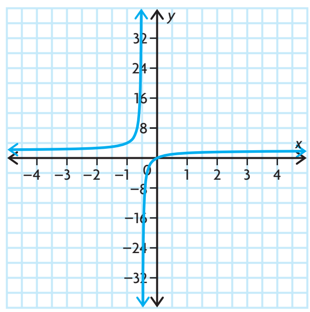
d) $x = -0.5$; vertical asymptote: $x = -0.5$; $D = \{x \in \mathbf{R} \mid x \neq -0.5\}$; x-intercept $= 0$; y-intercept $= 0$; horizontal asymptote $= 2$; $R = \{y \in \mathbf{R} \mid x \neq 2\}$; positive on $x < -0.5$ and $x > 0$; negative on $-0.5 < x < 0$



The function is never decreasing and is increasing on $(-\infty, -0.5)$ and $(-0.5, \infty)$.

6. Answers may vary. For example, consider the function $f(x) = \frac{1}{x - 6}$. You know that the vertical asymptote would be $x = 6$. If you were to find the value of the function very close to $x = 6$ (say $f(5.99)$ or $f(6.01)$) you would be able to determine the behaviour of the function on either side of the asymptote.

$$f(5.99) = \frac{1}{(5.99) - 6} = -100$$

$$f(6.01) = \frac{1}{(6.01) - 6} = 100$$

To the left of the vertical asymptote, the function moves toward $-\infty$. To the right of the vertical asymptote, the function moves toward ∞.

7. **a)** $x = 6$
b) $x = 0.2$ and $x = -\frac{2}{3}$
c) $x = -6$ or $x = 2$
d) $x = -1$ and $x = 3$

8. about 12 min

9. $x = 1.82$ days and 3.297 days

10. **a)** $x < -3$ and $-2.873 < x < 4.873$
b) $-16 < x < -11$ and $-5 < x$
c) $-2 < x < -1.33$ and $-1 < x < 0$
d) $0 < x < 1.5$

11. $-0.7261 < t < 0$ and $t > 64.73$

12. **a)** -6; $x = 3$
b) 0.2; $x = -2$ and $x = -1$

13. **a)** 0.455 mg/L/h
b) -0.04 mg/L/h
c) The concentration of the drug in the blood stream appears to be increasing most rapidly during the first hour and a half; the graph is steep and increasing during this time.

14. $x = 5$ and $x = 8$; $x = 6.5$

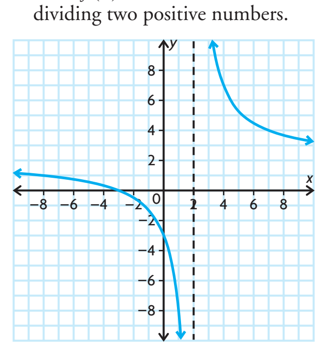
15. **a)** As the x-coordinate approaches the vertical asymptote of a rational function, the line tangent to graph will get closer and closer to being a vertical line. This means that the slope of the line tangent to the graph will get larger and larger, approaching positive or negative infinity depending on the function, as x gets closer to the vertical asymptote.
b) As the x-coordinate grows larger and larger in either direction, the line tangent to the graph will get closer and closer to being a horizontal line. This means that the slope of the line tangent to the graph will always approach zero as x gets larger and larger.

Chapter Self-Test, p. 310

1. **a)** B
b) A

2. **a)** If $f(n)$ is very large, then that would make $\frac{1}{f(n)}$ a very small fraction.
b) If $f(n)$ is very small (less than 1), then that would make $\frac{1}{f(n)}$ very large.
c) If $f(n) = 0$, then that would make $\frac{1}{f(n)}$ undefined at that point because you cannot divide by 0.
d) If $f(n)$ is positive, then that would make $\frac{1}{f(n)}$ also positive because you are dividing two positive numbers.

3.



4. 4326 kg; \$0.52/kg

5. **a)** Algebraic; $x = -1$ and $x = -3$
b) Algebraic with factor table
The inequality is true on $(-10, -5.5)$ and on $(-5, 1.2)$.

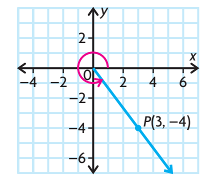
6. **a)** To find the vertical asymptotes of the function, find the zeros of the expression in the denominator. To find the equation of the horizontal asymptotes, divide the first two terms of the expressions in the numerator and denominator.
b) This type of function will have a hole when both the numerator and the denominator share the same factor $(x + a)$.

Chapter 6

Getting Started, p. 314

1. **a)** 28°
b) 332°

2. **a)**



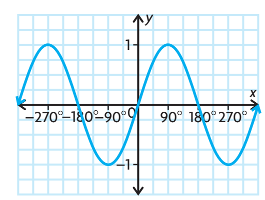
$\sin \theta = -\frac{4}{5}$, $\cos \theta = \frac{3}{5}$, $\tan \theta = -\frac{4}{3}$,
$\csc \theta = -\frac{5}{4}$, $\sec \theta = \frac{5}{3}$, $\cot \theta = -\frac{3}{4}$

b) 307°

3. **a)** $\frac{\sqrt{3}}{2}$ **c)** $\frac{\sqrt{3}}{2}$ **e)** $-\sqrt{2}$
b) 0 **d)** $\frac{1}{2}$ **f)** -1

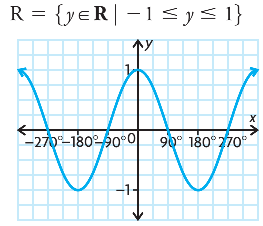
4. **a)** 60°, 300°
b) 30°, 210°
c) 45°, 225°
d) 180°
e) 135°, 315°
f) 90°

5. **a)**



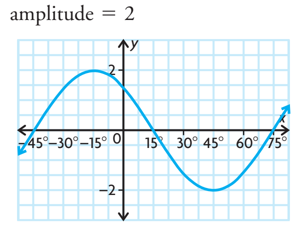
period $= 360°$; amplitude $= 1$; $y = 0$; $R = \{y \in \mathbf{R} \mid -1 \leq y \leq 1\}$

b)



