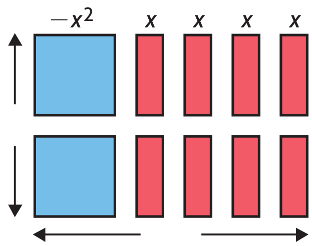
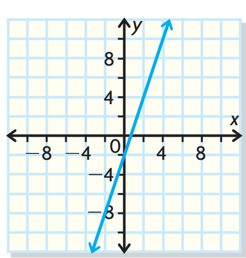
4. 

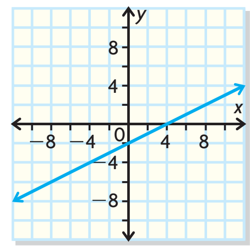
$-2x$ is the common factor. It divides into $-2x^2$, x times and into $8x$, -4 times. The factors are $-2x(x-4)$.

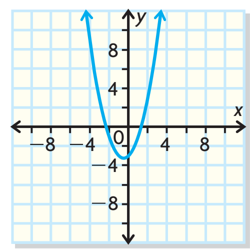
5. a) $(x+4)(x-3)$ c) $-5(x-8)(x-7)$
   b) $(a+7)(a+9)$ d) $(y-6)(y+9)$
6. a) $(x-5)(2x+1)$ c) $3(x-2)(2x-1)$
   b) $(3n-16)(4n-1)$ d) $(4a+3)(2a-5)$
7. 3 by $4x^2-x-5$; $(3x+3)$ by $(4x-5)$; $(x+1)$ by $(12x-15)$
8. $m = 12, -12$
9. a) $(11x-5)(11x+5)$ c) $(x-3)(x+3)(x^2+9)$
   b) $(6a-5)^2$ d) $(n+3)^2$
10. 7, 2; −7, −2; −7, 2; 7, −2; 9, 6; −9, −6; −9, 6; 9, −6; 23, 22; −23, −22; −23, 22; 23, −22

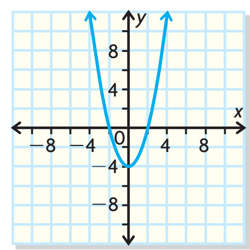
Chapter 3

Getting Started, pp. 126–128

1. a) (v) c) (iii) e) (ii)
   b) (vi) d) (iv) f) (i)
2. a) $y = 6$ c) $a = \frac{9}{2}$
   b) $x = \frac{16}{3}$ d) $c = \frac{7}{4}$
3. a) vertex: (0, 2); axis: $x = 0$; domain: $\{x \in \mathbf{R}\}$; range: $\{y \in \mathbf{R} \mid y \geq 2\}$
   b) vertex: (3, −5); axis: $x = 3$; domain: $\{x \in \mathbf{R}\}$; range: $\{y \in \mathbf{R} \mid y \leq -5\}$
4. a) $5y - 5x$ c) $6x^4 + 10x^3$
   b) $8m - 4$ d) $-x^2 - 2x + 12$
5. a) x-intercept: $\frac{7}{3}$; y-intercept: -7
   b) x-intercept: 6; y-intercept: -2
   c) x-intercept: 2; y-intercept: 5
   d) x-intercept: 4; y-intercept: 3
6. a) $5(x^2-x+3)$ d) $(2x+3)(3x-1)$
   b) $(x-10)(x-1)$ e) $2(x-1)(x+3)$
   c) $(x+5)(2x-3)$ f) $(x-11)(x+11)$
7. a) 

   b) 

   c) 

   d) 

8. a) x-intercepts: 3, −2; y-intercept: −6; min −6, the parabola opens up and $a > 0$
   b) x-intercepts: 3, −3; y-intercept: 9; max 9, the parabola opens down and $a < 0$
9. a) linear, the graph shows a straight line or first difference is −1
   b) nonlinear, the graph does not show a straight line or first difference is not constant
10.

