5. a. 19 000 fish/year
   b. 23 000 fish/year

6. a. i. 3
   ii. 1
   iii. 3
   iv. 2
   b. No, $\lim_{x\to4} f(x)$ does not exist. In order for the limit to exist, $\lim_{x\to4^-} f(x)$ and $\lim_{x\to4^+} f(x)$ must exist and they must be the same. In this case, $\lim_{x\to4^-} f(x) = \infty$, but $\lim_{x\to4^+} f(x) = -\infty$, so $\lim_{x\to4} f(x)$ does not exist.

7. $f(x)$ is discontinuous at $x = 2$. $\lim_{x\to2^-} f(x) = 5$, but $\lim_{x\to2^+} f(x) = 3$.

8. a. $-\frac{1}{5}$ d. $\frac{4}{3}$
   b. 6 e. $\frac{1}{12}$
   c. $-\frac{1}{9}$ f. $\frac{1}{2}$

9. a. $6x + 1$
   b. $-\frac{1}{x^2}$

10. a. $3x^2 - 8x + 5$
   b. $\frac{3x^2}{\sqrt{2x^3 + 1}}$
   c. $\frac{6}{(x + 3)^2}$
   d. $4x(x^2 + 3)(4x^5 + 5x + 1) + (x^2 + 3)^2(20x^4 + 5)$
   e. $\frac{(4x^2 + 1)^4(84x^2 - 80x - 9)}{(3x - 2)^4}$
   f. $5[x^2 + (2x + 1)^3]^4 \times [2x + 6(2x + 1)^2]$

11. $4x + 3y - 10 = 0$

12. 3

13. a. $p'(t) = 4t + 6$
   b. 46 people per year
   c. 2006

14. a. $f'(x) = 5x^4 - 15x^2 + 1$; $f''(x) = 20x^3 - 30x$
   b. $f'(x) = \frac{4}{x^3}$; $f''(x) = -\frac{12}{x^4}$
   c. $f'(x) = -\frac{2}{\sqrt{x^3}}$; $f''(x) = \frac{3}{\sqrt{x^5}}$
   d. $f'(x) = 4x^3 + \frac{4}{x^5}$; $f''(x) = 12x^2 - \frac{20}{x^6}$

15. a. maximum: 82, minimum: 6
   b. maximum: $9\frac{1}{3}$, minimum: 2
   c. maximum: $\frac{e^4}{1 + e^4}$, minimum: $\frac{1}{2}$
   d. maximum: 5, minimum: 1

16. a. $v(t) = 9t^2 - 81t + 162$, $a(t) = 18t - 81$
   b. stationary when $t = 6$ or $t = 3$, advancing when $v(t) > 0$, and retreating when $v(t) < 0$
   c. $t = 4.5$
   d. $0 \le t < 4.5$
   e. $4.5 < t \le 8$

17. 14 062.5 m^2

18. $r \doteq 4.3$ cm, $h \doteq 8.6$ cm

19. $r = 6.8$ cm, $h = 27.5$ cm

20. a. $140 - 2x$
   b. 101 629.5 cm^3; 46.7 cm by 46.7 cm by 46.6 cm

21. $x = 4$

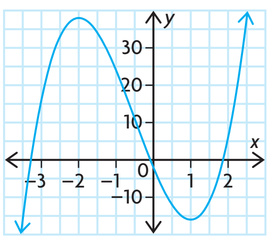
22. \$70 or \$80

23. \$1140

24. a. $\frac{dy}{dx} = -10x + 20$, $x = 2$ is critical number, Increase: $x < 2$, Decrease: $x > 2$
   b. $\frac{dy}{dx} = 12x + 16$, $x = -\frac{4}{3}$ is critical number, Increase: $x > -\frac{4}{3}$, Decrease: $x < -\frac{4}{3}$
   c. $\frac{dy}{dx} = 6x^2 - 24$, $x = \pm2$ are critical numbers, Increase: $x < -2$, $x > 2$, Decrease: $-2 < x < 2$
   d. $\frac{dy}{dx} = -\frac{2}{(x - 2)^2}$. The function has no critical numbers. The function is decreasing everywhere it is defined, that is, $x \ne 2$.