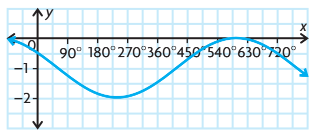
period $= 360°$; amplitude $= 1$; $y = 0$; $R = \{y \in \mathbf{R} \mid -1 \leq y \leq 1\}$

6. **a)** period $= 120°$; $y = 0$; 45° to the left; amplitude $= 2$



Answers

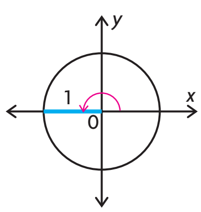
b) period $= 720°$; $y = -1$; $60°$ to the right; amplitude $= 1$



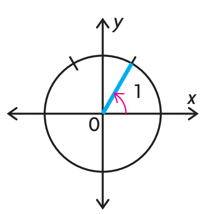
7. a is the amplitude, which determines how far above and below the axis of the curve of the function rises and falls; k defines the period of the function, which is how often the function repeats itself; d is the horizontal shift, which shifts the function to the right or the left; and c is the vertical shift of the function.

Lesson 6.1, pp. 320–322

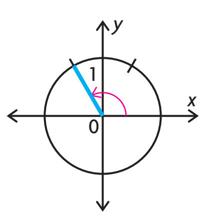
1. a) π radians; 180°
   b) $\frac{\pi}{2}$ radians; 90°
   c) $-\pi$ radians; $-180°$
   d) $-\frac{3\pi}{2}$ radians; $-270°$
   e) -2π radians; $-360°$
   f) $\frac{3\pi}{2}$ radians; 270°
   g) $-\frac{4\pi}{3}$ radians $= -240°$
   h) $\frac{2\pi}{3}$ radians; 120°
2. a)



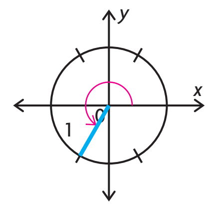
b)



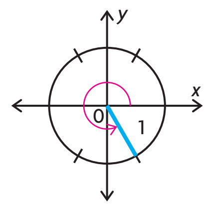
c)



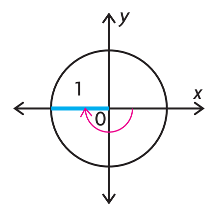
d)



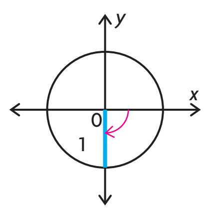
e)



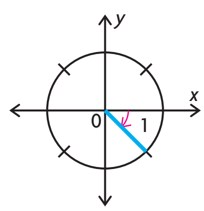
f)



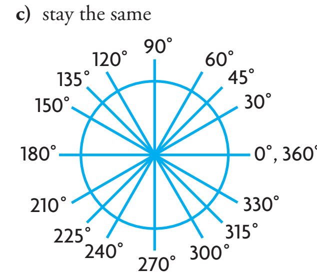
g)



h)



3. a) $\frac{5\pi}{12}$ radians c) $\frac{20\pi}{9}$ radians
   b) $\frac{10\pi}{9}$ radians d) $= \frac{16\pi}{9}$ radians
4. a) 300° c) 171.89°
   b) 54° d) 495°
5. a) 2 radians; 114.6°
   b) $\frac{25\pi}{9}$ cm
6. a) 28 cm
   b) $\frac{40\pi}{3}$ cm
7. a) $\frac{\pi}{2}$ radians e) $\frac{5\pi}{4}$ radians
   b) $\frac{3\pi}{2}$ radians f) $\frac{\pi}{3}$ radians
   c) π radians g) $\frac{4\pi}{3}$ radians
   d) $\frac{\pi}{4}$ radians h) $\frac{4\pi}{3}$ radians
8. a) 120° e) 210°
   b) 60° f) 90°
   c) 45° g) 330°
   d) 225° h) 270°
9. a) $\frac{247\pi}{4}$ m
   b) 162.5 m
   c) $\frac{325\pi}{6}$ cm
10. $4.50\sqrt{2}$ cm
11. a) $\doteq 0.418\ 88$ radians/s
    b) $\doteq 377.0$ m
12. a) 36
    b) 0.8 m
13. a) equal to
    b) greater than
    c) stay the same
14.

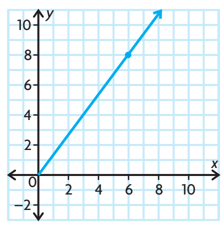


$0° = 0$ radians; $30° = \frac{\pi}{6}$ radians;
$45° = \frac{\pi}{4}$ radians; $60° = \frac{\pi}{3}$ radians;
$90° = \frac{\pi}{2}$ radians; $120° = \frac{2\pi}{3}$ radians;
$135° = \frac{3\pi}{4}$ radians; $150° = \frac{5\pi}{6}$ radians;
$180° = \pi$ radians; $210° = \frac{7\pi}{6}$ radians;
$225° = \frac{5\pi}{4}$ radians; $240° = \frac{4\pi}{3}$ radians;
$270° = \frac{3\pi}{2}$ radians; $300° = \frac{5\pi}{3}$ radians;
$315° = \frac{7\pi}{4}$ radians; $330° = \frac{11\pi}{6}$ radians;
$360° = 2\pi$ radians
15. Circle B, Circle A, and Circle C
16. about 144.5 radians/s

Lesson 6.2, pp. 330–332

1. a) second quadrant; $\frac{\pi}{4}$; positive
   b) fourth quadrant; $\frac{\pi}{3}$; positive
   c) third quadrant; $\frac{\pi}{3}$; positive
   d) second quadrant; $\frac{\pi}{6}$; negative
   e) second quadrant; $\frac{\pi}{3}$; negative
   f) fourth quadrant; $\frac{\pi}{4}$; negative

2. a) i)



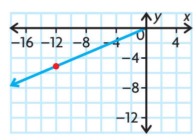
ii) $r = 10$

iii) $\sin\theta = \frac{4}{5}$, $\cos\theta = \frac{3}{5}$, $\tan\theta = \frac{4}{3}$,