Factoring atrategies:
Common factor to be done first
Difference of squares for 2 terms separated by a − sign
Simple trinomials for 3 terms starting with 1 or a prime number times x^2
Complex trinomials for 3 terms not starting with 1 or a prime number times x^2

Factoring Quadratics

Examples:
$3x^2 + 6x + 9 = 3(x^2 + 2x + 3)$
$4x^2 - 25 = (2x + 5)(2x - 5)$
$x^2 + x - 20 = (x + 5)(x - 4)$
$4x^2 + 16x + 15 = (2x + 3)(2x + 5)$

Non-examples:
$3x + 6$ is not quadratic
$x^3 + 1$ is not quadratic
$x^2 + x + 1$ does not factor

Lesson 3.1, p. 131

1. Yes; it matches the minimum number of moves I found when I played the game, and when I substituted 6 into the model, I got 48.
2. Answers may vary. E.g.: R = red, B = blue, S = slide, J = jump

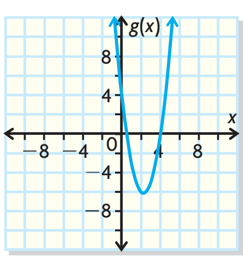
N															
1	RS	BJ	RS												
2	RS	BJ	BS	RJ	RJ	BS	BJ	RS							
3	RS	BJ	BS	RJ	RJ	RS	BJ	BJ	BJ	RS	RJ	RJ	BS	BJ	RS

It is very symmetric. Each row of the table starts and ends with a slide.

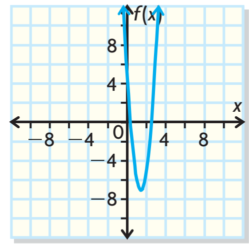
3. Yes; number of moves: 5, 11, 19, …; $f(x) = x^2 + 3x + 1$, when graphed it appears quadratic

Lesson 3.2, pp. 139–142

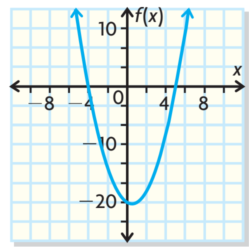
1. a) $-5, 3$ b) $f(x) = (x + 5)(x - 3)$
2. a) $f(x) = 2x(x + 6)$, zeros: $0, -6$; axis: $x = -3$; vertex: $(-3, -18)$
   b) $f(x) = (x - 4)(x - 3)$, zeros: 4, 3; axis: $x = \frac{7}{2}$; vertex: $\left(\frac{7}{2}, -\frac{1}{4}\right)$
   c) $f(x) = -(x + 10)(x - 10)$, zeros: $-10, 10$; axis: $x = 0$; vertex: $(0, 100)$
   d) $f(x) = (x + 3)(2x - 1)$, zeros: $-3, \frac{1}{2}$; axis: $x = -\frac{5}{4}$; vertex: $\left(-\frac{5}{4}, -\frac{49}{8}\right)$
3. a) $f(x) = 3x^2 - 12x$; 0
   b) $f(x) = x^2 + 2x - 35$; -35
   c) $f(x) = 6x^2 - 20x - 16$; -16
   d) $f(x) = 6x^2 + 7x - 20$; -20
4. a) zeros: $0, -6$; axis of symmetry: $x = -3$; vertex: $(-3, -18)$
   b) zeros: $8, -4$; axis: $x = 2$; vertex: $(2, -36)$
   c) zeros: 10, 2; axis: $x = 6$; vertex: $(6, 16)$
   d) zeros: $-\frac{5}{2}, \frac{9}{2}$; axis: $x = 1$; vertex: $(1, 49)$
   e) zeros: $-\frac{3}{2}, 2$; axis: $x = \frac{1}{4}$; vertex: $\left(\frac{1}{4}, -\frac{49}{8}\right)$
   f) zeros: $5, -5$; axis $x = 0$; vertex: $(0, 25)$
5. a) $g(x) = 3x(x - 2)$; zeros: 0, 2; axis: $x = 1$; vertex: $(1, -3)$
   b) $g(x) = (x + 3)(x + 7)$; zeros: $-7, -3$; axis: $x = -5$; vertex: $(-5, -4)$
   c) $g(x) = (x + 2)(x - 3)$; zeros: $-2, 3$; axis: $x = \frac{1}{2}$; vertex: $\left(\frac{1}{2}, -6.25\right)$
   d) $g(x) = 3(x - 1)(x + 5)$; zeros: $-5, 1$; axis: $x = -2$; vertex: $(-2, -27)$
   e) $g(x) = (x - 7)(2x + 1)$; zeros: $-\frac{1}{2}, 7$; axis: $x = 3.25$; vertex: $(3.25, -28.125)$
   f) $g(x) = -6(x - 2)(x + 2)$; zeros: $-2, 2$; axis: $x = 0$; vertex: $(0, 24)$
6. a) (iii) c) (iv) e) (v)
   b) (ii) d) (i)
   I expanded or graphed.
7. a) 20.25, max c) 45.125, max e) 25, max
   b) -49, min d) -2.25, min f) -4, min
8. a)



