 2)$ **10.** $y + \frac{2}{5} = \frac{7}{3}\left(x - \frac{1}{4}\right)$ **11.** $y - 5 = \frac{63}{10}\left(x - \frac{5}{7}\right)$
12. $y - 4 = 6(x - 1)$ **13.** $y = 0$ **14.** $y - 1 = \frac{48}{49}\left(x - \frac{2}{3}\right)$ **15.** $y = 9$ **16.** $x - \frac{y}{3} = 1$ or $y = 3x - 3$
17. $-\frac{x}{\pi} + y = 1$ or $y = \frac{x}{\pi} + 1$ **18.** $y = 2(x + 3)$ **19.** $y = -2x - 4$ **20.** $y = 2$ **21.** $y = x - 2$
22. $y - 2 = -\frac{1}{2}(x - 1)$ **23.** $y = 3x - 6$ **24.** $y = x$ **25.** $y = x - 2$ **26.** $y - 5 = \frac{1}{5}(x - 1)$

27. Start at (1, 0). To get back to the line, move one unit to the right and then one unit up.



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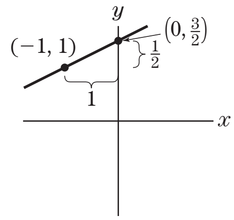
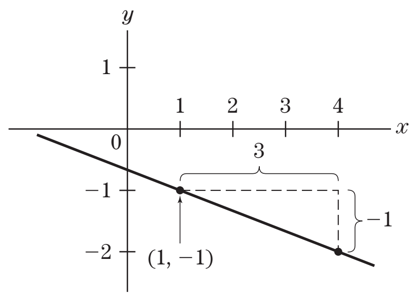


29. Start at (1, −1). To get back to the line, move 3 units to the right and then 1 unit down.



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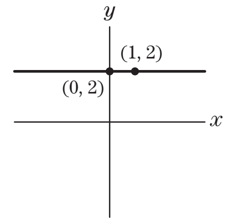
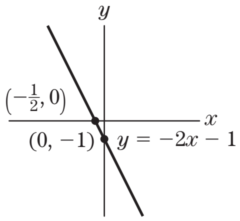
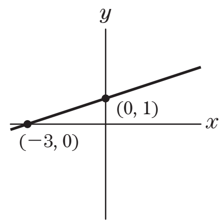


31. **(a)** C **(b)** B **(c)** D **(d)** A **32.** $b = 0$ **33.** 1 **34.** 1 **35.** $-\frac{3}{4}$ **36.** $\frac{1}{3}$ **37.** (2, 5); (3, 7); (0, 1) **38.** (3, −1); (4, −4); (1, 5)
39. $f(3) = 2$ **40.** $m_1 = \frac{2-4}{-1-3} = \frac{-2}{-4} = \frac{1}{2}$; $2x + 3y = 0$, $y = -\frac{2}{3}x$, $m_2 = -\frac{2}{3}$, $m_1 \neq m_2$, not parallel **41.** l_1 **42.** l_2

43.



44. $y = \frac{1}{3}x + 1$

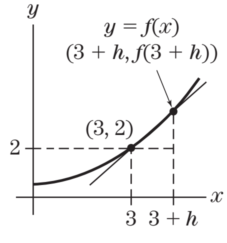


45. $a = 2$, $f(2) = 2$ **46.** $a = 2$, $f(a) = 2$ **47.** **(a)** $C(10) = \$1220$.
(b) Marginal cost is \$12 per item. **(c)** $C(11) - C(10) =$ marginal cost $= \$12$.
48. $C(x + 1) - C(x) = 12(x + 1) + 1100 - 12x - 1100 = 12$.
49. $P(x) = 2.19 - .04x$ dollars, where $P(x)$ is the price of 1 gallon x months since January 1. Price of 1 gallon on April 1 is $P(3) = \$2.07$. Price of 15 gallons is \$31.05. Price of 1 gallon on September 1 is $P(8) = \$1.87$. Price of 15 gallons is \$28.05.
50. $y = 42.5x$, $y(4) = \$170$ million. **51.** $C(x) = .03x + 5$.
52. **(a)** $Q(x) = \frac{-2}{75}x + \frac{59}{150}$. **(b)** \$11.

53. $G(x) = -\frac{5000}{3}x + 5000$, $G(2.34) = 1100$ gallons. **54.** \$1.68. **55.** **(a)** $C(x) = 7x + 1500$. **(b)** Marginal cost is \$7 per rod. **(c)** \$7
56. slope = price per sale y-int = base commission. **57.** If the manufacturer wants to sell one more unit of goods, then the price per unit must be lowered by 2 cents. No one is willing to pay \$7 or more for a unit of goods. **58.** $m = \frac{5}{9}$, $b = -\frac{160}{9}$, 98.6°F = 37°C.
59. Let $A(x)$ be the amount in ml of the drug in the blood after x minutes; then, $A(x) = 6x + 1.5$. **60.** $y = \frac{179}{30}x + 1.5$. **61.** $y(t) = 2t - 212$

62. $y(t) = \begin{cases} 2t - 212 & 0 \le t \le 31 \\ -150 & 31 \le t \le 331 \\ 2t - 812 & 331 \le t \end{cases}$ 406 sec. **63.** **(a)** $C(x) = 7x + 230$ dollars **(b)** $R(x) = 12x$ dollars

64. Breakeven when $x = 46$. **66.** (a), (b), (c)



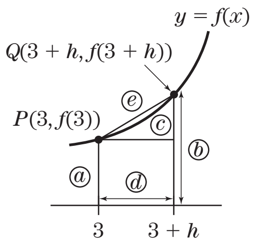
(d) $m = \frac{f(3+h) - 2}{3 + h - 3} = \frac{f(3+h) - 2}{h}$.