$\csc\theta = \frac{5}{4}$, $\sec\theta = \frac{5}{3}$, $\cot\theta = \frac{3}{4}$

iv) $\theta \doteq 0.93$

b) i)



ii) $r = 13$

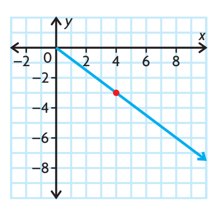
iii) $\sin\theta = -\frac{5}{13}$, $\cos\theta = -\frac{12}{13}$,

$\tan\theta = \frac{5}{12}$, $\csc\theta = -\frac{13}{5}$,

$\sec\theta = -\frac{13}{12}$, $\cot\theta = \frac{12}{5}$

iv) $\theta \doteq 3.54$

c) i)



ii) $r = 5$

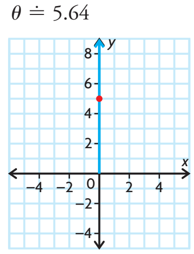
iii) $\sin\theta = -\frac{3}{5}$, $\cos\theta = \frac{4}{5}$,

$\tan\theta = -\frac{3}{4}$, $\csc\theta = -\frac{5}{3}$,

$\sec\theta = \frac{5}{4}$, $\cot\theta = -\frac{4}{3}$

iv) $\theta \doteq 5.64$

d) i)



ii) $r = 5$

iii) $\sin\theta = \frac{5}{5} = 1$,

$\cos\theta = \frac{0}{5} = 0$,

$\tan\theta = \frac{5}{0} = \text{undefined}$,

$\csc\theta = \frac{5}{5} = 1$,

$\sec\theta = \frac{5}{0} = \text{undefined}$,

$\cot\theta = \frac{0}{5} = 0$

iv) $\theta \doteq \frac{\pi}{2}$

3. a) $\sin\left(-\frac{\pi}{2}\right) = -1$,

$\cos\left(-\frac{\pi}{2}\right) = 0$,

$\tan\left(-\frac{\pi}{2}\right) = \text{undefined}$,

$\csc\left(-\frac{\pi}{2}\right) = -1$,

$\sec\left(-\frac{\pi}{2}\right) = \text{undefined}$,

$\cot\left(-\frac{\pi}{2}\right) = 0$

b) $\sin(-\pi) = 0$,
$\cos(-\pi) = -1$,
$\tan(-\pi) = 0$,
$\csc(-\pi) = \text{undefined}$,
$\sec(-\pi) = -1$,
$\cot(-\pi) = \text{undefined}$

c) $\sin\left(\frac{7\pi}{4}\right) = -\frac{\sqrt{2}}{2}$,

$\cos\left(\frac{7\pi}{4}\right) = \frac{\sqrt{2}}{2}$,

$\tan\left(\frac{7\pi}{4}\right) = -1$,

$\csc\left(\frac{7\pi}{4}\right) = -\sqrt{2}$,

$\sec\left(\frac{7\pi}{4}\right) = \sqrt{2}$,

$\cot\left(\frac{7\pi}{4}\right) = -1$

d) $\sin\left(-\frac{\pi}{6}\right) = -\frac{1}{2}$,

$\cos\left(-\frac{\pi}{6}\right) = \frac{\sqrt{3}}{2}$,

$\tan\left(-\frac{\pi}{6}\right) = -\frac{\sqrt{3}}{3}$,

$\csc\left(-\frac{\pi}{6}\right) = -2$,

$\sec\left(-\frac{\pi}{6}\right) = \frac{2\sqrt{3}}{3}$,

$\cot\left(-\frac{\pi}{6}\right) = -\sqrt{3}$

4. a) $\sin\frac{\pi}{6}$ **c)** $\cot\frac{3\pi}{4}$

b) $\cos\frac{\pi}{3}$ **d)** $\sec\frac{5\pi}{6}$

5. a) $\frac{\sqrt{3}}{2}$ **d)** $-\frac{\sqrt{2}}{2}$

b) $-\frac{\sqrt{2}}{2}$ **e)** 2

c) $-\frac{\sqrt{3}}{3}$ **f)** 2

6. a) $\frac{4\pi}{3}$ **d)** $\frac{7\pi}{6}$

b) $\frac{11\pi}{6}$ **e)** $\frac{3\pi}{2}$

c) $\frac{5\pi}{4}$ **f)** π

7. a) $\theta \doteq 2.29$ **d)** $\theta \doteq 3.61$
b) $\theta \doteq 0.17$ **e)** $\theta \doteq 0.84$
c) $\theta \doteq 1.30$ **f)** $\theta \doteq 6.12$

8. a) $\cos\frac{5\pi}{4}$ **d)** $\cot\frac{5\pi}{3}$

b) $\tan\frac{5\pi}{6}$ **e)** $\sin\frac{7\pi}{6}$

c) $\csc\frac{4\pi}{3}$ **f)** $\sec\frac{\pi}{4}$

9. $\pi - 0.748 \doteq 2.39$

10. $x \doteq 5.55$ cm

11. $x \doteq 4.5$ cm

12. Draw the angle and determine the measure of the reference angle. Use the CAST rule to determine the sign of each of the ratios in the quadrant in which the angle terminates. Use this sign and the value of the ratios of the reference angle to determine the values of the primary trigonometric ratios for the given angle.

13. a) second or third quadrant

b) $\sin\theta = \frac{12}{13}$ or $-\frac{12}{13}$,

$\tan\theta = \frac{12}{5}$ or $-\frac{12}{5}$,

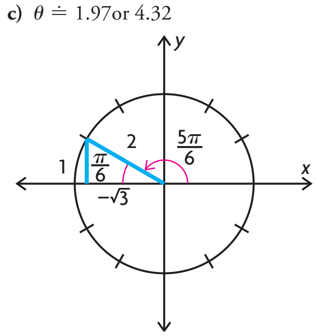
$\sec\theta = -\frac{13}{5}$,

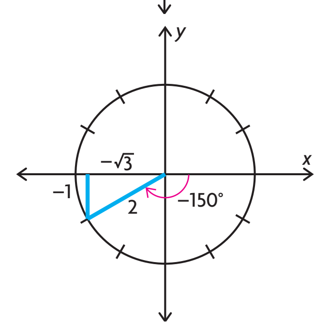
$\csc\theta = \frac{13}{12}$ or $-\frac{13}{12}$,

$\cot\theta = \frac{5}{12}$ or $-\frac{5}{12}$

c) $\theta \doteq 1.97$or 4.32

14.