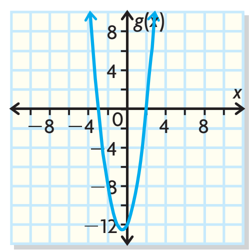
b)



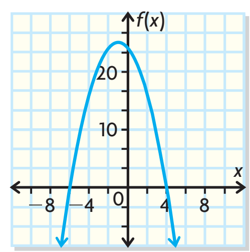
c)



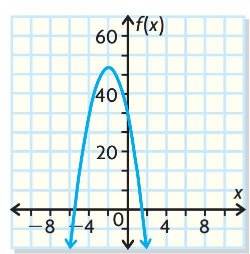
d)



e)

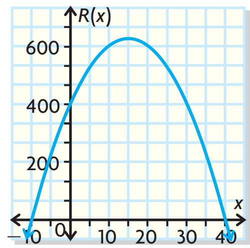


f)

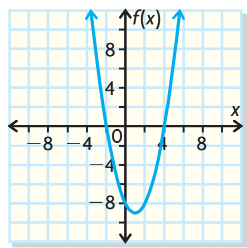


9. a) the y-intercept, the direction the parabola opens; in $f(x) = x^2 - x - 20$, the y-intercept is -20, and the parabola opens upward because a is $+1$, which is greater than 0
   b) the x-intercept(s), the axis of symmetry, the direction the parabola opens; in $f(x) = (x - 5)(x + 7)$, the zeros are 5 and -7, the axis of symmetry is $x = -1$, and the parabola opens upward because a is $+1$, which is greater than 0

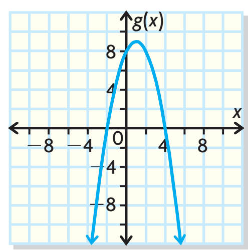
10. a) zeros: 40, -10; axis: $x = 15$; y-intercept: 400; vertex: $(15, 625)$; max: 625



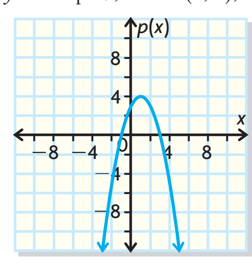
b) $f(x) = x^2 - 2x - 8$; zeros: 4, -2; axis: $x = 1$; y-intercept: -8; vertex: $(1, -9)$; min: -9



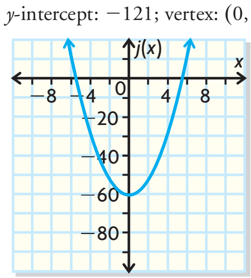
c) $f(x) = (4 - x)(x + 2)$; zeros: 4, -2; axis: $x = 1$; y-intercept: 8; vertex: $(1, 9)$; max: 9



d) $p(x) = -x^2 + 2x + 3$; zeros: 3, -1; axis: $x = 1$; y-intercept: 3; vertex: $(1, 4)$; max: 4



e) $j(x) = (2x - 11)(2x + 11)$; zeros: $\frac{11}{2}$, $-\frac{11}{2}$; axis: $x = 0$; y-intercept: -121; vertex: $(0, -121)$; min: -121



11. $h(t) = -5t(t - 3)$; 11.25 m

12. a) $f(x) = (x + 2)(x - 7)$; $f(x) = x^2 - 5x - 14$

b) $f(x) = (7 - x)(x + 5)$; $f(x) = -x^2 + 2x + 35$

c) $f(x) = \frac{1}{2}(x + 3)(x + 6)$; $f(x) = \frac{1}{2}x^2 + \frac{9}{2}x + 9$

d) $f(x) = -\frac{2}{9}x(x - 6) = -\frac{2x^2}{9} + \frac{4x}{3}$

13. a) $x = 5$; $(5, 6)$; $f(x) = -\frac{2}{3}(x - 2)(x - 8)$;