67. **(a)** $y = \frac{1}{3}x + 54$. **(b)** Every year since 2014, .33% more of the world becomes urban. **(c)** 56%. **(d)** 2068.
68. **(a)** $y = .0217x + 295$ **(c)** slope = increase in deductions per dollar increase in income **(d)** \$1922.50 **(e)** \$60,138.25 approx
(f) \$325.50

Exercises 1.2, page 69

1. $-\frac{4}{3}$ **2.** 0 **3.** 1 **4.** 1 **5.** 1 **6.** 1/2 **7.** −2 **8.** −1/3 **9.** Small positive, large positive **10.** Zero slope, large negative **11.** Zero slope, small negative **12.** Let m_P = slope at P. Then, $m_A = 1, m_B = 8, m_C = 0, m_D = -6, m_E = 0, m_F = -\frac{1}{2}$. **13.** $-.8, y - .16 = -.8(x + .4)$ **14.** $m = -4, y - 4 = -4(x + 2)$ **15.** $\frac{2}{3}; y - \frac{1}{9} = \frac{2}{3}(x - \frac{1}{3})$ **16.** $-3; y - 2.25 = 3(x + 1.5)$ **17.** $m = -\frac{1}{2}$ **18.** $m = -.4$ **19.** $y - 6.25 = 5(x - 2.5)$ **20.** $y - 4.41 = 4.2(x - 2.1)$ **21.** $(\frac{7}{4}, \frac{49}{16})$ **22.** $(-3, 9)$ **23.** $(-\frac{1}{3}, \frac{1}{9})$ **24.** $(\frac{3}{4}, \frac{9}{16})$ **25.** Approximately \$17.5. The price was rising on both days. **26.** Yes, the slopes of the graph on these days are almost equal. **27.** \$27.25; rising at the rate of \$0.05 per day. **28.** About \$27, $m = 0$. The price was holding steady. **29.** 12 **30.** $\frac{27}{4} = 6.75$ **31.** $\frac{3}{4}$ **32.** $y + 1 = 3(x + 1)$. **33.** $a = 1, f(1) = 1$, slope is 2. **34.** $a = -\frac{1}{2}, f(a) = \frac{1}{4}, m = -1$. **35.** $\left(\frac{1}{\sqrt{2}}, \frac{1}{2\sqrt{2}}\right), \left(-\frac{1}{\sqrt{2}}, -\frac{1}{2\sqrt{2}}\right)$. **36.** $(\sqrt{\frac{2}{3}}, \frac{2}{3}\sqrt{\frac{2}{3}}), (-\sqrt{\frac{2}{3}}, -\frac{2}{3}\sqrt{\frac{2}{3}})$. **37.** **(a)** 3, 9 **(b)** increase.

38.



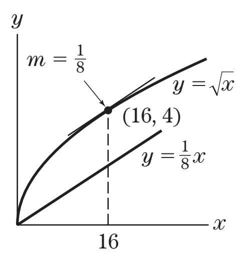
(e) is $\overline{PQ}$

39. −3 **40.** $\frac{1}{2}$ **41.** .25 **42.** $\frac{1}{12}$

Exercises 1.3, page 79

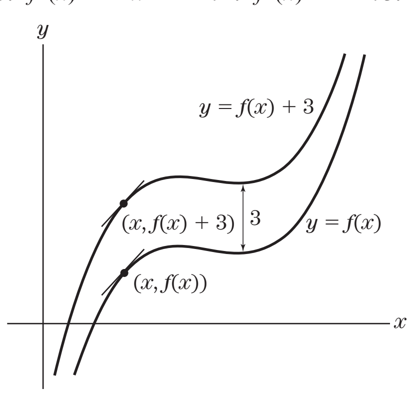
1. 3 **2.** −2 **3.** $\frac{3}{4}$ **4.** $\frac{2}{7}$ **5.** $7x^6$ **6.** $-2x^{-3} = -\frac{2}{x^3}$ **7.** $\frac{2}{3}x^{-1/3} = \frac{2}{3\sqrt[3]{x}}$ **8.** $-\frac{1}{2}x^{-3/2}$ **9.** $-\frac{5}{2}x^{-7/2}$ **10.** $-3x^{-4} = -\frac{3}{x^4}$ **11.** $\frac{1}{3}x^{-2/3}$ **12.** $-\frac{1}{5}x^{-6/5}$ **13.** $f(x) = x^2; f'(x) = 2x$ **14.** $\frac{2}{7}x^{-5/7}$ **15.** 0 **16.** 0 **17.** $\frac{3}{4}$ **18.** $\frac{405}{16} = 25.3125$ **19.** $-\frac{9}{4}$ **20.** 0 **21.** 1 **22.** $\frac{1}{12}$ **23.** 2 **24.** $-\frac{1}{320}$ **25.** 32 **26.** $\frac{5}{81}$ **27.** $f(-5) = -125, f'(-5) = 75$ **28.** $f(0) = 6, f'(0) = 2$ **29.** $f(8) = 2, f'(8) = \frac{1}{12}$ **30.** $f(1) = 1, f'(1) = -2$ **31.** $f(-2) = -\frac{1}{32}, f'(-2) = -\frac{5}{64}$ **32.** $f(16) = 64, f'(16) = 6$ **33.** $y + 8 = 12(x + 2)$ **34.** $y - \frac{1}{4} = -(x + \frac{1}{2})$ **35.** $y = 3x + 1$ **36.** $y = 5$ **37.** $y - \frac{1}{3} = \frac{3}{2}(x - \frac{1}{9})$ **38.** $y - 100 = -10{,}000(x - .01)$ **39.** $y - 1 = -\frac{1}{2}(x - 1)$ **40.** $y - \frac{1}{27} = -\frac{1}{27}(x - 3)$ **41.** $f(x) = x^4$, $f'(x) = 4x^3$, $f(1) = 1$, $f'(1) = 4$; then, (6) (with $a = 1$) becomes $y - 1 = 4(x - 1)$, which is the given equation of the tangent line. **42.** $P = (2, \frac{1}{2})$ or $P = (-2, -\frac{1}{2})$. **43.** $P = (\frac{1}{16}, \frac{1}{4}), b = \frac{1}{8}$ **44.** $a = 27, b = 54$