By examining the special triangles, we see $\cos\left(\frac{5\pi}{6}\right) = \cos(-150°) = -\frac{\sqrt{3}}{2}$

15. $2\left(\sin^2\left(\frac{11\pi}{6}\right)\right) - 1 = 2\left(-\frac{1}{2}\right)^2 - 1$

$$= 2\left(\frac{1}{4}\right) - 1$$
$$= -\frac{1}{2}$$

$\left(\sin^2\frac{11\pi}{6}\right) - \left(\cos^2\frac{11\pi}{6}\right)$

$$= \left(-\frac{1}{2}\right)^2 - \left(\frac{\sqrt{3}}{2}\right)^2$$
$$= \frac{1}{4} - \frac{3}{4}$$
$$= -\frac{1}{2}$$

$2\left(\sin^2\left(\frac{11\pi}{6}\right)\right) - 1$

$$= \left(\sin^2\frac{11\pi}{6}\right) - \left(\cos^2\frac{11\pi}{6}\right)$$

16. $AB = 16$;

$\sin D = \frac{8}{8\sqrt{2}} = \frac{\sqrt{2}}{2}$;

$\cos D = \frac{8}{8\sqrt{2}} = \frac{\sqrt{2}}{2}$;

$\tan D = \frac{8}{8} = 1$

17. **a)** The first and second quadrants both have a positive y-value.
b) The first quadrant has a positive y-value, and the fourth quadrant has a negative y-value.
c) The first quadrant has a positive x-value, and the second quadrant has a negative x-value.
d) The first quadrant has a positive x-value and a positive y-value, and the third quadrant has a negative x-value and a negative y-value.

18. 1

19. $\cos 150° \doteq -0.26$

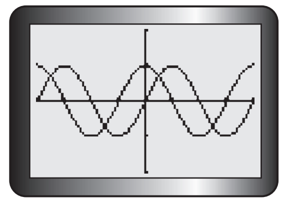
20. The ranges of the cosecant and secant functions are both $\{y \in \mathbf{R} \mid -1 \geq y$ or $y \geq 1\}$. In other words, the values of these functions can never be between -1 and 1. For the values of these functions to be between -1 and 1, the values of the sine and cosine functions would have to be greater than 1 and less than -1, which is never the case.

21. $\frac{2\sqrt{3} - 3}{4}$

Lesson 6.3, p. 336

1. **a)** $y = \sin\theta$ and $y = \cos\theta$ have the same period, axis, amplitude, maximum value, minimum value, domain, and range. They have different y- and θ-intercepts.
b) $y = \sin\theta$ and $y = \tan\theta$ have no characteristics in common except for their y-intercept and zeros.

2. **a)**



b) $\theta = -5.50, \theta = -2.36, \theta = 0.79, \theta = 3.93$
c) **i)** $t_n = n\pi, n \in \mathbf{I}$
ii) $t_n = \frac{\pi}{2} + 2n\pi, n \in \mathbf{I}$
iii) $t_n = \frac{3\pi}{2} + 2n\pi, n \in \mathbf{I}$

3. **a)** $t_n = \frac{\pi}{2} + n\pi, n \in \mathbf{I}$
b) $t_n = 2n\pi, n \in \mathbf{I}$
c) $t_n = -\pi + 2n\pi, n \in \mathbf{I}$

4. The two graphs appear to be identical.

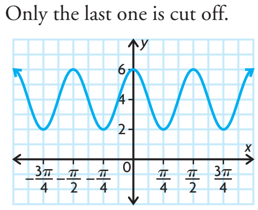
5. **a)** $t_n = n\pi, n \in \mathbf{I}$
b) $t_n = \frac{\pi}{2} + n\pi, n \in \mathbf{I}$

Lesson 6.4, pp. 343–346

1. **a)** period: $\frac{\pi}{2}$
amplitude: 0.5
horizontal translation: 0
equation of the axis: $y = 0$
b) period: 2π
amplitude: 1
horizontal translation: $\frac{\pi}{4}$
equation of the axis: $y = 3$
c) period: $\frac{2\pi}{3}$
amplitude: 2
horizontal translation: 0
equation of the axis: $y = -1$
d) period: π
amplitude: 5
horizontal translation: $\frac{\pi}{6}$
equation of the axis: $y = -2$

2. Only the last one is cut off.

3.

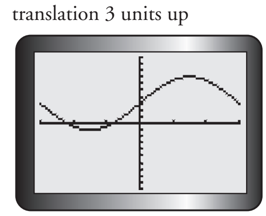


period: $\frac{\pi}{2}$
amplitude: 2
horizontal translation: $\frac{\pi}{4}$ to the left
equation of the axis: $y = 4$

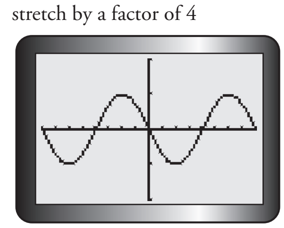
4. **a)** $f(x) = 25\sin(2x) - 4$
b) $f(x) = \frac{2}{5}\sin\left(\frac{\pi}{5}x\right) + \frac{1}{15}$
c) $f(x) = 80\sin\left(\frac{1}{3}x\right) - \frac{9}{10}$
d) $f(x) = 11\sin(4\pi x)$

5. **a)** period $= 2\pi$, amplitude $= 18$, equation of the axis is $y = 0$; $y = 18\sin x$
b) period $= 4\pi$, amplitude $= 6$, equation of the axis is $y = -2$; $y = -6\sin(0.5x) - 2$
c) period $= 6\pi$, amplitude $= 2.5$, equation of the axis is $y = 6.5$; $y = -2.5\cos\left(\frac{1}{3}x\right) + 6.5$
d) period $= 4\pi$, amplitude $= 2$, equation of the axis is $y = -1$; $y = -2\cos\left(\frac{1}{2}x\right) - 1$

