3. $AB = BC = 5$, or about 5 units, so two sides are equal; $m_{AB} = -\frac{1}{m_{BC}} = \frac{3}{4}$, so the slopes of two sides are negative reciprocals.

4. a) Answers may vary, e.g., $PR = QS = \sqrt{21\ 125} \doteq 145.3$, or about 145.3 units
   b) 390 units

5. rhombus

6. about $(-4.6, -51.4)$

7. Answers may vary, e.g., to solve for the intercept, calculate the slope of a line through the first two points, and then substitute one of these points into the equation of a line. To determine the equation of the new line, substitute the third point into the equation of a line with a slope equal to the negative reciprocal of the first slope. To determine the point of intersection, set these two equations equal to each other. Calculate the distance between the point of intersection and the third point.

8. right isosceles

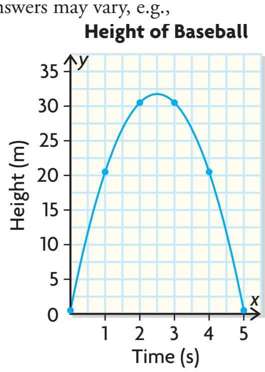
Chapter 3

Getting Started, page 130

1. a) v c) i e) vi
   b) ii d) iv f) iii

2. a) about 58 beats per minute
   b) about 38 years old

3. Answers may vary, e.g.,
   a)



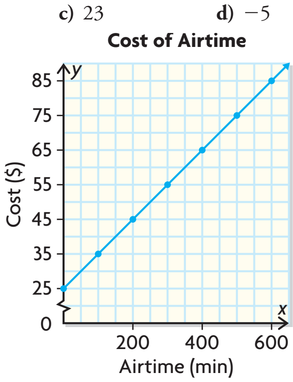
   b) about 32 m c) about 1.4 s and 3.6 s

4. a) $4x + 12$ c) $-3x^3 + 6x^2$ e) $14x^4 + 25x^3 - 44x^2 + 2x$
   b) $2x^2 - 10x$ d) $-7x^2 + 9x$ f) $-10x^4 + 40x^3 - 6x^2$

5. a) 0 b) 9 c) 23 d) -5

6.

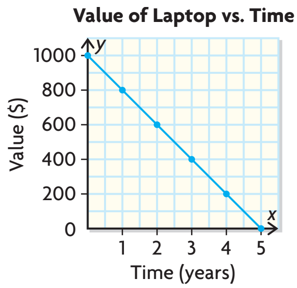
Airtime (min)	Cost ($)
0	25
100	35
200	45
300	55
400	65
500	75
600	85



$C = 25 + 0.1t$

7.

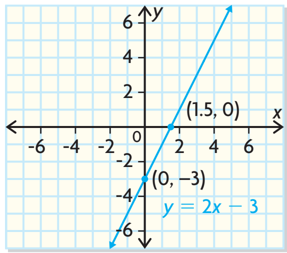
Time (years)	Value ($)
0	1000
1	800
2	600
3	400
4	200
5	0



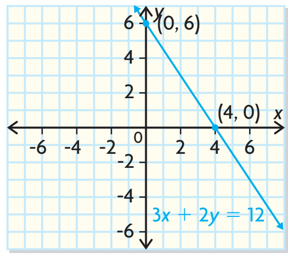
$V = 1000 - 200t$

8. x-intercept: $(-4, 0)$; y-intercept: $(0, -8)$

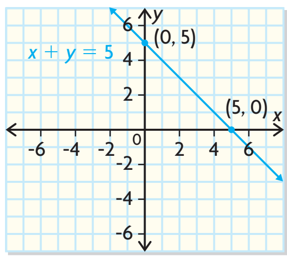
9. a) x-intercept: $(1.5, 0)$; y-intercept: $(0, -3)$



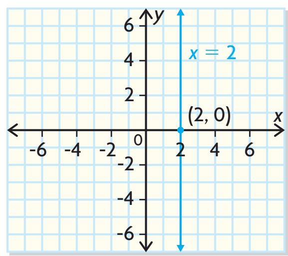
   d) x-intercept: $(4, 0)$; y-intercept: $(0, 6)$



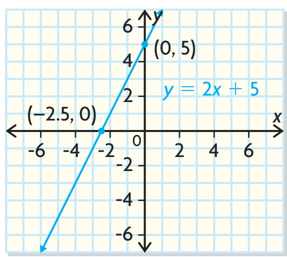
   b) x-intercept: $(5, 0)$; y-intercept: $(0, 5)$



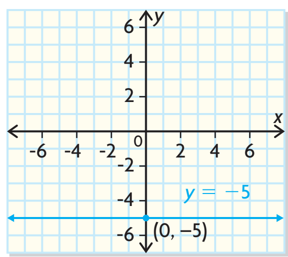
   e) x-intercept: $(2, 0)$; y-intercept: none



   c) x-intercept: $(-2.5, 0)$; y-intercept: $(0, 5)$



   f) x-intercept: none; y-intercept: $(0, -5)$



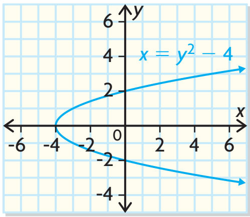
10. a) false, e.g., $y = x^2$

x	y	First Difference
1	1	
		3
2	4	
		5
3	9	
		7
4	16	

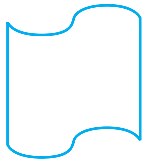
   b) false, e.g., $y = 2x$

x	y	First Difference
1	2	
		2
2	4	
		2
3	6	
		2
4	8	

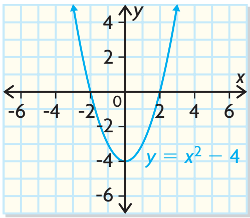
c) false, e.g., $x = y^2 - 4$



e) false, e.g.,



d) false, e.g., $y = x^2 - 4$



11. Answers may vary, e.g.,

Definition:
- Any relation that is not linear; any relation that has terms with power 2 or higher

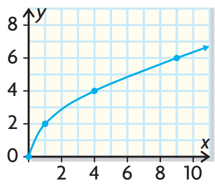
Characteristics:
- Its graph is not a straight line.
- First differences are not constant.