45. **(a)** (16, 4) **(b)**



46. $P_1(\frac{1}{\sqrt{3}}, \frac{1}{3\sqrt{3}})$ and $P_2(-\frac{1}{\sqrt{3}}, -\frac{1}{3\sqrt{3}})$. **47.** No, such a point would have to have an x-coordinate satisfying $3x^2 = -1$, which has no real solutions. **48.** $f(2) = 3, f'(2) = -2$ **49.** $8x^7$ **50.** $-3x^{-4}$ **51.** $\frac{3}{4}x^{-1/4}$ **52.** $-\frac{1}{3}x^{-4/3}$ **53.** 0 **54.** $-4x^{-5}$ **55.** $\frac{1}{5}x^{-4/5}$ **56.** $\frac{1}{3}$ **57.** 4, $\frac{1}{3}$ **58.** $f(1) = 4, f'(1) = 0$ **59.** $a = 4, b = 1$ **60.** $a = 4$ **61.** 1, 1.5; 2 **62.** $f'(1) \approx \frac{1.1 - .8}{1.2 - 1} = \frac{.3}{.2} = 1.5$ **63.** $y - 5 = \frac{1}{2}(x - 4)$ **64.** P is (2, 1.75), $m = .5$, $y - 1.75 = .5(x - 2)$, or $y = .5x + .75$ is the tangent line. **65.** $4x + 2h$ **66.** $2x + h$ **67.** $-2x + 2 - h$ **68.** $-4x + 1 - 2h$ **69.** $3x^2 + 3xh + h^2$ **70.** $6x^2 + 2x + 6xh + h + 2h^2$ **71.** $f'(x) = -2x$ **72.** $f'(x) = 6x$ **73.** $f'(x) = 14x + 1$ **74.** $f'(x) = 1$ **75.** $f'(x) = 3x^2$ **76.** $f'(x) = 6x^2 - 1$

77. **(a)** and **(b)**



(c) Parallel lines have equal slopes: Slope of the graph of $y = f(x)$ at the point $(x, f(x))$ is equal to the slope of the graph of $y = f(x) + 3$ at the point $(x, f(x) + 3)$, which implies the given equation.

78. Tangent lines are parallel. **79.** .69315 **80.** $f'(1) \approx -.5$ **81.** .70711 **82.** $f'(3) \approx -.75$ **83.** .11111 **84.** $f'(0) \approx 23.02587$

Exercises 1.4, page 89

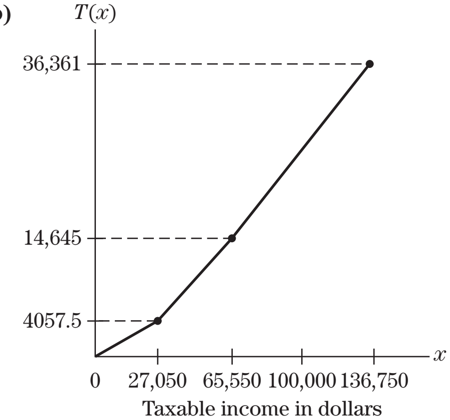
1. No limit **2.** 2 **3.** 1 **4.** No limit **5.** No limit **6.** No limit **7.** -5 **8.** No limit **9.** 5 **10.** 57 **11.** $\frac{13}{5}$ **12.** $\frac{2288}{3}$ **13.** 288 **14.** $\frac{5}{194}$ **15.** $\frac{\sqrt{14}}{23}$ **16.** 0 **17.** 3 **18.** 2 **19.** -4 **20.** 5 **21.** -8 **22.** $\frac{1}{5}$ **23.** $\frac{6}{7}$ **24.** $\frac{38}{7}$ **25.** No limit **26.** No limit **27.** **(a)** 0 **(b)** $-\frac{3}{2}$ **(c)** $-\frac{1}{4}$ **(d)** -1 **28.** $f(x+h) = mx + mh + b$, $f(x+h) - f(x) = mh$, $\frac{f(x+h)-f(x)}{h} = m$, $\lim_{h\to 0} m = m$ **29.** 6 **30.** 12 **31.** 3 **32.** 2 **33.** Step 1. $\frac{f(x+h)-f(x)}{h} = \frac{(x+h)^2+1-(x^2+1)}{h}$ Step 2. $\frac{f(x+h)-f(x)}{h} = 2x + h$ Step 3. $f'(x) = 2x$ **34.** $f(x+h) = -x^2 - 2xh - h^2 + 2$, $f(x+h) - f(x) = -2xh - h^2$, $\frac{f(x+h)-f(x)}{h} = -2x - h$, $f'(x) = -2x$ **35.** Step 1. $\frac{f(x+h)-f(x)}{h} = \frac{(x+h)^3-1-(x^3-1)}{h}$ Step 2. $\frac{f(x+h)-f(x)}{h} = 3x^2 + 3xh + h^2$ Step 3. $f'(x) = 3x^2$ **36.** $f(x+h) = -3x^2 - 6xh - 3h^2 + 1$, $f(x+h) - f(x) = -6xh - 3h^2$, $\frac{f(x+h)-f(x)}{h} = -6x - 3h$, $f'(x) = -6x$ **37.** Steps 1, 2: $\frac{f(3+h)-f(3)}{h} = 3.$ Step 3: $f'(x) = \lim_{h\to 0} 3 = 3$ **38.** $f'(x) = -1$ **39.** Steps 1, 2: $\frac{f(x+h)-f(x)}{h} = 1 + \frac{-1}{x(x+h)}$. Step 3: $f'(x) = \lim_{h\to 0} 1 + \frac{-1}{x(x+h)} = 1 - \frac{1}{x^2}$ **40.** $f'(x) = -\frac{2}{x^3}$ **41.** Steps 1, 2: $\frac{f(x+h)-f(x)}{h} = \frac{1}{(x+1)(x+h+1)}$. Step 3: $f'(x) = \lim_{h\to 0} \frac{1}{(x+1)(x+h+1)} = \frac{1}{(x+1)^2}$ **42.** $f'(x) = \frac{-2}{(x-2)^2}$ **43.** Steps 1, 2: $\frac{f(x+h)-f(x)}{h} = \frac{-2x-h}{((x+h)^2+1)(x^2+1)}$. Step 3: $f'(x) = \lim_{h\to 0} \frac{-2x-h}{((x+h)^2+1)(x^2+1)} = \frac{-2x}{(x^2+1)^2}$ **44.** $f'(x) = \frac{2}{(x+2)^2}$ **45.** Steps 1, 2: $\frac{f(x+h)-f(x)}{h} = \frac{1}{\sqrt{x+h+2}+\sqrt{x+2}}$. Step 3: $f'(x) = \lim_{h\to 0} \frac{1}{\sqrt{x+h+2}+\sqrt{x+2}} = \frac{1}{2\sqrt{x+2}}$ **46.** $f'(x) = \frac{x}{\sqrt{x^2+1}}$ **47.** Steps 1, 2: $\frac{f(x+h)-f(x)}{h} = \frac{-1}{\sqrt{x}\sqrt{x+h}(\sqrt{x}+\sqrt{x+h})}$. Step 3: $f'(x) = \lim_{h\to 0} \frac{-1}{\sqrt{x}\sqrt{x+h}(\sqrt{x}+\sqrt{x+h})} = \frac{-1}{2x\sqrt{x}} = \frac{-1}{2x^{3/2}}$ **48.** $f'(x) = \frac{3}{2}\sqrt{x}$ **49.** $f(x) = x^2$; $a = 1$ **50.** $f(x) = x^3$, $a = 2$ **51.** $f(x) = \frac{1}{x}$; $a = 10$ **52.** $f(x) = \sqrt[3]{x}$, $a = 64$ **53.** $f(x) = \sqrt{x}$; $a = 9$ **54.** $f(x) = \frac{1}{\sqrt{x}}$, $a = 1$ **55.** 0 **56.** 0 **57.** $\frac{5}{3}$ **58.** 0 **59.** 0 **60.** 1 **61.** $\frac{3}{4}$ **62.** 1 **63.** 0 **64.** 3 **65.** 0 **66.** $\frac{9}{16}$ **67.** 0 **68.** 0 **69.** .5 **70.** -8