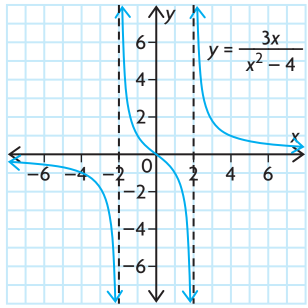
25. a. $y = 0$ is a horizontal asymptote. $x = \pm3$ are the vertical asymptotes. There is no oblique asymptote. $\left(0, -\frac{8}{9}\right)$ is a local maximum.
   b. There are no horizontal asymptotes. $x = \pm1$ are the vertical asymptotes. $y = 4x$ is an oblique asymptote. $(-\sqrt{3}, -6\sqrt{3})$ is a local maximum, $(\sqrt{3}, 6\sqrt{3})$ is a local minimum.

26. a.



$y = 4x^3 + 6x^2 - 24x - 2$

   b.



27. a. $(-20)e^{5x+1}$
   b. $e^{3x}(3x + 1)$
   c. $(3\ln 6)6^{3x-8}$
   d. $(\cos x)e^{\sin x}$

28. $y = 2e(x - 1) + e$

29. a. 5 days
   b. 27

30. a. $2\cos x + 15\sin 5x$
   b. $8\cos 2x(\sin 2x + 1)^3$
   c. $\frac{2x + 3\cos 3x}{2\sqrt{x^2 + \sin 3x}}$
   d. $\frac{1 + 2\cos x}{(\cos x + 2)^2}$
   e. $2x\sec^2 x^2 - 2\tan x \sec^2 x$
   f. $-2x\sin x^2 \cos(\cos x^2)$

31. about 4.8 m

32. about 8.5 m

Chapter 6

Review of Prerequisite Skills, p. 273

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

2. $\frac{4}{3}$

3. a. $AB \doteq 29.7$, $\angle B \doteq 36.5°$, $\angle C \doteq 53.5°$
   b. $\angle A \doteq 97.9°$, $\angle B \doteq 29.7°$, $\angle C \doteq 52.4°$

4. $\angle Z \doteq 50°$, $XZ \doteq 7.36$, $YZ \doteq 6.78$

5. $\angle R \doteq 44°$, $\angle S \doteq 102°$, $\angle T \doteq 34°$

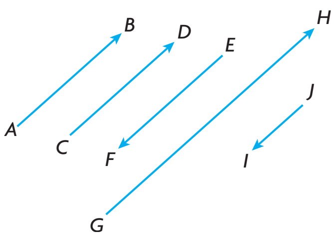
6. 5.82 km

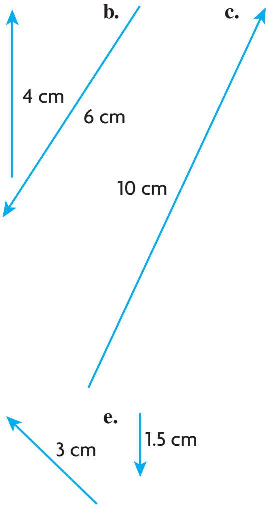
7. 8.66 km

8. 21.1 km

9. 59.4 cm^2

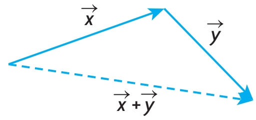
Section 6.1, pp. 279–281

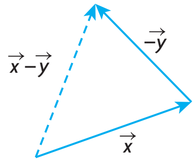
1. **a.** False; two vectors with the same magnitude can have different directions, so they are not equal.
   b. True; equal vectors have the same direction and the same magnitude.
   c. False; equal or opposite vectors must be parallel and have the same magnitude. If two parallel vectors have different magnitude, they cannot be equal or opposite.
   d. False; equal or opposite vectors must be parallel and have the same magnitude. Two vectors with the same magnitude can have directions that are not parallel, so they are not equal or opposite.
2. The following are scalars: height, temperature, mass, area, volume, distance, and speed. There is not a direction associated with any of these qualities.
   The following are vectors: weight, displacement, force, and velocity. There is a direction associated with each of these qualities.
3. Answers may vary. For example:
   A rolling ball stops due to friction, which resists the direction of motion.
   A swinging pendulum stops due to friction resisting the swinging pendulum.
4. Answers may vary. For example:
   a. $\vec{AD} = \vec{BC}$; $\vec{AB} = \vec{DC}$; $\vec{AE} = \vec{EC}$; $\vec{DE} = \vec{EB}$
   b. $\vec{AD} = -\vec{CB}$; $\vec{AB} = -\vec{CD}$; $\vec{AE} = -\vec{CE}$; $\vec{ED} = -\vec{EB}$; $\vec{DA} = -\vec{BC}$
   c. $\vec{AC}$ & $\vec{DB}$; $\vec{AE}$ & $\vec{EB}$; $\vec{EC}$ & $\vec{DE}$; $\vec{AB}$ & $\vec{CB}$
5. 