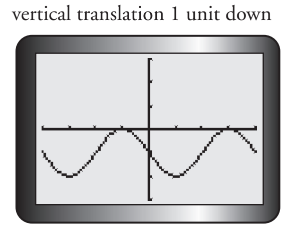
6. **a)** vertical stretch by a factor of 4, vertical translation 3 units up



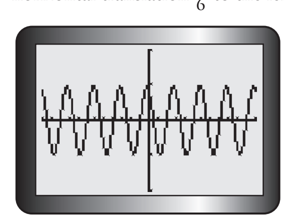
b) reflection in the x–axis, horizontal stretch by a factor of 4



c) horizontal translation π to the right, vertical translation 1 unit down



d) horizontal compression by a factor of $\frac{1}{4}$, horizontal translation $\frac{\pi}{6}$ to the left



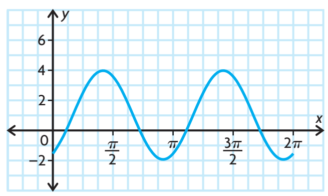
7. **a)** $f(x) = \frac{1}{2}\cos x + 3$

b) $f(x) = \cos\left(-\frac{1}{2}x\right)$

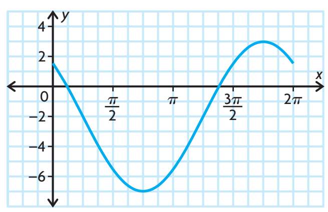
c) $f(x) = 3\cos\left(x - \frac{\pi}{2}\right)$

d) $f(x) = \cos\left(2\left(x + \frac{\pi}{2}\right)\right)$

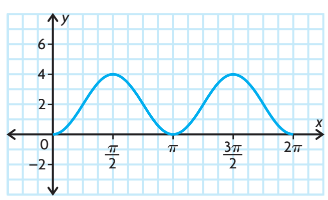
8. **a)**



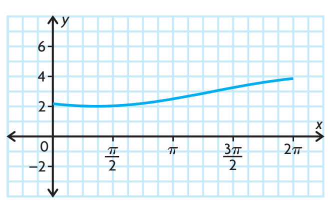
b)



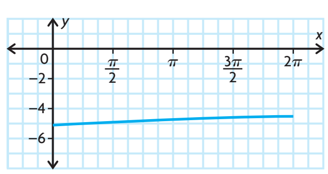
c)



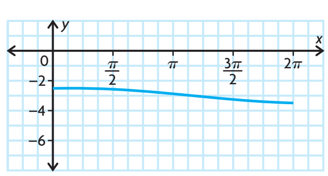
d)



e)



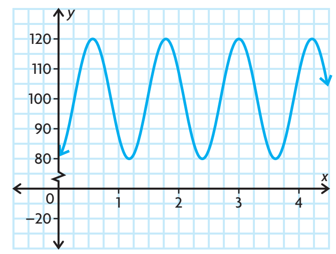
f)



9. **a)** The period of the function is $\frac{6}{5}$. This represents the time between one beat of a person's heart and the next beat.

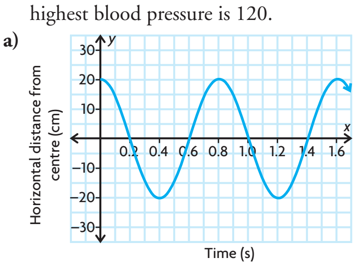
b) 80

c)



d) The range for the function is between 80 and 120. The range means the lowest blood pressure is 80 and the highest blood pressure is 120.

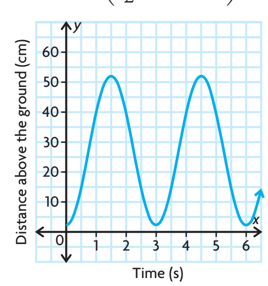
10. **a)**



b) There is a vertical stretch by a factor of 20, followed by a horizontal compression by a of factor of $\frac{2}{5\pi}$, and then a horizontal translation 0.2 to the left.

c) $y = 20\sin\left(\frac{5\pi}{2}(x + 0.2)\right)$

11. **a)**



b) vertical stretch by a factor of 25, reflection in the x-axis, vertical translation 27 units up, horizontal compression by a factor of $\frac{1}{|k|} = \frac{3}{2\pi}$

c) $y = -25\cos\left(\frac{2\pi}{3}x\right) + 27$

12. $\frac{2\pi}{7}$

13. Answers may vary. For example, $\left(\frac{14\pi}{13}, 5\right)$.

14. **a)** $y = \cos(4\pi x)$

b) $y = -2\sin\left(\frac{\pi}{4}x\right)$

c) $y = 4\sin\left(\frac{\pi}{20}(x - 10)\right) - 1$

15.

Start with graph of $y = \sin x$.

↓

Reflect in the x-axis and stretch vertically by a factor of 2 to produce graph of $y = -2\sin x$.

↓

Stretch horizontally by a factor of 2 to produce graph of $y = -2\sin(0.5x)$.

↓

Translate $\frac{\pi}{4}$ units to the right to produce graph of $y = -2\sin\left(0.5\left(x - \frac{\pi}{4}\right)\right)$.

↓

Translate 3 units up to produce graph of $y = -2\sin\left(0.5\left(x - \frac{\pi}{4}\right)\right) + 3$.