Exercises 1.5, page 96

1. No **2.** Yes **3.** Yes **4.** Yes **5.** No **6.** No **7.** No **8.** No **9.** Yes **10.** Yes **11.** No **12.** No **13.** Continuous, differentiable **14.** Continuous, differentiable **15.** Continuous, not differentiable **16.** Continuous, not differentiable **17.** Continuous, not differentiable **18.** Neither **19.** Not continuous, not differentiable **20.** Neither **21.** $f(5) = 3$ **22.** $f(-4) = -7$ **23.** Not possible **24.** Not possible **25.** $f(0) = 12$ **26.** $f(0) = \frac{1}{6}$

27. **(a)** $T(x) = \begin{cases} .15x & \text{for } 0 < x \le 27{,}050 \\ .275x - 3381.25 & \text{for } 27{,}050 < x \le 65{,}550 \\ .305x - 5347.75 & \text{for } 65{,}550 < x \le 136{,}750 \end{cases}$

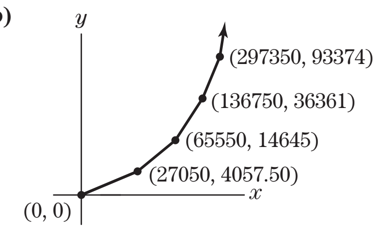
(b)



(c) $T(65,550) - T(27,050) = 10,587.5$ dollars

28. **(a)** $T(x) = \begin{cases} .15x & \text{for } 0 < x \le 27{,}050 \\ .275x - 3381.25 & \text{for } 27{,}050 < x \le 65{,}550 \\ .305x - 5347.75 & \text{for } 65{,}550 < x \le 136{,}750 \\ .355x - 12{,}185.25 & \text{for } 136{,}750 < x \le 297{,}350 \\ .391x - 22{,}889.85 & \text{for } x > 297{,}350 \end{cases}$

(b)



(c) \$57,013

29. **(a)** $R(x) = \begin{cases} .07x + 2.5 & \text{for } 0 \le x \le 100 \\ .04x + 5.5 & \text{for } 100 < x \end{cases}$ **(b)** $P(x) = \begin{cases} .04x + 2.5 & \text{for } 0 \le x \le 100 \\ .01x + 5.5 & \text{for } 100 < x \end{cases}$

30. **(a)** $R(x) = \begin{cases} .10x & \text{for } 0 \le x \le 50 \\ .05x + 2.5 & \text{for } x > 50 \end{cases}$ **(b)** $P(x) = \begin{cases} .07x & \text{for } 0 \le x \le 50 \\ .02x + 2.5 & \text{for } x > 50 \end{cases}$

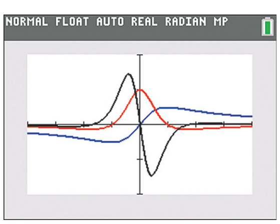
31. **(a)** \$3000 per hour **(b)** \$3000 per hour, between 8 A.M. and 10 A.M. **32.** **(a)** Midnight to 2 A.M. and 2 A.M. to 4 A.M. \$250/hour. **(b)** \$4000 and \$6000. **33.** $a = 1$ **34.** $a = -\frac{1}{2}$