$f(x) = -\frac{2}{3x^2} + \frac{20}{3x} - \frac{32}{3}$

b) $x = -\frac{9}{2}$; $\left(-\frac{9}{2}, -2\right)$; $f(x) = \frac{8}{25}(x + 7)(x + 2)$;

$f(x) = \frac{8}{25x^2} + \frac{72x}{25} + \frac{112}{25}$

c) $x = 4$; $(4, 5)$; $f(x) = -\frac{1}{5}(x + 1)(x - 9)$;

$f(x) = -\frac{x^2}{5} + \frac{8x}{5} + \frac{9}{5}$

d) $x = -4$; $(-4, -5)$; $f(x) = \frac{5}{16x}(x + 8)$;

$f(x) = \frac{5}{16x^2} + \frac{5}{2x}$

14. a) $t = 7$ s

b) $t = 5$ s

15. 75 km/h

16. Find the zeros and then the axis of symmetry. Find the vertex and use all those points to graph the function.

17. $y = \left(-\frac{1}{48}\right)x^2 + 192$

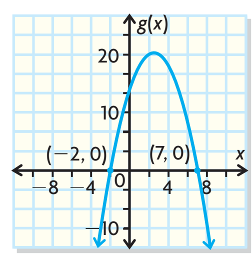
18. $h(t) = -t(4.9t - 30)$

19. a) $h(d) = -0.0502(d - 21.9)(d + 1.2)$

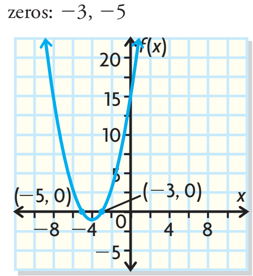
b) r and s are the points where the shot is on the ground.

Lesson 3.3, pp. 149–152

1. a) zeros: -2, 7



b) zeros: -3, -5



2. **a)** zeros: $-4, 5$ **b)** zeros: $-1.4, 6.4$

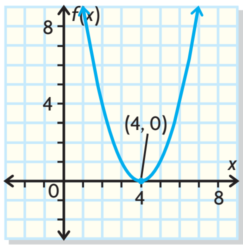
3. **a)** $x^2 - 2x - 35 = 0$; zeros: $-5, 7$

b) $-x^2 + 3x + 4 = 0$; zeros: $-1, 4$

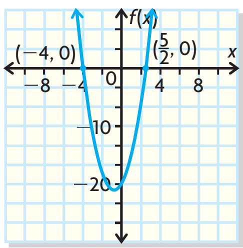
c) $x^2 + 3x - 5 = 0$; zeros: $-4.2, 1.2$