16. **a)** 100 m
b) 400 m
c) 300 m
d) 80 s
e) about 23.561 94 m/s

Mid-Chapter Review, p. 349

1. **a)** 22.5°
b) 720°
c) 286.5°
d) 165°

2. **a)** $125° \doteq 2.2$ radians
b) $450° \doteq 7.9$ radians
c) $5° \doteq 0.1$ radians
d) $330° \doteq 5.8$ radians
e) $215° \doteq 3.8$ radians
f) $-140° \doteq -2.4$ radians

3. **a)** 20π
b) 4π radians/s
c) 380π cm

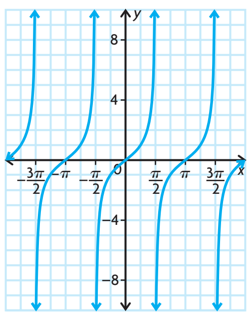
4. **a)** $\frac{\sqrt{2}}{2}$
b) $-\frac{1}{2}$
c) $-\sqrt{3}$
d) $-\frac{\sqrt{3}}{3}$
e) 0
f) $-\frac{1}{2}$

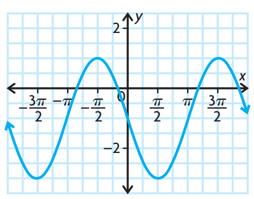
5. **a)** about 1.78
b) about 0.86
c) about 1.46
d) about 4.44
e) about 0.98
f) about 4.91

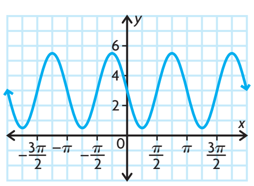
Answers

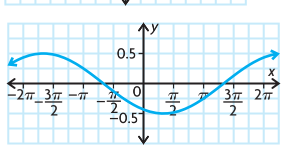
6. a) $\sin \frac{\pi}{6}$
b) $\cot \frac{3\pi}{4}$
c) $\sec \frac{\pi}{2}$
d) $\cos \frac{5\pi}{6}$

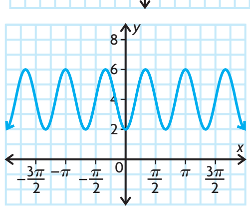
7. a) $x = 0, \pm\pi, \pm 2\pi, \ldots; y = 0$
b) $x = \pm\frac{\pi}{2}, \pm\frac{3\pi}{2}, \pm\frac{5\pi}{2}, \ldots; y = 1$
c) $x = 0, \pm\pi, \pm 2\pi, \ldots; y = 0$

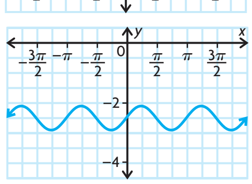
8. a)


b)


c)


d)


e)


f)


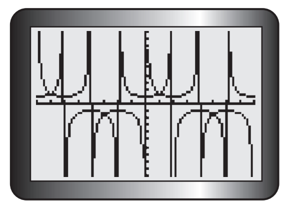
9. $y = \frac{1}{3}\sin\left(-3\left(x + \frac{\pi}{8}\right)\right) - 23$

Lesson 6.5, p. 353

1. a) $t_n = n\pi, n \in \mathbf{I}$
b) no maximum value
c) no minimum value

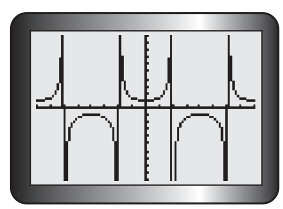
2. a) $t_n = \frac{\pi}{2} + n\pi, n \in \mathbf{I}$
b) no maximum value
c) no minimum value

3. a) $t_n = n\pi, n \in \mathbf{I}$
b) $t_n = \frac{\pi}{2} + n\pi, n \in \mathbf{I}$

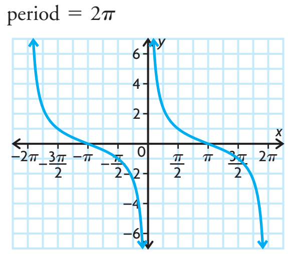
4.


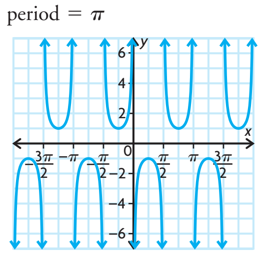
$-5.50, -2.35, 0.79, 3.93$

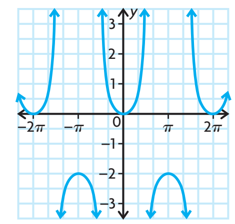
5. Yes, the graphs of $y = \csc\left(x + \frac{\pi}{2}\right)$ and $y = \sec x$ are identical.

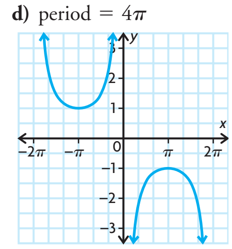


6. Answers may vary. For example, reflect the graph of $y = \tan x$ across the y-axis and then translate the graph $\frac{\pi}{2}$ units to the left.

7. a) period $= 2\pi$


b) period $= \pi$


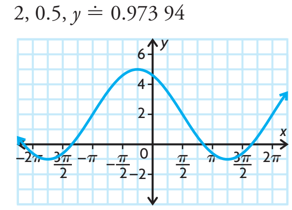
c) period $= 2\pi$


d) period $= 4\pi$


Lesson 6.6, pp. 360–362

1. $y = 3\cos\left(\frac{2}{3}\left(x + \frac{\pi}{4}\right)\right) + 2$

2. $2, 0.5, y \doteq 0.973\ 94$

3.


$x = 1.3$

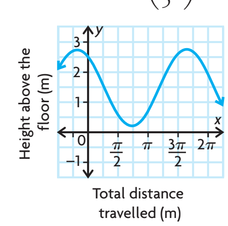
4. amplitude and equation of the axis

5. a) the radius of the circle in which the tip of the sparkler is moving
b) the time it takes Mike to make one complete circle with the sparkler
c) the height above the ground of the centre of the circle in which the tip of the sparkler is moving
d) cosine function

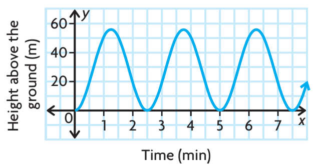
6. $y = 90\sin\left(\frac{\pi}{12}x\right) + 30$

7. $y = 250\cos\left(\frac{2\pi}{3}x\right) + 750$

8. $y = -1.25\sin\left(\frac{4}{5}x\right) + 1.5$



9. 0.98 min $< t <$ 1.52 min, 3.48 min $< t <$ 4.02 min, 5.98 min $< t <$ 6.52 min



10. **a)** $y = 3.7 \sin\left(\frac{2\pi}{365}x\right) + 12$

b) $y \doteq 13.87$ hours

11. $T(t) = 16.2 \sin\left(\frac{2\pi}{365}(t - 116)\right) + 1.4$, $0 < t < 111$ and $304 < t < 365$

12. The student should graph the height of the nail above the ground as a function of the total distance travelled by the nail, because the nail would not be travelling at a constant speed. If the student graphed the height of the nail above the ground as a function of time, the graph would not be sinusoidal.