Nonlinear Relations

Examples:

$C = \pi r^2$

x	0	1	2	3	4
y	1	3	9	27	81



Non-examples:

$y = 3x - 4$

$x = 3$

$a = 2b + 3c - d$

Lesson 3.1, page 136

1. a) No, e.g., this is a straight line.
b) No, e.g., there are two openings.
c) Yes, e.g., the graph opens up in a U shape with a vertical line of symmetry.
d) Yes, e.g., the graph opens down in a U shape with a vertical line of symmetry.
e) No, e.g., the two arms of the graph are straight.
f) No, e.g., the line segments are straight.

2. a) i) 1 ii) 2 iii) 2 iv) 3
b) ii) and iii), since they are degree 2

3. i) not a quadratic relation
ii) (0, 4)
iii) (0, 0)
iv) not a quadratic relation

4. a) first differences: 20, 20, 20; linear
b) first differences: 3, 5, 5; nonlinear; second differences: 2, 0
c) first differences: −1, −2, −3; nonlinear; second differences: −1, −1; quadratic
d) first differences: −2, 8, −18; nonlinear; second differences: 10, −26
e) first differences: 1, 7, 19; nonlinear; second differences: 6, 12
f) first differences: 1, 2, 4, 8; nonlinear; second differences: 1, 2, 4

5. a) downward b) upward c) downward d) upward

6. a) upward, the coefficient of x^2 is positive
b) downward, the coefficient of x^2 is negative
c) downward, the coefficient of x^2 is negative
d) upward, the coefficient of x^2 is positive

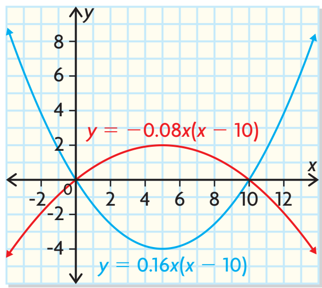
7. The condition $a \neq 0$ is needed. Without this condition, there would be no x^2 term and the relation would be linear.

Lesson 3.2, page 145

1. a) y-intercept: 0; zeros: −4, 0; vertex: (−2, 4); equation of the axis of symmetry: $x = -2$
b) y-intercept: −3; zeros: −2, 2; vertex: (0, −3); equation of the axis of symmetry: $x = 0$
c) y-intercept: 0; zeros: 0, 4; vertex: (2, 4); equation of the axis of symmetry: $x = 2$

2. a) maximum value: 4
b) minimum value: −3
c) maximum value: 4

3.



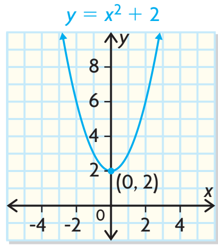
4. a) i) (3, 2)
ii) 0, 6
iii) $x = 3$
iv) negative, because the curve opens downward
b) i) (2, −3)
ii) 0, 4
iii) $x = 2$
iv) positive, because the curve opens upward

5. a) The vertex is a minimum because the curve opens upward.
b) The y-value is negative because there are two zeros and the vertex is a minimum.
c) The x-value is 3; it must be halfway between the zeros.

6. a) i) $x = -4$ ii) (−4, −8) iii) 0 iv) −8, 0 v) −8 (minimum)
b) i) $x = 2$ ii) (2, 2) iii) 0 iv) 0, 4 v) 2 (maximum)
c) i) $x = 0$ ii) (0, 8) iii) 8 iv) −6, 6 v) 8 (maximum)

7. a)

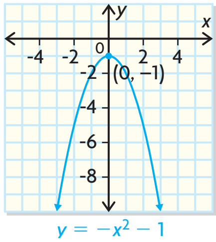
x	y
−2	6
−1	3
0	2
1	3
2	6



i) $x = 0$
ii) (0, 2)
iii) 2
iv) none
v) 2 (minimum)

b)

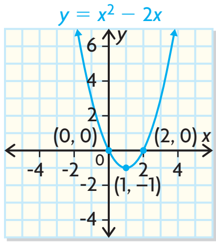
x	y
−2	−5
−1	−2
0	−1
1	−2
2	−5



i) $x = 0$
ii) $(0, -1)$
iii) -1
iv) none
v) -1 (maximum)

c)

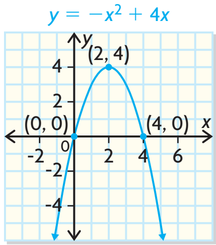
x	y
−2	8
−1	3
0	0
1	−1
2	0



i) $x = 1$
ii) $(1, -1)$
iii) 0
iv) 0, 2
v) -1 (minimum)

d)

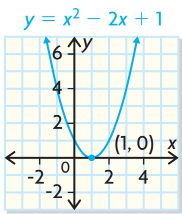
x	y
−1	−5
0	0
1	3
2	4
3	3
4	0



i) $x = 2$
ii) $(2, 4)$
iii) 0
iv) 0, 4
v) 4 (maximum)

e)

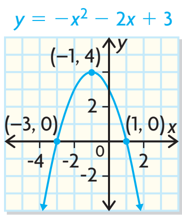
x	y
−1	4
0	1
1	0
2	1
3	4



i) $x = 1$
ii) $(1, 0)$
iii) 1
iv) 1
v) 0 (minimum)

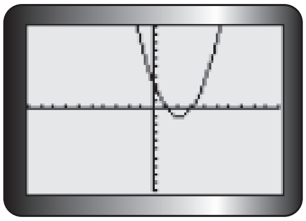
f)

x	y
−3	0
−2	3
−1	4
0	3
1	0



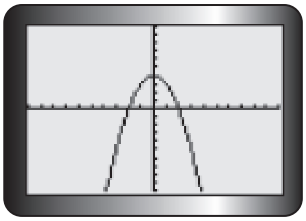
i) $x = -1$
ii) $(-1, 4)$
iii) 3
iv) $-3, 1$
v) 4 (maximum)

8. a)



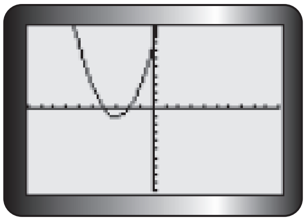
i) $x = 2$
ii) $(2, -1)$
iii) 3
iv) 1, 3
v) -1 (minimum)

b)



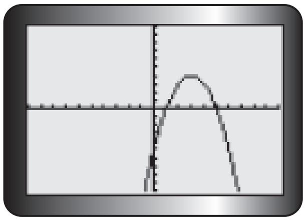
i) $x = 0$
ii) $(0, 4)$
iii) 4
iv) $-2, 2$
v) 4 (maximum)

c)