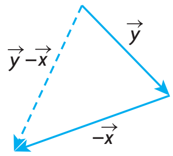
   a. $\vec{AB} = \vec{CD}$
   b. $\vec{AB} = -\vec{EF}$
   c. $|\vec{AB}| = |\vec{EF}|$ but $\vec{AB} \neq \vec{EF}$
   d. $\vec{GH} = 2\vec{AB}$
   e. $\vec{AB} = -2\vec{JI}$
6. 

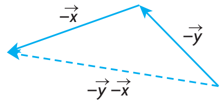
7. **a.** 100 km/h, south
   b. 50 km/h, west
   c. 100 km/h, northeast
   d. 25 km/h, northwest
   e. 60 km/h, east
8. **a.** 400 km/h, due south
   b. 70 km/h, southwesterly
   c. 30 km/h southeasterly
   d. 25 km/h, due east
9. **a.** **i.** False; they have equal magnitude, but opposite direction.
   ii. True; they have equal magnitude.
   iii. True; the base has sides of equal length, so the vectors have equal magnitude.
   iv. True; they have equal magnitude and direction.
   b. $|\vec{BD}| = \sqrt{18}$, $|\vec{BE}| = \sqrt{73}$, $|\vec{BH}| = \sqrt{82}$
10. **a.** The tangent vector describes James's velocity at that moment. At point *A*, his speed is 15 km/h and he is heading north. The tangent vector shows his velocity is 15 km/h, north.
   b. James's speed
   c. The magnitude of James's velocity (his speed) is constant, but the direction of his velocity changes at every point.
   d. *C*
   e. 3.5 min
   f. southwest
11. **a.** $\sqrt{10}$ or 3.16
   b. $(-3, 1)$
   c. $(0, -3)$
   d. $(0, 0)$

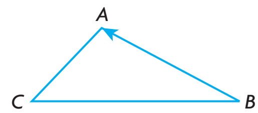
Section 6.2, pp. 290–292

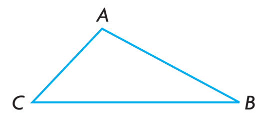
1. **a.** 

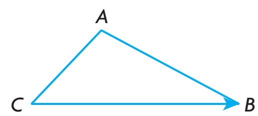
   b. 

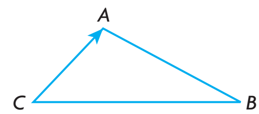
   c. 

   d. 

2. **a.** 

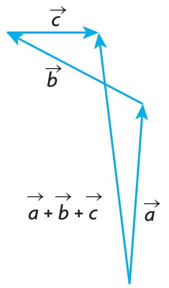
   $\vec{BA}$
   b. 

   $\vec{0}$
   c. 

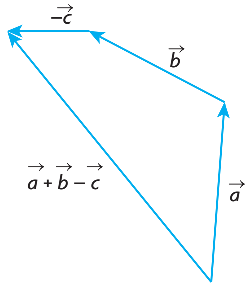
   $\vec{CB}$
   d. 

   $\vec{CA}$

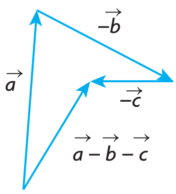
3. **a.**



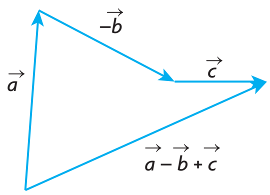
b.



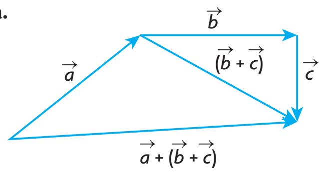
c.



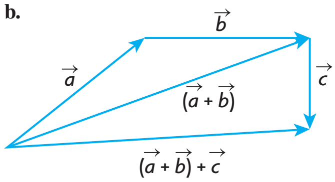
d.



4. **a.**

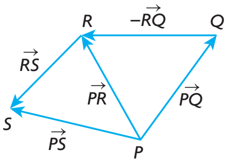


b.