13. minute hand:
$D(t) = 15 \cos\left(\frac{\pi}{30}t\right) + 300$;
second hand:
$D(t) = 15 \cos(2\pi t) + 300$;
hour hand:
$D(t) = 8 \cos\left(\frac{\pi}{360}t\right) + 300$

Lesson 6.7, pp. 369–373

1. **a)** $0 < x < \pi, \pi < x < 2\pi$

b) $-\frac{\pi}{2} < x < \frac{\pi}{2}, \frac{3\pi}{2} < x < \frac{5\pi}{2}$

c) $\frac{\pi}{2} < x < \frac{3\pi}{2}, \frac{5\pi}{2} < x < 3\pi$

2. **a)** $x = \frac{\pi}{4}, x = \frac{5\pi}{4}$

b) $x = \frac{\pi}{2}, x = \frac{5\pi}{2}$

c) $x = 0, x = 2\pi$

3. 0

4. **a)** about 0.465
b) 0
c) about -0.5157
d) about -1.554

5. **a)** $0 < x < \frac{\pi}{2}, \pi < x < \frac{3\pi}{2}$

b) $0 < x < \frac{\pi}{4}, \pi < x < \frac{5\pi}{4}$

c) $\frac{\pi}{4} < x < \frac{\pi}{2}, \frac{5\pi}{4} < x < \frac{3\pi}{2}$

6. **a)** $x = \frac{1}{4}, x = \frac{3}{4}$

b) $x = 0, x = 1$

c) $x = \frac{1}{2}, x = \frac{3}{2}$

7. **a)** about -0.7459
b) about -1.310
c) 0

8. negative

9. **a)** $R(t) = 4.5 \cos\left(\frac{\pi}{12}t\right) + 20.2$

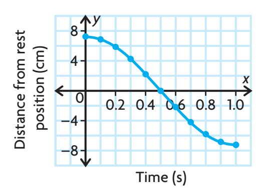
b) fastest: $t = 6$ months, $t = 18$ months, $t = 30$ months, $t = 42$ months; slowest: $t = 0$ months, $t = 12$ months, $t = 24$ months, $t = 36$ months, $t = 48$ months

c) about 1.164 mice per owl/s

10. **a)** **i)** 0.25 t/h
ii) about 0.2588 t/h
iii) 0.2612 t/h

b) The estimate calculated in part iii) is the most accurate. The smaller the interval, the more accurate the estimate.

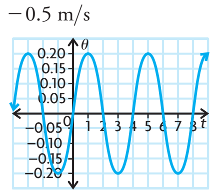
11. **a)**



b) half of one cycle
c) -14.4 cm/s
d) The bob is moving the fastest when it passes through its rest position. You can tell because the images of the balls are farthest apart at this point.
e) The pendulum's rest position is halfway between the maximum and minimum values on the graph. Therefore, at this point, the pendulum's instantaneous rate of change is at its maximum.

12. **a)** 0
b) -0.5 m/s

13. **a)**

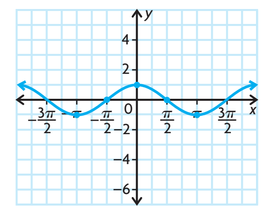


b) 0.2 radians/s
c) Answers may vary. For example, about $-\frac{2}{3}$ radians/s.
d) $t = 0, 2, 4, 6,$ and 8

14. Answers may vary. For example, for $x = 0$, the instantaneous rate of change of $f(x) = \sin x$ is approximately 0.9003, while the instantaneous rate of change of $f(x) = 3 \sin x$ is approximately 2.7009. (The interval $-\frac{\pi}{4} < x < \frac{\pi}{4}$ was used.) Therefore, the instantaneous rate of change of $f(x) = 3 \sin x$ is at its maximum three times more than the instantaneous rate of change of $f(x) = \sin x$. However, there are points where the instantaneous rate of change is the same for the two functions. For example, at $x = \frac{\pi}{2}$, it is 0 for both functions.

15. **a)** $-1, 0, 1, 0,$ and -1

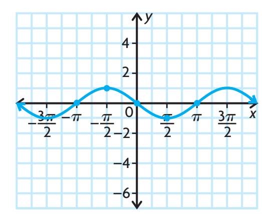
b)



The function is $f(x) = \cos x$. Based on this information, the derivative of $f(x) = \sin x$ is $\cos x$.

16. **a)** $0, 1, 0, -1,$ and 0

b)



The function is $f(x) = -\sin x$. Based on this information, the derivative of $f(x) = \cos x$ is $-\sin x$.

Chapter Review, pp. 376–377

1. $\frac{33}{16}$

2. 70π

3. **a)** $\frac{\pi}{9}$ radians

b) $\frac{-5\pi}{18}$ radians

c) $\frac{8\pi}{9}$ radians

d) $\frac{7\pi}{3}$ radians

4. **a)** 45° **b)** $-225°$ **c)** 480° **d)** $-120°$

5. **a)** $\frac{5\pi}{6}$ **b)** $\frac{4\pi}{3}$ **c)** $\frac{3\pi}{4}$ **d)** $\frac{7\pi}{6}$

6. **a)** $\tan\theta = \frac{12}{13}$

b) $\sec\theta = -\frac{13}{5}$

c) about 5.14

7. 2.00

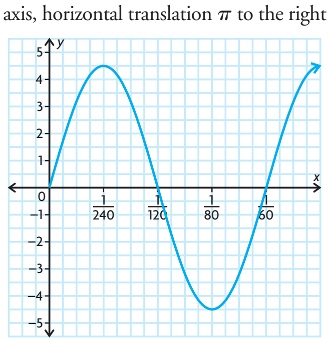
8. a) 2π radians
b) 2π radians
c) π radians