Exercises 1.6, page 102

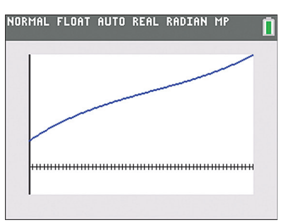
1. $18x^2$ **2.** $12x^3$ **3.** $3(\frac{1}{3})x^{-2/3}$ or $\frac{1}{x^{2/3}}$ **4.** $-\frac{1}{x^4}$ **5.** $\frac{1}{2} - 2(-1)x^{-2}$ or $\frac{1}{2} + \frac{2}{x^2}$ **6.** 0 **7.** $4x^3 + 3x^2 + 1$ **8.** $12x^2 - 4x + 1$
9. $3(2x + 4)^2(2)$ or $6(2x + 4)^2$ **10.** $3(x^2 - 1)^2(2x) = 6x(x^2 - 1)^2$ **11.** $7(x^3 + x^2 + 1)^6(3x^2 + 2x)$
12. $-2(x^2 + x)^{-3}(2x + 1)$ **13.** $-\frac{8}{x^3}$ **14.** $-12(x^2 - 6)^{-4} \cdot 2x = \frac{-24x}{(x^2-6)^4}$ **15.** $3(\frac{1}{3})(2x^2 + 1)^{-\frac{2}{3}}(4x)$ or $4x(2x^2 + 1)^{-\frac{2}{3}}$
16. $\frac{1}{\sqrt{x+1}}$ **17.** $2 + 3(x + 2)^2$ **18.** $3(x - 1)^2 + 4(x + 2)^3$ **19.** $\frac{1}{5}(-5)x^{-6}$ or $-\frac{1}{x^6}$ **20.** $4x(x^2 + 1) + 12x(x^2 - 1)$
21. $(-1)(x^3 + 1)^{-2}(3x^2)$ or $-\frac{3x^2}{(x^3+1)^2}$ **22.** $\frac{-2}{(x+1)^2}$ **23.** $1 - (x + 1)^{-2}$ **24.** $2 \cdot \frac{1}{4}(x^2 + 1)^{-3/4} \cdot 2x = x(x^2 + 1)^{-3/4}$ **25.** $\frac{45x^2+5}{2\sqrt{3x^3+x}}$
26. $-(x^3 + x + 1)^{-2} \cdot (3x^2 + 1) = -\frac{3x^2+1}{(x^3+x+1)^2}$ **27.** 3 **28.** $\frac{x}{\sqrt{1+x^2}}$ **29.** $\frac{1}{2}(1 + x + x^2)^{-\frac{1}{2}}(1 + 2x)$ **30.** $\frac{-2}{(2x+5)^2}$ **31.** $10(1 - 5x)^{-2}$
32. $7 \cdot (-\frac{1}{2})(1 + x)^{-3/2} = -\frac{7}{2}(1 + x)^{-3/2}$ **33.** $-45(1 + x + \sqrt{x})^{-2}(1 + \frac{1}{2}x^{-\frac{1}{2}})$ **34.** $11(1 + x + x^2)^{10}(1 + 2x)$ **35.** $1 + \frac{1}{2}(x + 1)^{-\frac{1}{2}}$
36. π^2 **37.** $\frac{3}{2}(\frac{\sqrt{x}}{2} + 1)^{1/2}(\frac{1}{4}x^{-1/2})$ or $\frac{3}{8\sqrt{x}}(\frac{\sqrt{x}}{2} + 1)^{1/2}$ **38.** $-(x - \frac{1}{x})^{-2}(1 + \frac{1}{x^2})$ **39.** 4 **40.** $-\frac{1}{2}$ **41.** 15 **42.** $y - 6 = 15(x - 2)$
43. $f'(4) = 48$, $y = 48x - 191$ **44.** $y - 1 = -\frac{5}{8}(x - 2)$ **45.** **(a)** $y' = 2(3x^2 + x - 2) \cdot (6x + 1) = 36x^3 + 18x^2 - 22x - 4$
(b) $y = 9x^4 + 6x^3 - 11x^2 - 4x + 4$, $y' = 36x^3 + 18x^2 - 22x - 4$ **46.** $\frac{d}{dx}[f(x) + (-1)g(x)] = \frac{d}{dx}f(x) + \frac{d}{dx}(-1)g(x) = \frac{d}{dx}f(x) - \frac{d}{dx}g(x)$
47. 4.8; 1.8 **48.** $h(1) = f(1) + g(1) = 2.2 + 1.36 = 3.56$, $h'(1) = f'(1) + g'(1) = -.4 + .26 = -.14$. **49.** 14; 11
50. $f(3) = 2 \cdot 2^3 = 16$, $f'(3) = 6(g(3))^2 \cdot g'(3) = 96$. **51.** 10; $\frac{15}{4}$ **52.** $h(1) = 1^2 + \sqrt{4} = 3$, $h'(1) = 2f(1)f'(1) + \frac{g'(1)}{2\sqrt{g(1)}} = -1$.
53. $(5, \frac{161}{3})$; $(3, 49)$ **54.** $(-2, 27)$, $(6, -213)$ **55.** $f(4) = 5$, $f'(4) = \frac{1}{2}$ **56.** $b = -8$

Exercises 1.7, page 110

1. $10t(t^2 + 1)^4$ **2.** $3P^2 + 6P - 7$ **3.** $8t + \frac{11}{2}t^{-\frac{1}{2}}$ **4.** $2y - 2$ **5.** $5T^4 - 16T^3 + 6T - 1$ **6.** $32t + 45$ **7.** $6P - \frac{1}{2}$ **8.** $\frac{s}{\sqrt{s^2+1}}$
9. $2a^2t + b^2$ **10.** $3(T^2 + 3P)^2 \cdot 3 = 9(T^2 + 3P)^2$ **11.** $y' = 1$, $y'' = 0$ **12.** $y' = 3(x + 12)^2$, $y'' = 6(x + 12)$
13. $y' = \frac{1}{2}x^{-1/2}$, $y'' = -\frac{1}{4}x^{-3/2}$ **14.** $y' = 0$, $y'' = 0$ **15.** $y' = \frac{1}{2}(x + 1)^{-\frac{1}{2}}$, $y'' = -\frac{1}{4}(x + 1)^{-\frac{3}{2}}$ **16.** $v' = 4t + 3$, $v'' = 4$
17. $f'(r) = 2\pi r$, $f''(r) = 2\pi$ **18.** $y' = 6x$, $y'' = 6$ **19.** $f'(P) = 15(3P + 1)^4$, $f''(P) = 180(3P + 1)^3$
20. $T' = 4(1 + 2t) + 3t^2$, $T'' = 8 + 6t$ **21.** 36 **22.** −1 **23.** 0 **24.** 152 **25.** 34 **26.** 6 **27.** $f'(1) = -\frac{1}{9}$, $f''(1) = \frac{2}{27}$
28. $g'(0) = 12$, $g''(0) = 12$ **29.** $\frac{d}{dt}(\frac{dx}{dt}) = 18t + \frac{8}{t^3}$; 37. **30.** $v'' = 4 + \frac{2}{(1+t)^3}$ **31.** 20 **32.** 1 **33.** **(a)** $\frac{ds}{dP} = T$ **(b)** $\frac{ds}{dT} = P$
34. **(a)** $\frac{ds}{dP} = 2PT$; $\frac{d^2s}{dP^2} = 2T$ **(b)** $\frac{ds}{dT} = P^2$; $\frac{d^2s}{dT^2} = 0$ **35.** **(a)** $2Tx + 3P$ **(b)** $3x$ **(c)** $x^2 + 2T$ **36.** **(a)** $\frac{d^2s}{dx^2} = 14y\sqrt{z}$
(b) $\frac{d^2s}{dy^2} = 0$ **(c)** $\frac{ds}{dz} = \frac{7}{2}x^2yz^{-1/2}$ **37.** When 50 bicycles are manufactured, the cost is \$5000. For every additional bicycle manufactured, there is an additional cost of \$45. **38.** \$5045 **39.** **(a)** \$2.60 per unit **(b)** 100 or 200 more units
40. A → d, B → b, C → a, D → c **41.** **(a)** $R(12) = 22$, $R'(12) = .075$ **(b)** $P(x) = R(x) - C(x)$ so $P'(x) = R'(x) - C'(x)$. When 1200 chips are produced, the marginal profit is $.75 - 1.5 = -.75$ dollars per chip. **42.** Since $C(12) = 14$ and $R(12) = 22$, then $P(12) = R(12) - C(12) = 8$. Since $P'(12) = -.075$, then $P(13) \approx 8 - .075 = 7.925 > 0$, so yes, it is profitable.
43. **(a)** $S(1) = 120.560$, $S'(1) = 1.5$ **(b)** $S(3) = 80$, $S'(3) = -6$ **44.** **(a)** $S(10) = \frac{372}{121} \approx 3.07$, $S'(10) = -\frac{18}{1331} \approx -.0135$
(b) Rate of change is less negative. **45.** **(a)** $S(10) = \frac{372}{121} \approx 3.074$ thousand dollars; $S'(10) = -\frac{18}{11^3} \approx -.0135$ thousand dollars per day. **(b)** $S(11) \approx S(10) + S'(10) \approx 3.061$ thousand dollars. $S(11) = \frac{49}{16} = 3.0625$ thousand dollars.
46. **(a)** $T(1) = 5.25$, $T'(1) = -.675$, $S(1) = 5.25$, $S'(1) = -2.25$. **(b)** The new model does not have such a large rate of decrease in sales. **47.** **(a)** $A(8) = 12$, $A'(8) = .5$ **(b)** $A(9) \approx A(8) + A'(8) = 12.5$. If the company spends \$9000, it should expect to sell 1250 computers. **48.** $S(n) =$ # of videos sold on day n, $S'(n) =$ rate of sales on day n, $S(n) + S'(n) =$ approximately the # of videos sold on day $n + 1$. **49.** **(a)** $f'''(x) = 60x^2 - 24x$ **(b)** $f'''(x) = \frac{15}{2\sqrt{x}}$ **50.** **(a)** $f'''(t) = 720t^7$ **(b)** $f'''(z) = \frac{-6}{(z+5)^4}$
51.