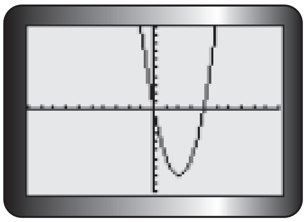
i) $x = -3$
ii) $(-3, -1)$
iii) 8
iv) $-4, -2$
v) -1 (minimum)

d)



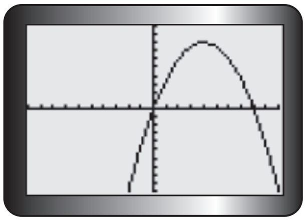
i) $x = 3$
ii) $(3, 4)$
iii) -5
iv) 1, 5
v) 4 (maximum)

e)



i) $x = 2$
ii) $(2, -8)$
iii) 0
iv) 0, 4
v) -8 (minimum)

f)



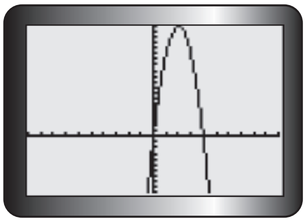
i) $x = 4$
ii) (4, 8)
iii) 0
iv) 0, 8
v) 8 (maximum)

9. **a)** $x = 6$ **b)** $x = -5.5$ **c)** $x = -0.75$ **d)** $x = -3$

10. (2, 5)

11. **a)** Disagree, e.g., not all parabolas intersect the x-axis.
b) Agree, e.g., all parabolas intersect the y-axis once.
c) Disagree, e.g., all parabolas that open downward have negative (constant) second differences.

12. **a)** 0, 4; 4 s
b) (2, 20)
c)

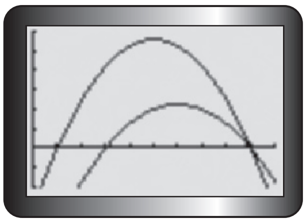


d) 20 m; 2 s

13. **a)** $60 000
b) 1000
c) Yes. There are two break-even points: 0 players and 2000 players.

14. **a)** 500 m **b)** 10 s **c)** 320 m **d)** about 8.9 s

15. Profits increased (or losses decreased) if less than 900 000 game players were sold, since the y-value of the line representing this year's profit is higher for $x < 9$. If more than 900 000 game players were sold, then losses increased.



16. **a)** If a is negative, the quadratic relation has a maximum; if a is positive, it has a minimum.
b) The y-value of the vertex is the maximum or minimum value of the parabola.

17. **a)** **i)**

y	x	First Difference	Second Difference
1	2		
		6	
2	8		4
		10	
3	18		4
		14	
4	32		4
		18	
5	50		

ii)

x	y	First Difference	Second Difference
1	2		
		2	
2	4		2
		4	
3	8		4
		8	
4	16		

iii)

x	y	First Difference	Second Difference
1	1		
		7	
2	8		12
		19	
3	27		18
		37	
4	64		

iv)

x	y	First Difference	Second Difference
1	2		
		30	
2	32		100
		130	
3	162		220
		350	
4	512		

b) Yes. The relation in part i) represents a parabola because it has constant second differences.
c) Yes. The relation in part i) is quadratic because it has constant second differences.

18. Answers may vary, e.g., I looked at several examples and compared the x-coordinate of the vertex with the coefficient of x:

$y = 5x^2 - 4.2x + 8$; 0.42: $-\frac{1}{10}$ of the coefficient of x

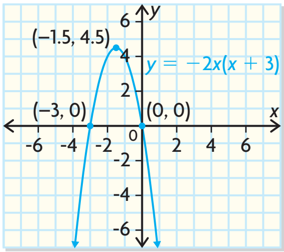
$y = 2x^2 - 3.2x + 8$; 0.64: not $-\frac{1}{10}$ of the coefficient of x

$y = 5x^2 - 3.2x + 6$; 0.32: $-\frac{1}{10}$ of the coefficient of x

I made the hypothesis that the x-coordinate of the vertex will equal $-\frac{1}{10}$ of the coefficient of x whenever the coefficient of x^2 equals 5. To prove my hypothesis, I investigated the equation $y = 5x^2 + bx$, where $c = 0$. Since the zeros of this equation are 0 and $-\frac{b}{5}$, the x-coordinate of the vertex is $-\frac{b}{10}$. Different values of c will change the y-intercept, but not the line of symmetry or the x-coordinate of the vertex.

Lesson 3.3, page 155

1. **a)** **i)** 0, -3
ii) The zeros are the values of x where a factor equals 0.
iii) 0
iv) $x = -1.5$
v) $(-1.5, 4.5)$
vi) Yes. The highest power of x in the expanded form is 2.

vii) 

b) i) −1, 3

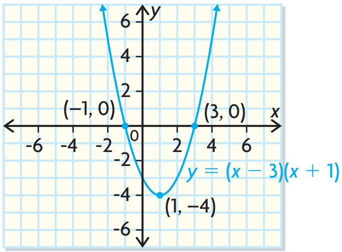
ii) The zeros are the values of *x* where a factor equals 0.

iii) –3

iv) $x = 1$

v) (1, −4)

vi) Yes. The highest power of *x* in the expanded form is 2.

vii) 

c) i) −2, 1

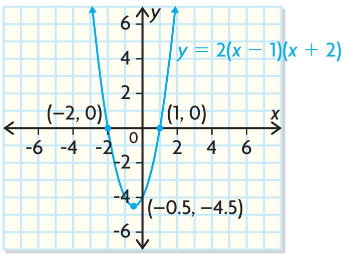
ii) The zeros are the values of *x* where a factor equals 0.

iii) −4

iv) $x = -0.5$

v) (−0.5, −4.5)

vi) Yes. The highest power of *x* in the expanded form is 2.

vii) 

2. **a)** ii **b)** iv **c)** i **d)** vi **e)** v **f)** iii

3. $\frac{5}{9}$

4. **a)** *y*-intercept: −9; zeros: −3, 3; equation of the axis of symmetry: $x = 0$; vertex: (0, −9)

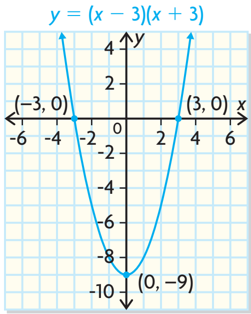
b) *y*-intercept: 4; zero: −2; equation of the axis of symmetry: $x = -2$; vertex: (−2, 0)