d) $-6x^2 - x + 2 = 0$; zeros: $-\frac{2}{3}, \frac{1}{2}$

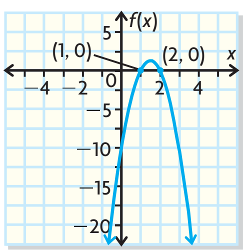
4. **a)** zero: 4



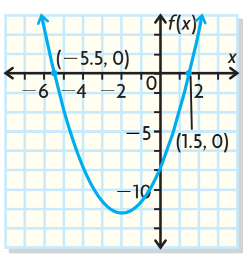
b) zeros: $-4, \frac{5}{2}$



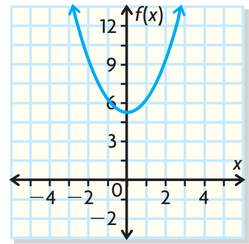
c) zeros: 1, 2



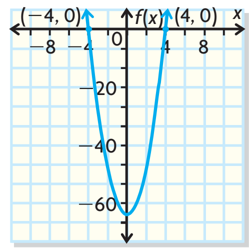
d) zeros: $-5.5, 1.5$



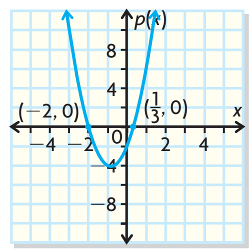
e) no solution



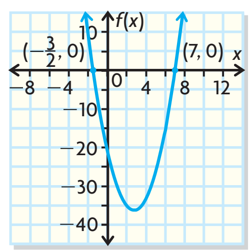
f) zeros: $-4, 4$



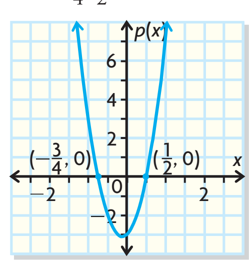
5. **a)** zeros: $-2.0, \frac{1}{3}$



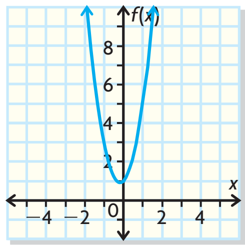
b) zeros: $-\frac{3}{2}, 7$



c) zeros: $-\frac{3}{4}, \frac{1}{2}$



d) no solution



6. a) 71 900 people **b)** partway through 2019
c) 1983

7. 26.9 s

8. 3.53 s

9. 2

10. a) $b = 5$ or $b = 2$, so to break even, the company must produce 5000 or 2000 skateboards
b) 3500

11. a) 45 m **b)** 4 s

12. a) 15 min **b)** $160

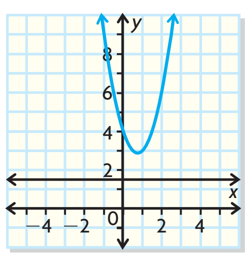
13. a) i) Answers may vary. E.g., $f(x) = 8x^2 + 2x - 3$
ii) Answers may vary. E.g., $f(x) = x^2 - 6x + 9$
iii) Answers may vary. E.g., $f(x) = x^2 + 2$
b) There can only be no zeros, one zero, or two zeros because a quadratic function either decreases and increases (or increases and decreases), so it will not be able to cross the x-axis a third time.

14. a) $f(x) = 3x^2 - 2x + 1$
b) Graph the function and find where the graph crosses the x-axis.

15. $y = -0.3x^2 + 150$

16. a) (1.5, 5) and (−2, −9)
b) (−1.5, −3.75) and (5, 6)

17. The graphs $y = 2x^2 - 3x + 4$ and $y = 1.5$ do not intersect.



Mid-Chapter Review, p. 155

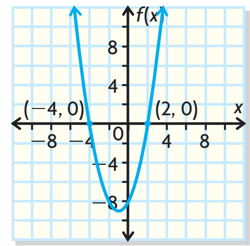
1. a) $f(x) = 2x^2 + 17x + 21$
b) $g(x) = -3x^2 + 16x + 12$
c) $f(x) = -8x^2 - 2x + 15$
d) $g(x) = -6x^2 + 13x - 5$

2. a) (ii) **c)** (i) **e)** (iii)
b) (i) **d)** (ii)

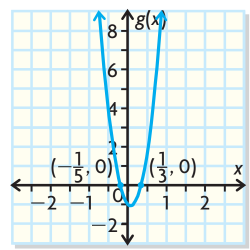
3. a) minimum −36 **c)** minimum −28.125
b) maximum 40.5 **d)** maximum 15.125

4. Answers may vary. E.g., Factored form is most useful because it gives the zeros, and the midpoint of the zeros gives the vertex. In $f(x) = (x - 2)(x - 6)$, the zeros are 2 and 6, and the vertex is (4, −4).