52. **(a)**



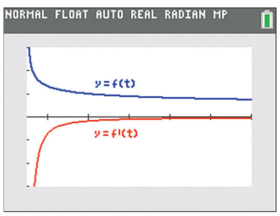
(b) $x = 10$ **(c)** at $x = 20$ or $x = 47$

Exercises 1.8, page 119

1. **(a)** 1$\frac{f(2)-f(1)}{2-1} = 6$; **(b)** $\frac{f(1.5)-f(1)}{1.5-1} = 5.5$; **(c)** $\frac{f(1.1)-f(1)}{1.1-1} = 5.1$ **2.** **(a)** $\frac{f(.5)-f(0)}{.5} = 1.5$; **(b)** $\frac{f(0.1)-f(0)}{0.1} = .3$;
(c) $\frac{f(0.01)-f(0)}{0.01} = .03$ **3.** **(a)** 12; 10; 8.4 **(b)** 8 **4.** **(a)** $\frac{f(2)-f(1)}{2-1} = \frac{-3-(-6)}{1} = 3$, $\frac{f(1.5)-f(1)}{1.5-1} = \frac{-4-(-6)}{.5} = 4$, $\frac{f(1.2)-f(1)}{1.2-1} = \frac{-5-(-6)}{.2} = 5$.
(b) $f'(1) = 6$. **5.** **(a)** 14 **(b)** 13 **6.** **(a)** $\frac{f(3)-f(2)}{3-2} = \frac{7-2}{1} = 5$ **(b)** $f'(2) = 6$ **7.** **(a)** 28 km/h **(b)** 96 km **(c)** $\frac{1}{2}$ hr
8. $\frac{f(4)-f(3)}{4-3} = \frac{180-169}{1} = 11$, $f'(2) = 20$ units/day **9.** 63 units/h **10.** 5.25 gallons/h **11.** **(a)** $v(t) = -12t + 72$ feet per sec.

(b) $a(t) = -12$ feet per sec per sec. **(c)** $t = 6$ sec. **(d)** $s(6) = 216$ feet **12. (a)** At A **(b)** Negative **(c)** It is zero. **(d)** Backward **(e)** It is back to start, and at rest. **(f)** The velocity is zero. **13. (a)** 160 ft/sec **(b)** 96 ft/sec **(c)** -32 ft/sec^2 **(d)** 10 sec **(e)** -160 ft/sec **14. (a)** $t = 4$ secs **(b)** $v = 9$ ft/sec, $a = 2$ ft/sec^2 **15.** A–b; B–d; C–f; D–e; E–a; F–c; G–g **16.** $\frac{47.4-45.0}{1.05-1.00} = 48$ mph; approximate speed 40 mph **17. (a)** 15 ft/sec. **(b)** No; positive velocity indicates the object is moving away from the reference point. **(c)** 5 ft/sec. **18. (a)** Picture (b) **(b)** Picture (c) **(c)** Picture (d) **(d)** Picture (a) **(e)** Picture (e) **19. (a)** 5010 **(b)** 5005 **(c)** 4990 **(d)** 4980 **(e)** 4997.5 **20. (a)** 6 **(b)** 8 **(c)** 9.5 **(d)** 12 **(e)** 13 **21.** Four minutes after it has been poured, the coffee is 120°. At that time, its temperature is decreasing by 5°/min; 119.5°. **22.** $f(3) = 2$ means in 3 hours, 2 mg of drug remain; $f'(3) = -.5$ means in 3 hr, the amount of drug is decreasing at.5 mg/hr; $f(3.5) = 1.75$ mg. **23.** When the price of a car is \$10,000, 200,000 cars are sold. At that price, the number of cars sold decreases by 3 for each dollar increase in price. **24.** At \$100,000 spent on advertisement, 3 million toys are sold; the rate of toys sold is increasing by 30 toys for every dollar spent on advertisement. **25.** When the price is set at \$1200, 60,000 computers are sold. For every \$100 increase in price, the sales decrease by 2000 computers. 59,000 computers. **26.** It costs \$50,000 to manufacture 2000 items. When 2000 items are manufactured, the cost per item is increasing by \$10 for every new item manufactured. Cost of manufacturing 1998 items is approximately \$49,980. **27.** The profit from manufacturing and selling 100 cars is \$90,000. Each additional car made and sold creates an additional profit of \$1200; \$88,800. **28. (a)** In 100 days, one share is worth \$16. In 100 days, the share's worth is increasing at a rate of 25 cents per day. **(b)** \$16.25 **29. (a)** $C'(5) = \$74{,}000$ per unit. **(b)** $C(5.25) \approx C(5) + C'(5)(.25) = 256.5$ thousand dollars. **(c)** $x = 4$ **(d)** $C'(4) = 62$, $R'(4) = 29$. If the production is increased by one unit, cost will rise by \$62,000, and revenue will increase by \$29,000. The company should not increase production beyond the breakeven point. **30.** Increase by.05 **31. (a)** \$500 billion **(b)** \$50 billion/yr **(c)** 1994 **(d)** 1994 **32. (a)** 60 ft **(b)** 20 ft/sec **(c)** 10 ft/sec^2 **(d)** in 5.5 secs **(e)** at $t = 7$ secs **(f)** 30 ft/sec at $t = 4.5$ secs; 90 ft