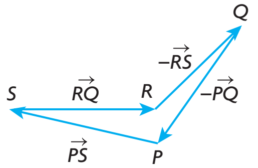


c. The resultant vectors are the same. The order in which you add vectors does not matter.
$(\vec{a}+\vec{b})+\vec{c}=\vec{a}+(\vec{b}+\vec{c})$

5. **a.** $=\overrightarrow{PS}$



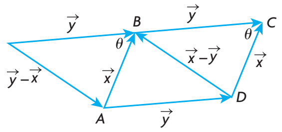
b. $\vec{0}$



6. $\vec{x}+\vec{y}=\overrightarrow{MR}+\overrightarrow{RS}$
$=\overrightarrow{MS}$
$\vec{z}+\vec{t}=\overrightarrow{ST}+\overrightarrow{TQ}$
$=\overrightarrow{SQ}$
so
$(\vec{x}+\vec{y})+(\vec{z}+\vec{t})=\overrightarrow{MS}+\overrightarrow{SQ}$
$=\overrightarrow{MQ}$

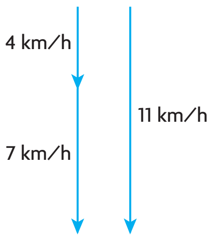
7. **a.** $-\vec{x}$
b. $\vec{y}$
c. $\vec{x}+\vec{y}$
d. $-\vec{x}+\vec{y}$
e. $\vec{x}+\vec{y}+\vec{z}$
f. $-\vec{x}-\vec{y}$
g. $-\vec{x}+\vec{y}+\vec{z}$
h. $-\vec{x}-\vec{z}$

8. **a.**

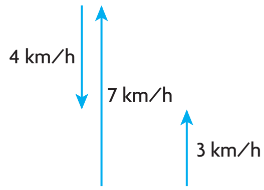


b. See the figure in part a. for the drawn vectors.
$|\vec{y}-\vec{x}|^2=|\vec{y}|^2+|\vec{x}|^2-$
$2|\vec{y}||-\vec{x}|\cos(\theta)$ and $|-\vec{x}|=|\vec{x}|$,
so $|\vec{y}-\vec{x}|^2=|\vec{x}-\vec{y}|^2$

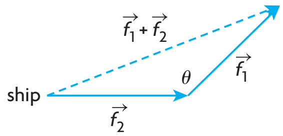
9. **a.** 11 km/h
b.



c. 3 km/h



10. **a.**



b. The vectors form a triangle with side lengths $|\vec{f_1}|$, $|\vec{f_2}|$, and $|\vec{f_1}+\vec{f_2}|$. Find $|\vec{f_1}+\vec{f_2}|$ using the cosine law.
$|\vec{f_1}+\vec{f_2}|^2=|\vec{f_1}|^2+|\vec{f_2}|^2$
$-2|\vec{f_1}||\vec{f_2}|\cos(\theta)$
$|\vec{f_1}+\vec{f_2}|$
$=\sqrt{|\vec{f_1}|^2+|\vec{f_2}|^2-2|\vec{f_1}||\vec{f_2}|\cos(\theta)}$

11. 170 km/h, N28.1°W

12. $|\vec{x}+\vec{y}|=25$, $\theta \doteq 73.7°$

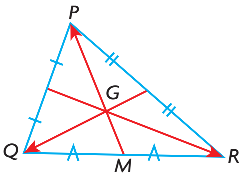
13. 0.52

14. The diagonals of a parallelogram bisect each other. So, $\overrightarrow{EA}=-\overrightarrow{EC}$ and $\overrightarrow{ED}=-\overrightarrow{EB}$.
Therefore,
$\overrightarrow{EA}+\overrightarrow{EB}+\overrightarrow{EC}+\overrightarrow{ED}=\vec{0}$.

15. Multiple applications of the Triangle Law for adding vectors show that $\overrightarrow{RM}+\vec{b}=\vec{a}+\overrightarrow{TP}$ (since both are equal to the undrawn vector $\overrightarrow{TM}$), and that $\overrightarrow{RM}+\vec{a}=\vec{b}+\overrightarrow{SQ}$ (since both are equal to the undrawn vector $\overrightarrow{RQ}$).
Adding these two equations gives
$2\overrightarrow{RM}+\vec{a}+\vec{b}=\vec{a}+\vec{b}+\overrightarrow{TP}+\overrightarrow{SQ}$
$2\overrightarrow{RM}=\overrightarrow{TP}+\overrightarrow{SQ}$

16. $\vec{a}+\vec{b}$ and $\vec{a}-\vec{b}$ represent the diagonals of a parallelogram with sides $\vec{a}$ and $\vec{b}$.
Since $|\vec{a}+\vec{b}|=|\vec{a}-\vec{b}|$, and the only parallelogram with equal diagonals is a rectangle, the parallelogram must also be a rectangle.

17.