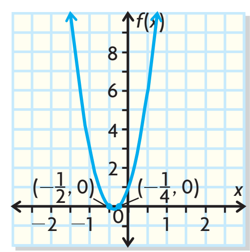
5. a) zeros: −4, 2



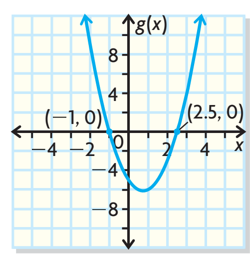
b) zeros: $\frac{1}{3}, -\frac{1}{5}$



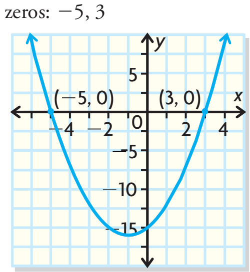
c) zeros: $-\frac{1}{4}, -\frac{1}{2}$



d) zeros: 2.5, −1

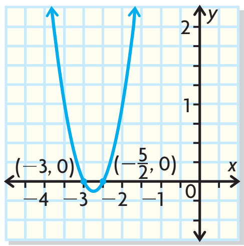


6. a) zeros: −5, 3

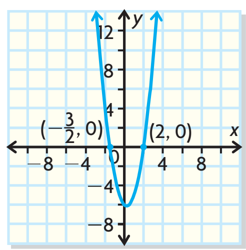


Answers

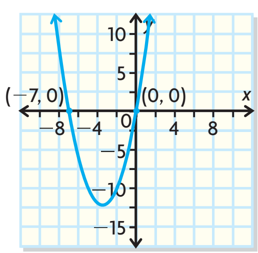
b) zeros: $-3, -\frac{5}{2}$



c) zeros: $2, -\frac{3}{2}$



d) zeros: $-3, -4$



7. It is a dangerous ball. It is above 1 m from $0.11 < t < 1.9$.

8. No. $(x - 3)(x + 4) = x^2 - x + 12$

Lesson 3.4, pp. 161–163

1. **a)** $x = -3, 5$ **c)** $x = -\frac{1}{2}, \frac{5}{3}$
b) $x = 6, 9$ **d)** $x = 0, 3$

2. **a)** $(x + 5)(x - 4); x = -5, 4$
b) $(x - 6)(x + 6), x = -6, 6$
c) $(x + 6)(x + 6); x = -6$
d) $x(x - 10); x = 0, 10$

3. **a)** yes **c)** yes
b) no **d)** no

4. **a)** $x = -6, 9$ **c)** $x = -7$ **e)** $x = -\frac{1}{2}, 5$
b) $x = 13, -13$ **d)** $x = 14, 3$ **f)** $x = \frac{1}{3}, -4$

5. **a)** $x = 17, -17$ **c)** $x = -3, 5$ **e)** $x = -3, 5$
b) $x = \frac{5}{3}$ **d)** $x = -\frac{1}{2}, 7$ **f)** $x = -\frac{3}{2}, 5$

6. **a)** $x = -10, 0$ **c)** $x = -7, -2$ **e)** $x = 5, \frac{16}{3}$
b) $x = -\frac{1}{3}, 0$ **d)** $x = -3, 9$ **f)** $x = -\frac{5}{2}, -\frac{1}{3}$

7. **a)** $x = -6, 7$ **c)** $x = 4, -9$ **e)** $x = -\frac{1}{4}, -\frac{3}{2}$
b) $x = -4, 1$ **d)** $x = 2, \frac{8}{3}$ **f)** $x = \frac{3}{2}, -\frac{1}{5}$

8. 5 s

9. **a)** 0, 24 **b)** 288 m^2

10. **a)** at 0 and 6000 snowboards
b) when they sell between 0 and 6000 snowboards

11. $t = 3$ *s*

12. 9 s

13. $30 025

14. **a)** $P(x) = -5x^2 + 19x - 10$
b) between 631 and 3169 pairs of shorts

15. No. Some equations do not factor or are too difficult to factor.

16. It is faster and helps find the maximum or minimum value, but it can be difficult or impossible to factor the equation.

17. 14.1 s

18. $2 < t < 10$

Lesson 3.5, pp. 168–169

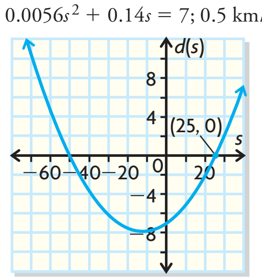
1. **a)** between 400 and 900 games
i) table of values

x	$P(x)$
3	−6
4	0
5	4
6	6
7	6
8	4
9	0

ii) factoring: $P(x) = -(x - 9)(x - 4)$

2. $-5(t - 10)(t + 1) = 0$; $t = 10$ or $t = -1$; the ball hits the ground after 10 s.

3. $0.0056s^2 + 0.14s = 7$; 0.5 km/h

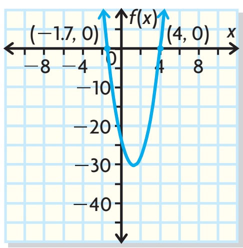


4. Beverly used an appropriate method, but she should have substituted 20 instead of 2020 because $t = 0$ corresponds to the year 2000 to get a population of 74 000.