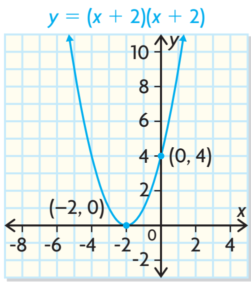
c) *y*-intercept: 4; zero: 2; equation of the axis of symmetry: $x = 2$; vertex: (2, 0)

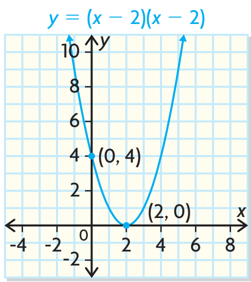
d) *y*-intercept: 4; zeros: −2, 2; equation of the axis of symmetry: $x = 0$; vertex: (0, 4)

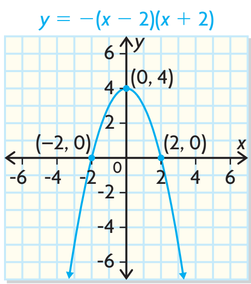
e) *y*-intercept: 18; zero: −3; equation of the axis of symmetry: $x = -3$; vertex: (−3, 0)

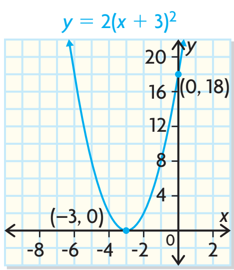
f) *y*-intercept: −64; zero: 4; equation of the axis of symmetry: $x = 4$; vertex: (4, 0)

5. **a)** 

b) 

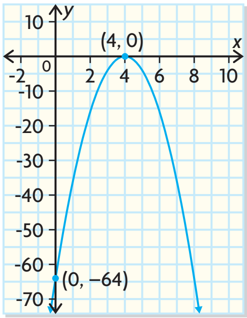
c) 

d) 

e) 

Answers

f) $y = -4(x - 4)^2$



6. **a)** $\frac{1}{8}$ **b)** $\frac{1}{8}$ **c)** 1.6 **d)** $-\frac{3}{8}$ **e)** -0.4

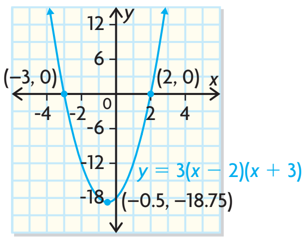
7. **a)** zeros: $-40, 40$; equation of the axis of symmetry: $x = 0$; vertex: $(0, 40)$; equation: $y = -\frac{1}{40}(x - 40)(x + 40)$

b) zeros: 10, 30; equation of the axis of symmetry: $x = 20$; vertex: $(20, -10)$; equation: $y = \frac{1}{10}(x - 10)(x - 30)$

c) zeros: $-4, 1$; equation of the axis of symmetry: $x = -1.5$; vertex: $(-1.5, -2)$; equation: $y = 0.32(x + 4)(x - 1)$

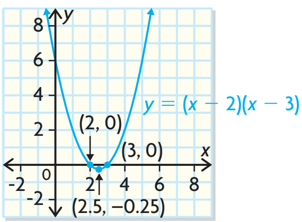
d) zeros: $-1, -5$; equation of the axis of symmetry: $x = -3$; vertex: $(-3, 3.5)$; equation: $y = -0.875(x + 1)(x + 5)$

8. **a)**



b) $a = 2$: vertex shifts up, curve is wider;
$a = 1$: vertex shifts up farther, curve is even wider;
$a = 0$: straight line along x-axis;
$a = -1$: reflection of curve when $a = 1$ about x-axis;
$a = -2$: reflection of curve when $a = 2$ about x-axis;
$a = -3$: reflection of curve when $a = 3$ about x-axis

9. **a)**

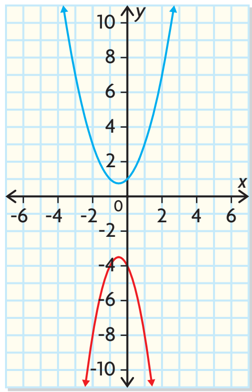


b) The second zero would move from 3 to match each value of s. The farther the second zero was from 2, the lower the vertex would shift.

10. **a)** $y = 5(x + 3)(x - 5)$ **b)** $(1, -80)$

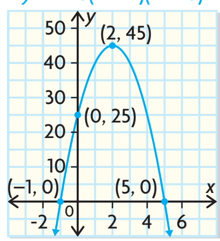
11. The equation $y = a(x - r)(x - s)$ cannot be used if there are no zeros. This occurs when a quadratic of the form $y = ax^2 + bx + c$ cannot be factored. Two examples are $y = x^2 + x + 1$ (blue) and $y = -2x^2 - 2x - 4$ (red).

$y = x^2 + x + 1$



$y = -2x^2 - 2x - 4$

12. **a), b)** $y = -5(x + 1)(x - 5)$



c) -1 s **d)** $-1, 5$ **e)** $(2, 45)$ **f)** $y = -5(x + 1)(x - 5)$

g) $(5, 0)$ represents the point where the ball hits the ground; $(-1, 0)$ represents negative time and has no physical meaning.

13. **a)** $y = -\frac{1}{2500}(x + 250)(x - 50)$

b) The price should be decreased by $100.

14. $13

15. **a)** $y = (5 + 0.1x)(700 - 10x)$ **b)** $3600 **c)** 600

16. Answers will vary, e.g.,

Determine the two zeros: r and s.
↓
Determine the y-intercept: c.
↓
Calculate $a = c \times r \times s$.
↓
Write the equation as: $y = a(x - r)(x - s)$.

17. Expansion gives
a) iv **b)** i **c)** ii **d)** v

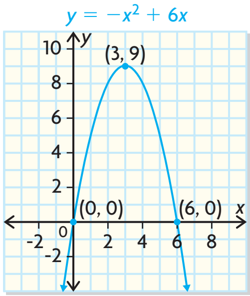
18. 12 m by 24 m

Mid-Chapter Review, page 160

1. **a)** Yes. The graph has a U shape.
b) Yes. The degree of the equation is 2.
c) No. The second differences are not a non-zero constant.