9. $y = 5 \sin\left(x + \frac{\pi}{3}\right) + 2$

10. $y = -3 \cos\left(2\left(x + \frac{\pi}{4}\right)\right) - 1$

11. a) reflection in the x-axis, vertical stretch by a factor of 19, vertical translation 9 units down
b) horizontal compression by a factor of $\frac{1}{10}$, horizontal translation $\frac{\pi}{12}$ to the left
c) vertical compression by a factor of $\frac{10}{11}$, horizontal translation $\frac{\pi}{9}$ to the right, vertical translation 3 units up
d) reflection in the x-axis, reflection in the y-axis, horizontal translation π to the right

12. a)



b) $\frac{1}{60}$
c) $\frac{1}{240}$
d) $\frac{1}{80}$

13. a) 2π radians
b) 2π radians
c) π radians

14. a) the radius of the circle in which the bumblebee is flying
b) the time that the bumblebee takes to fly one complete circle
c) the height, above the ground, of the centre of the circle in which the bumblebee is flying
d) cosine function

15. $P(m) = 7250 \cos\left(\frac{\pi}{6}m\right) + 7750$

16. $h(t) = 30 \sin\left(\frac{5\pi}{3}t - \frac{\pi}{2}\right) + 150$

17. a) $0 < x < 5\pi$, $10\pi < x < 15\pi$
b) $2.5\pi < x < 7.5\pi$, $12.5\pi < x < 17.5\pi$
c) $0 < x < 2.5\pi$, $7.5\pi < x < 12.5\pi$

18. a) $x = 0$, $x = \frac{1}{2}$
b) $x = \frac{1}{8}$, $x = \frac{5}{8}$
c) $x = \frac{3}{8}$, $x = \frac{7}{8}$

19. a) $x = \frac{3}{4}$ s
b) the time between one beat of a person's heart and the next beat
c) 140
d) −129

Chapter Self-Test, p. 378

1. $y = \sec x$
2. $\sec 2\pi$
3. $y \doteq 108.5$
4. about 0.31 °C per day
5. $\frac{3\pi}{5}$, 110°, $\frac{5\pi}{8}$, 113°, and $\frac{2\pi}{3}$
6. $y = \sin\left(x + \frac{5\pi}{8}\right)$
7. $y \doteq -30$
8. a) $-3\cos\left(\frac{\pi}{12}x\right) + 22$
b) about 0.5 °C per hour
c) about 0 °C per hour

Cumulative Review Chapters 4–6, pp. 380–383

1.	(d)	**9.**	(c)	**17.**	(d)	**25.**	(b)
2.	(b)	**10.**	(c)	**18.**	(b)	**26.**	(d)
3.	(a)	**11.**	(d)	**19.**	(b)	**27.**	(a)
4.	(c)	**12.**	(a)	**20.**	(b)	**28.**	(c)
5.	(a)	**13.**	(d)	**21.**	(d)	**29.**	(b)
6.	(b)	**14.**	(c)	**22.**	(c)		
7.	(a)	**15.**	(d)	**23.**	(a)		
8.	(c)	**16.**	(a)	**24.**	(d)		

30. a) If x is the length in centimetres of a side of one of the corners that have been cut out, the volume of the box is $(50 - 2x)(40 - 2x)x$ cm^3.
b) 5 cm or 10 cm
c) $x \doteq 7.4$ cm
d) $3 < x < 12.8$

31. a) The zeros of $f(x)$ are $x = 2$ or $x = 3$. The zero of $g(x)$ is $x = 3$. The zero of $\frac{f(x)}{g(x)}$ is $x = 2$. $\frac{g(x)}{f(x)}$ does not have any zeros.
b) $\frac{f(x)}{g(x)}$ has a hole at $x = 3$; no asymptotes. $\frac{g(x)}{f(x)}$ has an asymptote at $x = 2$ and $y = 0$.
c) $x = 1$; $\frac{f(x)}{g(x)}$: $y = x - 2$, $\frac{g(x)}{f(x)}$: $y = -x$

32. a) Vertical compressions and stretches do not affect location of zeros; maximum and minimum values are multiplied by the scale factor, but locations are unchanged; instantaneous rates of change are multiplied by the scale factor.
Horizontal compressions and stretches move locations of zeros, maximums, and minimums toward or away from the y-axis by the reciprocal of the scale factor; instantaneous rates of change are multiplied by the reciprocal of scale factor.
Vertical translations change location of zeros or remove them; maximum and minimum values are increased or decreased by the amount of the translation, but locations are unchanged; instantaneous rates of change are unchanged.
Horizontal translations move location of zeros by the same amount as the translation; maximum and minimum values are unchanged, but locations are moved by the same amount as the translation; instantaneous rates of change are unchanged, but locations are moved by the same amount as the translation.
b) For $y = \cos x$, the answer is the same as in part **a)**, except that a horizontal reflection does not affect instantaneous rates of change. For $y = \tan x$, the answer is also the same as in part **a)**, except that nothing affects the maximum and minimum values, since there are no maximum or minimum values for $y = \tan x$.

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1. a) 1
b) $-\frac{22}{7}$
c) 8 or −3
d) $\frac{2}{3}$ or $-\frac{5}{2}$
e) $-1 \pm \sqrt{2}$
f) $\frac{3 \pm \sqrt{21}}{6}$

2. To do this, you must show that the two distances are equal:
$$D_{AB} = \sqrt{(2-1)^2 + \left(\tfrac{1}{2} - 0\right)^2} = \frac{\sqrt{5}}{2};$$
$$D_{CD} = \sqrt{\left(0 - \tfrac{1}{2}\right)^2 + (6-5)^2} = \frac{\sqrt{5}}{2}.$$
Since the distances are equal, the line segments are the same length.

3. a) $\sin A = \frac{8}{17}$, $\cos A = \frac{15}{17}$, $\tan A = \frac{8}{15}$, $\csc A = \frac{17}{8}$, $\sec A = \frac{17}{15}$, $\cot A = \frac{15}{8}$
b) 0.5 radians
c) 61.9°