33. (a)



(b) .85 sec
(c) 5 days
(d) $-.05$ sec/day
(e) 3 days

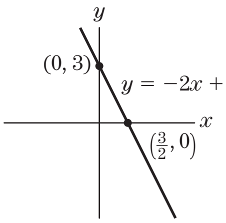
34. (b) 140 ft
(c) ≈ 5 secs
(d) ≈ -90 ft/sec
(e) ≈ 1 sec
(f) ≈ -102 ft/sec

Chapter 1: Answers to Fundamental Concept Check Exercises, page 128

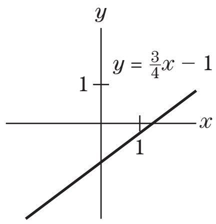
1. The slope of a nonvertical line is the rate of change of the line. It is given by the ratio $\frac{y_2-y_1}{x_2-x_1}$, where (x_1, y_1) and (x_2, y_2) are any two distinct points on the line. The slope measures the steepness of the line. **2.** $(y - y_1) = m(x - x_1)$, where m is the slope and (x_1, y_1) is a point on the line. **3.** First, find the slope: $m = \frac{y_2-y_1}{x_2-x_1}$. Then, use the point–slope form of the equation with any one of the given two points. **4.** Slopes of parallel lines are equal. Slopes of perpendicular lines are opposite reciprocal. **5.** The slope of $f(x)$ at the point $(2, f(2))$ is the slope of the tangent line to the graph of $y = f(x)$ at the point $(2, f(2))$. **6.** $f'(2)$ represents the slope of the tangent line to the graph of $y = f(x)$ at the point $(2, f(2))$. **7.** The derivative or slope formula for a linear function $f(x) = mx + b$ is m. For a constant function, $m = 0$, and so the derivative is 0. **8.** Power rule: $\frac{d}{dx}[x^n] = nx^{n-1}$ $\frac{d}{dx}[x^7] = 7x^6$; constant-multiple rule: $\frac{d}{dx}[k \cdot f(x)] = k\frac{d}{dx}[f(x)]$ $\frac{d}{dx}[-3x^4] = (-3)\frac{d}{dx}[x^4] = -12x^3$; sum rule: $\frac{d}{dx}[f(x) + g(x)] = \frac{d}{dx}[f(x)] + \frac{d}{dx}[g(x)]$ $\frac{d}{dx}[x + \frac{1}{x} = \frac{d}{dx}[x] + \frac{d}{dx}[x^{-1} = 1 - x^{-2} = 1 - \frac{1}{x^2}$. **9.** The slope of the secant line through $P = (2, f(2))$ and $Q = (2 + h, f(2 + h))$ is $\frac{f(2+h)-f(2)}{2+h-2} = \frac{f(2+h)-f(2)}{h}$. As h approaches 0, the point Q approaches P and the slope of the secant line approaches the slope of the tangent line $f'(2)$. **10.** $\lim_{x\to 2} f(x) = 3$ means that the values of $f(x)$ become arbitrarily close to 3 as x approaches 2. $\lim_{x\to 2}(2x - 1) = 4 - 1 = 3$. **11.** $f'(2) = \lim_{h\to 0}\frac{f(2 + h) - f(2)}{h}$ **12.** $\lim_{x\to\infty} f(x) = 3$ means that the values of $f(x)$ become arbitrarily close to 3 as x approaches infinity—that is, as x becomes very large in positive values. $\lim_{x\to-\infty} f(x) = 3$ means that the values of $f(x)$ become arbitrarily close to 3 as x approaches minus infinity—that is, as x becomes arbitrarily large in negative values. $\lim_{x\to\infty}(3 + \frac{1}{x}) = 3$ and $\lim_{x\to-\infty}(3 + \frac{1}{x}) = 3$. **13.** $f(x)$ is continuous at $x = 2$ if $\lim_{x\to 2} = f(2)$. $f(x) = \begin{cases} 1 & \text{if } x \geq 2 \\ -1 & \text{if } x < 2 \end{cases}$. **14.** $f(x)$ is differentiable at $x = 2$ if $f'(2)$ exists. If f is differentiable, then it has to be continuous. The example in the previous answer is not continuous at 2, and so it is not differentiable at 2. **15.** General power rule: $\frac{d}{dx}[g(x)]^n = n\,g(x)^{n-1}\frac{d}{dx}[g(x)]$. $\frac{d}{dx}\left[(x^2 + 2x - 3)^9\right] = 9(x^2 + 2x - 3)^8\frac{d}{dx}\left[(x^2 + 2x - 3)\right] = 9(x^2 + 2x - 3)^8(2x + 2)$. **16.** $f'(2)$ and $\frac{d}{dx}[f(x)]\big|_{x=2}$; $f''(2)$ and $\frac{d^2}{dx^2}[f(x)]\big|_{x=2}$ **17.** $\frac{f(b)-f(a)}{b-a}$ **18.** The average rate of change approaches the (instantaneous) rate of change as the size of the interval approaches 0. **19.** $v(t) = s'(t)$, $a(t) = v'(t) = s''(t)$. **20.** $f(a + h) - f(a) \approx f'(a) \cdot h$. **21.** Marginal cost, $C'(x)$, is the derivative of the cost function $C(x)$. **22.** [Unit of measure for $f'(x)$] equals [Unit of measure for $f(x)$] per [unit of measure for x]. If $C(x)$ is the cost in dollars of manufacturing x units of a certain item, then the marginal cost, $C'(x)$, is measured in dollars per unit item.