2. **a)** upward **b)** downward

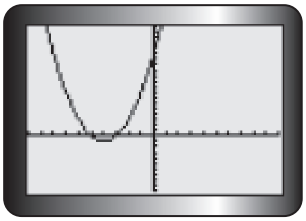
3.



a) $x = 3$ **b)** (3, 9) **c)** 0 **d)** 0, 6

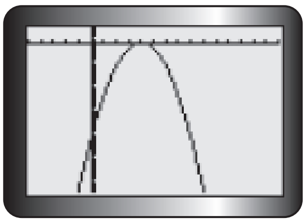
4. $x = 3$

5. **a)**



y-intercept: 15;
zeros: -3, -5;
equation of the axis of symmetry: $x = -4$;
vertex: $(-4, -1)$

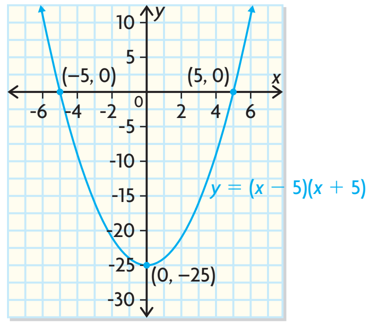
b)



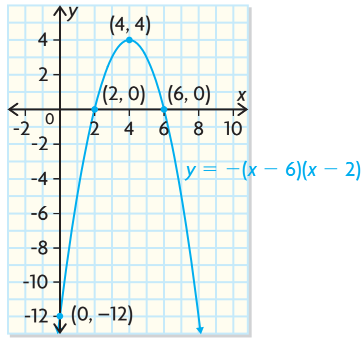
y-intercept: -32;
zero: 4;
equation of the axis of symmetry: $x = 4$;
vertex: (4, 0)

6. **a)** 0.5 m
b) about 3 s
c) 1.5 s
d) 11.75 m
e) 0.5 m; the ball is travelling downward because this is after it has reached its maximum height.
f) about 0.9 s and 2.1 s

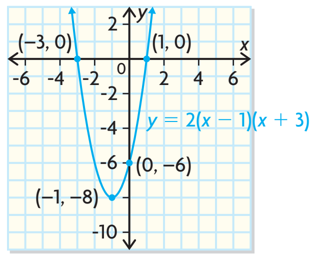
7. **a)** y-intercept: -25; zeros: -5, 5;
equation of the axis of symmetry: $x = 0$; vertex: $(0, -25)$



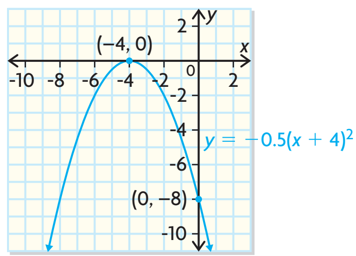
b) y-intercept: -12; zeros: 2, 6;
equation of the axis of symmetry: $x = 4$; vertex: (4, 4)



c) y-intercept: -6; zeros: -3, 1;
equation of the axis of symmetry: $x = -1$; vertex: $(-1, -8)$



d) y-intercept: -8; zero: -4;
equation of the axis of symmetry: $x = -4$; vertex: $(-4, 0)$



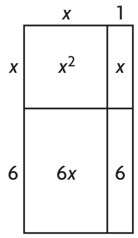
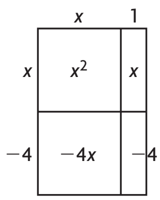
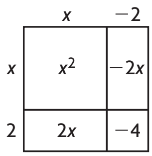
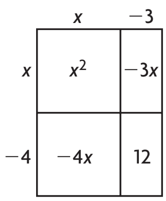
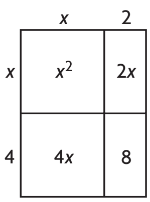
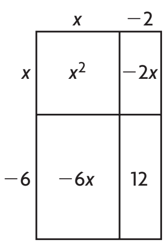
8. **a)** $y = -\frac{1}{6}(x - 30)(x + 10)$ **b)** $\left(10, \frac{200}{3}\right)$

9. $y = -2(x + 2)(x + 6)$

10. Answers may vary, e.g., $y = (x + 5)(x + 5)$

Lesson 3.4, page 165

1. a) $x + 1, x + 5; x^2 + 6x + 5$
   b) $x - 2, x - 2; x^2 - 4x + 4$

	Expression	Area Diagram	Expanded and Simplified Form
2. a)	$(x + 1)(x + 6)$		$x^2 + 7x + 6$
b)	$(x + 1)(x - 4)$		$x^2 - 3x - 4$
c)	$(x - 2)(x + 2)$		$x^2 - 4$
d)	$(x - 3)(x - 4)$		$x^2 - 7x + 12$
e)	$(x + 2)(x + 4)$		$x^2 + 6x + 8$
f)	$(x - 2)(x - 6)$		$x^2 - 8x + 12$

3. a) $m^2, 6$
   b) k^2, k
   c) $4r, 12$
   d) $5x, 2x$
   e) $6n^2, 4n$
   f) $15m, 6$

4. a) $x^2 + 7x + 10$
   b) $x^2 + 3x + 2$
   c) $x^2 - x - 6$
   d) $x^2 + x - 2$
   e) $x^2 - 6x + 8$
   f) $x^2 - 8x + 15$

5. a) $5x^2 + 12x + 4$
   b) $4x^2 + 9x + 2$
   c) $7x^2 - 11x - 6$
   d) $3x^2 + x - 2$
   e) $4x^2 - 14x + 12$
   f) $7x^2 - 26x + 15$

6. a) $x^2 - 9$
   b) $x^2 - 36$
   c) $4x^2 - 1$
   d) $9x^2 - 9$
   e) $16x^2 - 36$
   f) $49x^2 - 25$

7. a) $x^2 + 2x + 1$
   b) $a^2 + 8a + 16$
   c) $c^2 - 2c + 1$
   d) $25y^2 - 20y + 4$
   e) $36z^2 - 60z + 25$
   f) $9d^2 - 30d + 25$

8. a) $8m^2 + 4m - 12$
   b) $9m^2 + 12m + 4$
   c) $10x^2 - 14x - 12$
   d) $4x^2 + 6x + 2$

9. a) $4x^2 + 4x - 168$
   b) $-4x^2 - 11x + 3$
   c) $6x^3 + 12x^2 + 6x$
   d) $2x^2 + 6x - 13$
   e) $15x^2 - 6x - 10$
   f) $15x^2 + 60x + 20$

10. a) $2x^2 + 5xy + 3y^2$
    b) $3x^2 + 7xy + 2y^2$
    c) $15x^2 + 2xy - 8y^2$
    d) $56x^2 + 9xy - 2y^2$
    e) $36x^2 - 25y^2$
    f) $81x^2 - 126xy + 49y^2$