5. Solution 1: Using a table of values
$x = 4$

x	y
-2	12
-1.5	0
-1	-10
0	-24
1	-30
2	-28
3	-18
4	0

Solution 2: Using a graph
$x = 4$ and $x = -1.5$



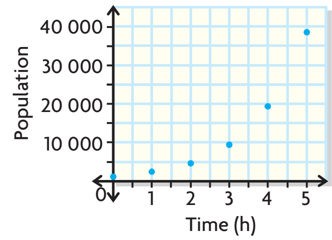
Solution 3: By factoring
$x = -\frac{3}{2}$ and $x = 4$
$2(2x + 3)(x - 4) = 0$

6. The population will be 312 000 in 2008 and 1972.
7. You can use graphing and factoring. Your answers will be $x = -3, 5$.
8. approximately 15.77 m
9. $450 000
10. 1 s
11. **a)** Answers may vary. E.g., $16 = -2x^2 + 32x + 110$
$0 = -2x^2 + 32x - 126$
$0 = -2(x^2 + 16x - 63)$
$0 = -2(x + 7)(x - 9)$
$x = 7$ and $x = 9$
They must sell either 7000 or 9000 games.
b) Answers may vary. E.g., I let $P(x) = 16$ in the function, since P is profit in thousands of dollars. I rearranged the equation to get 0 on the left side, then factored the right side. I determined values for x where each of the factors were zero. These were the solutions to the equation. I multipled these numbers by 1000, since they represent the number of games in thousands.
12. She noticed that when $t = -30$ and 10, $P(t) = 35\ 000$. Since $t = 0$ corresponds to 2000, then $t = -30$ corresponds to 1970.
13. 5 and 5; product is 25
14. 6 m × 6 m

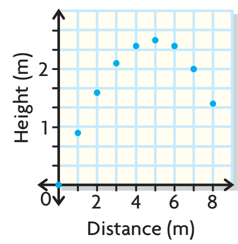
Lesson 3.6, pp. 176–179

1. **a)** $x = 3, x = -5; a = 2; y = 2(x - 3)(x + 5); y = 2x^2 + 4x - 30$
b) $x = 1.5, x = -3; a = -2; y = (-2x + 3)(x + 3)$;
$y = -2x^2 - 3x + 9$

2. **a)** not quadratic because the graph does not have a maximum or minimum because the data does not increase and decrease or vice versa



b) quadratic, the graph looks parabolic



3. **a)** $y = 0.5(x - 2)(x + 1); y = 0.5x^2 - 0.5x - 1$
b) $y = -0.5(x + 2)(x - 3); y = -0.5x^2 + 0.5x + 3$
4. **a)** $y = -2x^2 + 2x + 24$
b) $y = x^2 + 7x + 10$
c) $y = 3x^2 + 6x - 105$
d) $y = -3x^2 + 18x - 24$
5. $h(x) = -0.37x^2 + 1.48x - 0.52$; 3.6 m
6. $h(t) = -5t^2 + 35, t = 2.45$ s
7. $h(t) = -4.9t^2 + 9.7t + 1, t = 1.7$ s, 0.2 s
8. $h(t) = -4.9t^2 + 17.9t + 0.5, t = 3.7$ s
9. **a)** $y = 0.21(x - 3)(x - 12)$
b) -4.25 m
10. **a)** $y = -x^2 + 7x + 50$
b) They will sell no more shoes in month 12.
11. **a)** 0, 0, 1, 3, 6, 10, 15
b) number of lines $= \frac{n(n-1)}{2}$, where n is the number of dots and $n \geq 2$
12. The zeros are a and b. So, $f(x) = k(x - a)(x - b)$. To determine k, use another point on the parabola.
13. $y = 0.000\ 36x^2 + 4$
14. **a)**

Time (s)	2.5	3.0	3.5	4.0	4.5	5.0	5.06
Height (m)	32.125	30.9	27.225	21.1	12.525	1.5	0

b) $y = -4.9t^2 + 24.5t + 1.5$
c) 32.125 m

Chapter Review, pp. 182–183

1. **a)** (ii) **c)** (iv)
b) (iii) **d)** (i)
2. **a)** min -36 **b)** min -3.125 **c)** max 15.125
3. **a)** $x = -5$ or $x = 3$, min -16
b) $x = 7$ or $x = 1$, max 9
c) $x = -8$ or $x = -1$, min -24.5

d) $x = -\frac{1}{2}$ or $x = -3$, min -3.125

e) $x = -\frac{3}{2}$ or $x = \frac{1}{3}$, min $-\frac{121}{24}$

f) $x = -7$ or $x = 7$, max 49

4. a) 3.15 m b) 2.38 s

5. a) zeros: $-3, 5$; vertex: $(1, 32)$; y-int: 30
b) zeros: $4, -2$; vertex: $(1, -18)$; y-int: -16

6. a) $x = -7$ or $x = 5$
b) $x = 3$ or $x = -8$
c) $x = \frac{1}{3}$
d) $x = -\frac{1}{2}$ or $x = \frac{5}{3}$

7. $t = 1$ and 9 s

8. a) 2014 b) 87 850 people

9. $x = 2$; No, you cannot just change the 17 to be positive. The answer should be $x = 2$.