Chapter 1: Review Exercises, page 129

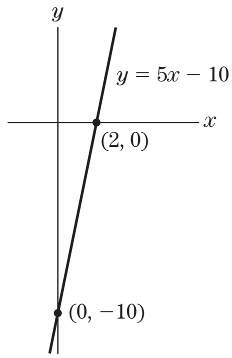
1. $y = -2x + 3$



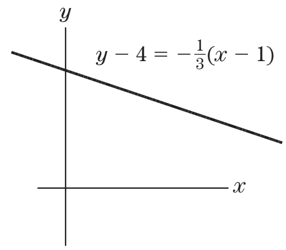
2.



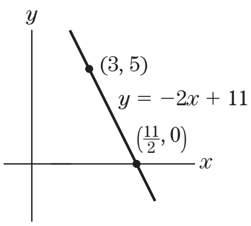
3. $y = 5x - 10$



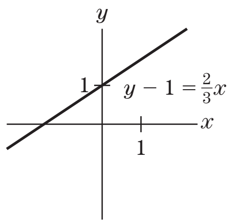
4. $y - 4 = -\frac{1}{3}(x - 1)$



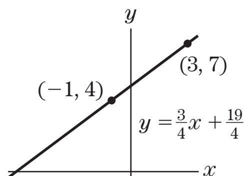
5. $y = -2x + 11$



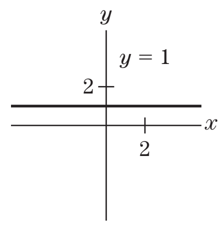
6. $y - 1 = \frac{2}{3}x$



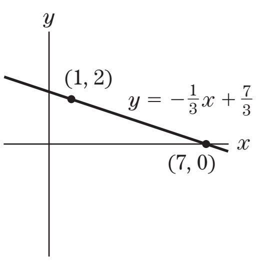
7. $y = \frac{3}{4}x + \frac{19}{4}$



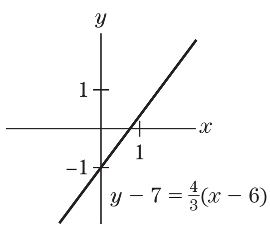
8. $y = 1$



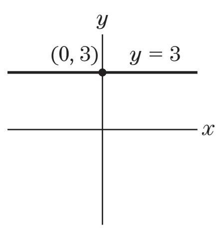
9. $y = -\frac{1}{3}x + \frac{7}{3}$



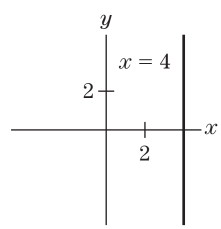
10. $y - 7 = \frac{4}{3}(x - 6)$



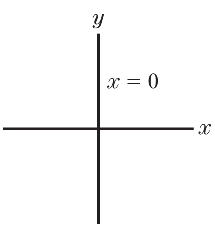
11. $y = 3$



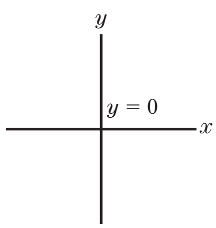
12. $x = 4$



13. $x = 0$



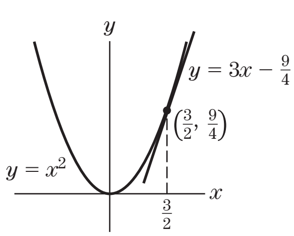
14. $y = 0$



15. $7x^6 + 3x^2$
16. $40x^7$
17. $\frac{3}{\sqrt{x}}$
18. $7x^6 + 15x^4$
19. $-\frac{3}{x^2}$
20. $4x^3 + \frac{4}{x^2}$
21. $48x(3x^2 - 1)^7$

22. $x^{1/3} + x^{-1/4}$
23. $-\frac{5}{(5x - 1)^2}$
24. $5(x^3 + x^2 + 1)^4(3x^2 + 2x)$
25. $\frac{x}{\sqrt{x^2+1}}$
26. $-\frac{70x}{(7x^2+1)^2}$
27. $-\frac{1}{4x^{5/4}}$
28. $6(2x + 1)^2$

29. 0 **30.** $\frac{5}{2} + \frac{2}{5x^2}$ **31.** $10[x^5 - (x - 1)^5]^9[5x^4 - 5(x - 1)^4]$ **32.** $10t^9 - 90t^8$ **33.** $\frac{3}{2}t^{-1/2} + \frac{3}{2}t^{-3/2}$ **34.** 0
35. $2(9t^2 - 1)/(t - 3t^3)^2$ **36.** $2.8^{-0.3}$ **37.** $\frac{9}{4}x^{1/2} - 4x^{-1/3}$ **38.** $\frac{1}{2\sqrt{x+\sqrt{x}}} \cdot \left(1 + \frac{1}{2\sqrt{x}}\right)$ **39.** 28 **40.** 10π **41.** 14; 3
42. $-1/2$; 0 **43.** $15/2$ **44.** 12 **45.** 33 **46.** -5 **47.** $4x^3 - 4x$ **48.** $\frac{5}{2}t^{3/2} + 3t^{1/2} - \frac{1}{2}t^{-1/2}$ **49.** $\frac{-3}{2\sqrt{1-3P}}$ **50.** $-5n^{-6}$
51. 29 **52.** 320 **53.** $300(5x + 1)^2$ **54.** $-\frac{1}{2}t^{-3/2}$ **55.** -2 **56.** 0 **57.** $3x^{-1/2}$ **58.** $\frac{2}{3}t^{-3}$ **59.** Slope -4; tangent $y = -4x + 6$
60. $y + 1/2 = -\frac{3}{4}(x - 1)$ **61.** $y = 3x - \frac{9}{4}$ **62.** $y - 4 = -4(x + 2)$ **63.** $y = 2$ **64.** $y - 8 = 60(x - 2)$



65. $f(2) = 3, f'(2) = -1$ **66.** $a = -1$ **67.** 96 ft/sec. **68.** 45 tons/hr **69.** 11 feet **70.** $v_{\text{ave}} = \frac{6-1}{4-1} = \frac{5}{3}$ feet/second
71. $\frac{5}{3}$ feet/second **72.** faster at $t = 6$ **73.** **(a)** \$16.10 **(b)** \$16 **74.** **(a)** 4400 **(b)** 4700 **(c)** 4100 **(d)** 4900
75. $\frac{3}{4}$ inch **76.** \$12.53 **77.** 4 **78.** Does not exist **79.** Does not exist **80.** 0 **81.** $-\frac{1}{50}$ **82.** 4
83. The slope of a secant line at (3, 9) **84.** $-\frac{1}{4}$