11. a) $y = x^2 - 2x - 8$
    b) $y = -x^2 - 6x - 8$
    c) $y = 2x^2 - 8x$
    d) $y = -0.5x^2 + 4x - 6$

12. a) $-\frac{5}{16}x^2 + \frac{15}{8}x + \frac{35}{16}$; downward
    b) $x^2 + 6x + 5$; upward
    c) $\frac{1}{7}x^2 - \frac{10}{7}x + 3$; upward
    d) $\frac{1}{7}x^2 - \frac{4}{7}x - \frac{12}{7}$; upward
    e) $-\frac{7}{25}x^2 + \frac{42}{25}x + \frac{112}{25}$; downward

13. Agree, e.g., there is a common factor of 2, which can be applied to either of the other factors.

14. The highest degree of each of the two factors is 1. Therefore, their product will have degree 2.

15. Answers may vary, e.g., $y = -\frac{88}{1764}x^2 + \frac{176}{42}x$

16. No, e.g., sometimes the like terms have a sum of zero and the result is binomial; two examples are $(x + 2)(x - 2) = x^2 - 4$ and $(3x + y)(3x - y) = 9x^2 - y^2$.

17. a) $x^3 + 9x^2 + 27x + 27$
    b) $8x^3 - 24x^2 + 24x - 8$
    c) $64x^3 + 96x^2y + 48xy^2 + 8y^3$
    d) $x^4 - 8x^2 + 16$
    e) $x^4 - 45x^2 + 324$
    f) $9x^4 + 36x^3 + 30x^2 - 12x + 1$

18. a) $a + b$
    b) $a^2 + 2ab + b^2$
    c) $a^3 + 3a^2b + 3ab^2 + b^3$
    d) $a^4 + 4a^3b + 6a^2b^2 + 4ab^3 + b^4$

19. Answers may vary, e.g., I noticed that the coefficients have a symmetrical pattern. I also noticed that the coefficients can be predicted using the following pyramid, where each number is the sum of the two numbers above it:

1
1 1
1 2 1
1 3 3 1
1 4 6 4 1
1 5 10 10 5 1

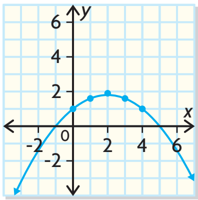
Lesson 3.5, page 175

1. **a)** Answers may vary, e.g.,

$$y = -\frac{1}{4}(x - 2)(x - 4) = -0.25x^2 + 1.5x - 2$$

b) Answers may vary, e.g., -0.75

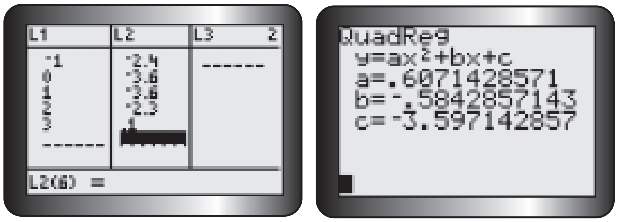
2. **a)** Answers may vary, e.g.,



$y = -0.2(x + 1)(x - 5) = -0.2x^2 + 0.8x + 1$

b) Answers may vary, e.g., about 1.75 m

3. **a)**



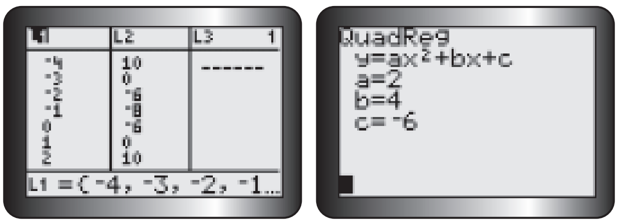
Answers may vary, e.g., $y = 0.6x^2 - 0.6x - 3.6$

b) Answers may vary, e.g., about 0.6

4. **a)** Answers may vary, e.g., $y = 2(x + 3)(x - 1)$

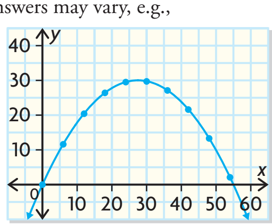
b) Answers may vary, e.g., $y = 2x^2 + 4x - 6$

c)



5. Answers may vary, e.g.,

a)



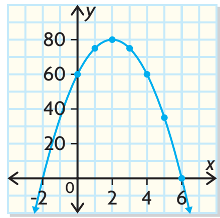
b) $y = -\frac{5}{126}x(x - 55)$

c) horizontal distance: about 27.5 m; maximum height: about 30 m

d) about 24 m

6. **a)** 60 m

b) Answers may vary, e.g.,



c) Answers may vary, e.g., $y = -5(x - 6)(x + 2)$

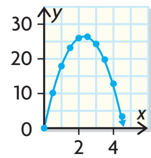
d) Answers may vary, e.g., about 79 m

7. **a)** 10 m

b) Answers may vary, e.g., $y = 1.2x^2 - 12x + 10$

c) Answers may vary, e.g., -20 m at 5 s

8. **a)** Answers may vary, e.g.,



b) 0, 4.6

c) $y = -5x(x - 4.6)$

d) maximum height: about 26.5 m

9. Answers may vary, e.g.,

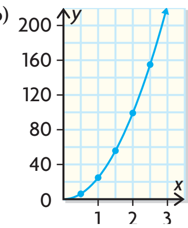
a) $y = -5x^2 + 22.5x + 2$

b) about 15.3 m

c) about 27.3 m at about 2.3 s

10. **a)** Yes. The second differences are the same: 12.4 cm.

b)



c) Answers may vary, e.g., $y = 24.8x^2$

d) Answers may vary, e.g., about 1.8 s

e) Answers may vary, e.g., about 131.2 cm

11. 1600; the number of dots in the diagram, n, is equal to $(2n)^2$.

12. **a), b)**

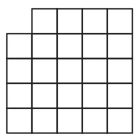


Figure 4

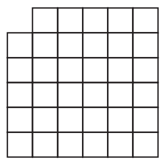


Figure 5

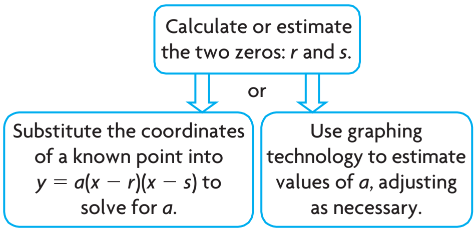
x	y	First Difference	Second Difference
1	3		
		5	
2	8		2
		7	
3	15		2
		9	
4	24		2
		11	
5	35		

Answers

c) $y = (x + 1)^2 - 1$
d) $(-2, 0), (0, 0)$
e) $y = (-2 + 1)^2 - 1 = 0$; $y = (0 + 1)^2 - 1 = 0$
f) The value of x must be 1 or greater.