10. a) $y = -4.9x^2 + 37.6x + 14$
b) It is close to most of the points on the graph.

11. $y = -3(x + 2)(x - 4)$ or $y = -3x^2 + 6x + 24$

Chapter Self-Test, p. 184

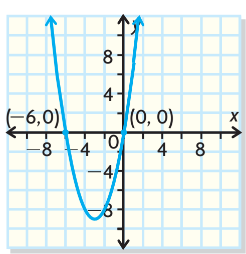
1. a) $f(x) = 6x^2 - 37x + 45$
b) $f(x) = -5x^2 - 4x + 12$

2. a) $f(x) = (x - 9)(x + 9)$
b) $f(x) = (2x - 1)(3x + 4)$

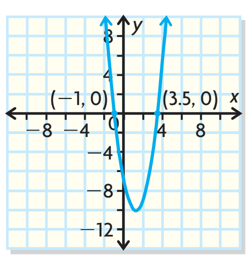
3. a) $x = 5, -7$; $x = -1$; minimum -36
b) $x = \frac{1}{2}, -\frac{7}{2}$; $x = -1.5$; maximum 16

4. No. Some may not factor at all, while for others it may not be as obvious what the factors are.

5. a) $x = 0$ and $x = -6$



b) $x = -1$ and $x = 3.5$



6. a) $x = -6$ and $x = \frac{1}{2}$
b) $x = -3$ and $x = 7$

7. a) 2015
b) 11 700 people

8. a) 6.4 s
b) 57 m

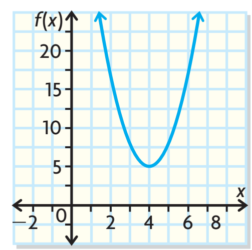
9. a) $y = -343x^2 + 965x - 243$
b) It is close to most of the data points.
c) 36491 kg/ha

10. It makes it easier to answer questions about the data.

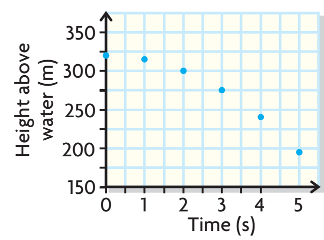
Cumulative Review Chapters 1–3, pp. 186–189

1. (a)	**5.** (c)	**9.** (d)	**13.** (c)	**17.** (a)
2. (c)	**6.** (b)	**10.** (b)	**14.** (a)	**18.** (b)
3. (a)	**7.** (d)	**11.** (d)	**15.** (c)	
4. (d)	**8.** (c)	**12.** (c)	**16.** (c)	

19. a) Domain $\{x \in \mathbf{R}\}$, Range $\{y \in \mathbf{R} \mid y \geq 4\}$
b) Transformations: vertical stretch by a factor of 3, horizontal translation 4 to the right, vertical translation 5 up
c)



20. a)

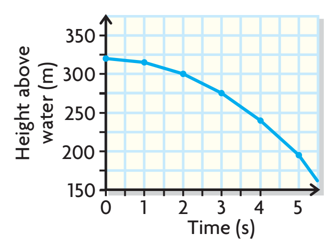


b) quadratic; the graph appears to have a shape of part of a parabola. The second differences are also constant.

c)

$t(s)$	6	7	8
$h(m)$	140	75	0

d)



e) vertex: $(0, 320)$; axis: $x = 0$; zeros: $x = 8$ and $x = -8$
$h(t) = -5(t - 8)(t + 8)$ or $h(t) = -5t^2 + 320$

f) domain $\{t \in \mathbf{R} \mid 0 \leq t \leq 8\}$;
range $\{h(t) \in \mathbf{R} \mid 0 \leq h(t) \leq 320\}$

g) i) 38.75 m ii) 7.35 s