13. No. If the curve does not cross the x-axis, then the factored form cannot be used.

14. Answers may vary, e.g.,



15. a) 449
b) Model 25

Lesson 3.6, page 181

1. a) 3^0
b) $\frac{3 \times 3 \times 3 \times 3}{3 \times 3 \times 3 \times 3} = \frac{1}{1} = 1$
c) Any non-zero base with exponent 0 is equal to 1.
d) $\frac{5^3}{5^3} = 5^0 = \frac{5 \times 5 \times 5}{5 \times 5 \times 5} = \frac{1}{1} = 1$

2. a) 3^{-1}
b) $\frac{3 \times 3 \times 3}{3 \times 3 \times 3 \times 3} = \frac{1}{3}$
c) Any non-zero base with the exponent -1 is equal to the reciprocal of the base.
d) $\frac{5^2}{5^4} = 5^{-2} = \frac{5 \times 5}{5 \times 5 \times 5 \times 5} = \frac{1}{5^2}$
e) $\frac{5^2}{5^5} = 5^{-3} = \frac{5 \times 5}{5 \times 5 \times 5 \times 5 \times 5} = \frac{1}{5^3}$

3. a) $\frac{1}{16}$ b) $\frac{1}{4}$ c) 1 d) $\frac{1}{25}$ e) $\frac{1}{81}$ f) $\frac{1}{49}$

4. a) $-\frac{1}{32}$ b) $-\frac{1}{16}$ c) -1 d) $-\frac{1}{5}$ e) $\frac{1}{9}$ f) $-\frac{1}{64}$

5. a) $\frac{1}{4}$ b) 4 c) $\frac{8}{27}$ d) $\frac{27}{8}$ e) $-\frac{16}{9}$ f) $\frac{16}{9}$

6. a) -3 b) 3 c) 0 d) 3 e) -2 f) 2 or -2

7. 5^{-2} is greater. It will have a denominator that is less when it is written in rational form.

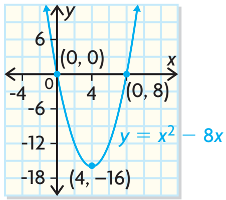
8. $(-1)^{-101}$ is less. Since it has an odd exponent, it will equal -1. In comparison, $(-1)^{-100}$ has an even exponent and will equal 1.

Chapter 3 Review, page 185

1. a) No. It is a first degree, or linear, relation.
b) Yes. The second differences are constant and non-zero.
c) Yes. It is a second degree relation.
d) Yes. It is a symmetrical U shape.

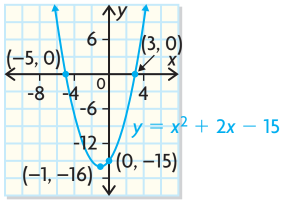
2. Increasing a makes the parabola narrower; increasing b shifts the parabola down and to the left; increasing c shifts the parabola up.

3. a)



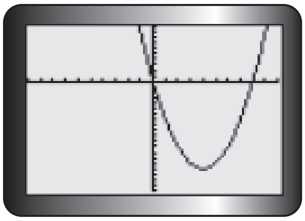
i) $x = 4$ ii) $(4, -16)$ iii) 0 iv) 0, 8

b)

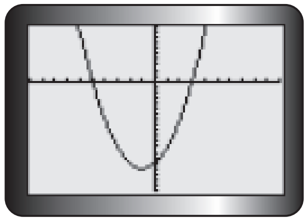


i) $x = -1$ ii) $(-1, -16)$ iii) -15 iv) $-5, 3$

4. a)



b)



5. a) maximum, because the second differences are negative
b) positive, because it is between the zeros and the curve opens downward
c) 1.5

6. Answers may vary, e.g.,

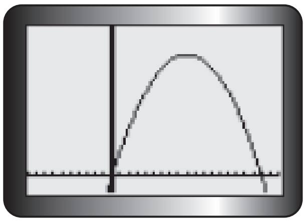
x	y	First Difference	Second Difference
1	2		
		5	
2	7		2
		7	
3	14		2
		9	
4	23		2
		11	
5	34		

x	y	First Difference	Second Difference
1	1		
		6	
2	7		4
		10	
3	17		4
		14	
4	31		4
		18	
5	49		

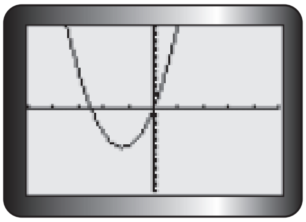
x	y	First Difference	Second Difference
1	2		
		5	
2	7		−1
		4	
3	11		−1
		3	
4	14		−1
		2	
5	16		

Each table of values represents a parabola because the second differences are constant and not zero.

7. **a) i)** 0, 18 **ii)** $x = 9$ **iii)** (9, 81)



b) i) 0, −2.5 **ii)** $x = -1.25$ **iii)** $(-1.25, -9.375)$



8. Answers may vary, e.g., the greater the value of a, the narrower the parabola is. Also, a positive a means that the parabola opens upward, and a negative a means that the parabola opens downward.

9. **a)** either 2000 or 5000
b) 3500

10. **a)** $y = 2(x + 2)(x - 7)$
b) $(2.5, -40.5)$

11. **a)** $y = 0.5(x - 5)(x - 9)$
b) $y = -0.16(x + 3)(x - 7)$
c) $y = 0.75(x + 6)(x - 2)$
d) $y = 0.5(x - 4)^2$
e) $y = -4(x - 3)(x + 3)$

12. \$2.00

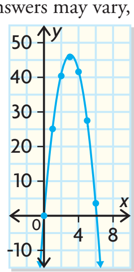
13. **a)** $2x^2 + 3x - 9 = (x + 3)(2x - 3)$
b) $15x^2 - 38x + 24 = (5x - 6)(3x - 4)$

14. **a)** $x^2 + 9x + 20$
b) $x^2 - 7x + 10$
c) $4x^2 - 9$
d) $12x^2 + 7x - 10$
e) $20x^2 + 2xy - 6y^2$
f) $30x^2 + 32x - 14$

15. **a)** $4x^2 + 24x + 36$
b) $12x^2 - 14x - 40$
c) $32x^3 - 2xy^2$

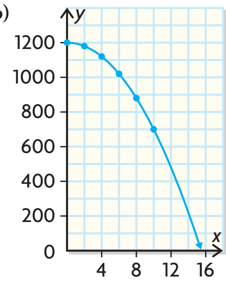
16. $y = -0.25x^2 + x + 8$

17. Answers may vary, e.g.,
a)



b) Yes. It is a symmetrical curve with a U shape.
c) $y = -5x^2 + 30.5x$
d) about 36 m
e) about 0.7 s and about 5.4 s

18. Answers may vary, e.g.,
a), b)



c) Yes. The equation to describe the curve is degree 2.
d) $y = -5x^2 + 1200$
e) about 15.5 s

19. **a)** $\frac{1}{8}$ **b)** $-\frac{1}{5}$ **c)** $\frac{25}{4}$ **d)** 1 **e)** $\frac{1}{64}$ **f)** −36

20. 3^{-2} is greater, for example, because it equals $\left(\frac{1}{3}\right)^2$, which has a denominator that is less than the denominator of $\left(\frac{1}{4}\right)^2$.

21. Answers may vary, e.g., using graphing technology, I can see that x^2 is greater than 2^x when x is between 2 and 4.

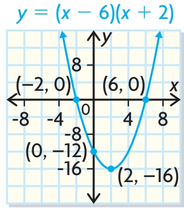
Chapter Self-Test, page 187

1. zeros: −6, 2; vertex: (−2, −4); equation of the axis of symmetry: $x = -2$

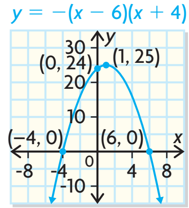
2. **a)** $x = 5$
b) $y = \frac{1}{7}(x + 9)(x - 19)$
c) $y = \frac{1}{7}x^2 - \frac{10}{7}x - \frac{171}{7}$

3. **a)** Yes. The second differences are constant.
b) Yes. The second differences are constant.

4. **a)** $y = (x - 6)(x + 2)$



b) $y = -(x - 6)(x + 4)$



5. **a)** 51 600
b) Answers may vary, e.g., between 1974 and 1983

6. **a)** $10x^2 - 11x - 6$
b) $15x^2 - 14xy - 8y^2$
c) $-5x^2 + 40x - 80$

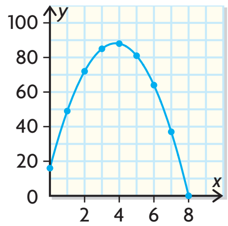
7. Answers may vary, e.g.,

a) 16 m

b) 8 s

c) Yes. The second differences are constant and non-zero.

d)



e) $y = -5x^2 + 38x + 16$

f) about 88 m

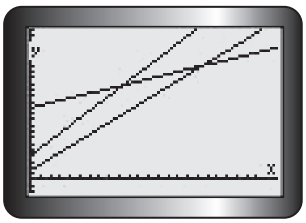
8. Answers may vary, e.g., in both cases, we try to find an equation that describes the relationship. Using a quadratic relation is generally more difficult because parabolas can be harder to match to data as they all have different shapes (narrower or wider openings). This gives more flexibility, however, and can be used to model a wider variety of relationships.

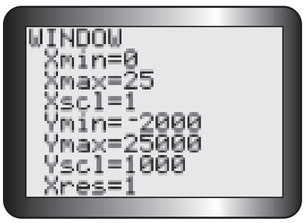
9. **a)** $\frac{1}{49}$ **b)** -1 **c)** $-\frac{81}{16}$ **d)** $-\frac{1}{125}$

Cumulative Review Chapters 1–3, page 189

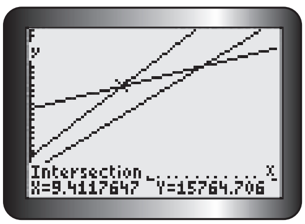
1. C	**6.** B	**11.** B	**16.** A	**21.** D
2. B	**7.** A	**12.** D	**17.** B	**22.** A
3. A	**8.** C	**13.** A	**18.** B	**23.** B
4. D	**9.** D	**14.** D	**19.** C	**24.** D
5. C	**10.** B	**15.** B	**20.** C	

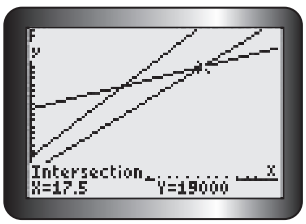
25. **a)** gas: $C = 4000 + 1250t$; electric: $C = 1500 + 1000t$; geothermal: $C = 12\,000 + 400t$





b)

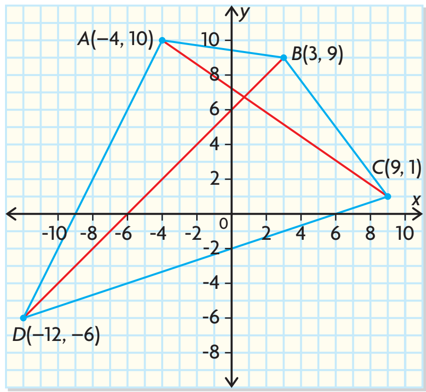




Electric baseboard heaters are the least expensive for the first 17.5 years. A gas furnace is more expensive than electric baseboard heaters, but it is less expensive than a geothermal heat pump for the first 9.4 years. After 17.5 years, the geothermal heat pump is the least expensive.

c) Answers may vary, e.g., The choice depends on how long Jenny and Oliver plan to live in the house. Another factor that they should consider is the uncertainty about gas and electricity prices over time. Geothermal costs will remain relatively stable.

26. **a)**



Answers may vary, e.g., If all four perpendicular bisectors intersect at the same location, you can draw a circle that passes through all four vertices. The centre of this circle is the point of intersection of the perpendicular bisectors. Determine the equations of the perpendicular bisectors, and then solve the linear system that is formed by two of these equations. Check to see if the solution satisfies the other equations.

b) perpendicular bisector of *AD*: $y = -0.5x - 2$; perpendicular bisector of *DC*: $y = -3x - 7$; perpendicular bisector of *CB*: $y = 0.75x + 0.5$; perpendicular bisector of *BA*: $y = 7x + 13$
All four lines intersect at $(-2, -1)$, so it is possible to draw a circle that passes through all four vertices. Therefore, quadrilateral *ABCD* is cyclic.