Let point M be defined as shown. Two applications of the triangle law for adding vectors show that

$\overrightarrow{GQ} + \overrightarrow{QM} + \overrightarrow{MG} = \vec{0}$

$\overrightarrow{GR} + \overrightarrow{RM} + \overrightarrow{MG} = \vec{0}$

Adding these two equations gives

$\overrightarrow{GQ} + \overrightarrow{QM} + 2\,\overrightarrow{MG} + \overrightarrow{GR} + \overrightarrow{RM} = \vec{0}$

From the given information,

$2\overrightarrow{MG} = \overrightarrow{GP}$ and

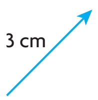
$\overrightarrow{QM} + \overrightarrow{RM} = \vec{0}$ (since they are opposing vectors of equal length), so

$\overrightarrow{GQ} + \overrightarrow{GP} + \overrightarrow{GR} = \vec{0}$, as desired.

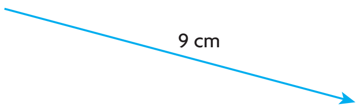
Section 6.3, pp. 298–301

1. A vector cannot equal a scalar.

2. **a.**



b.



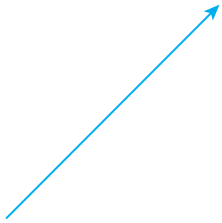
c.

d.

3. E25°N describes a direction that is 25° toward the north of due east. N65°E and “a bearing of 65°” both describe a direction that is 65° toward the east of due north.

4. Answers may vary. For example:

a.



$2\vec{v}$

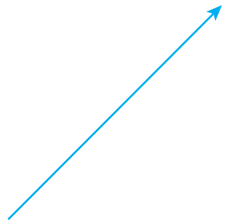
b.

$\frac{1}{2}\vec{v}$

c.

$-\frac{2}{3}\vec{v}$

d.

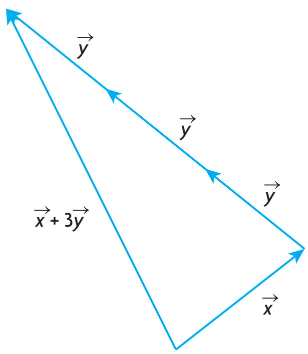


$-2\vec{v}$

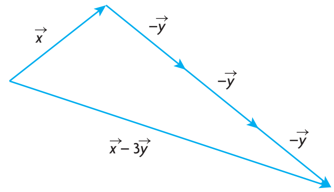
e.

$\frac{1}{|\vec{v}|}\vec{v}$

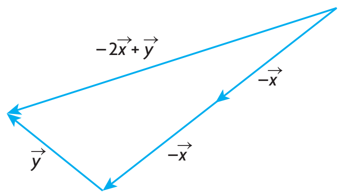
5. **a.**



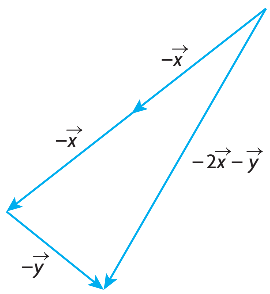
b.



c.

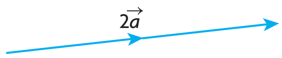


d.

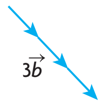


6. Answers may vary. For example:

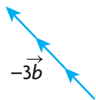
a.



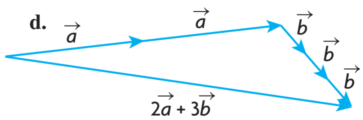
b.



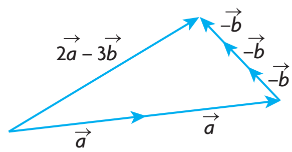
c.



d.



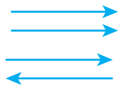
e.



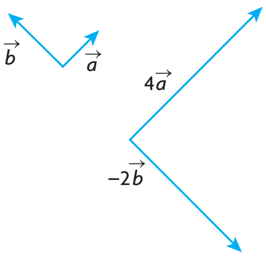
7. **a.** Answers may vary. For example: $m = 4,\ n = -3$, infinitely many

b. Answers may vary. For example: $d = 2, e = 0, f = -1$; not unique

8.



9. yes

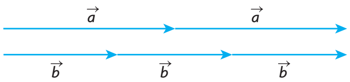


10. **a.** collinear
b. not collinear
c. not collinear
d. collinear

11. **a.** $\frac{1}{|\vec{x}|}\vec{x}$ is a vector with length 1 unit in the same direction as $\vec{x}$.

b. $-\frac{1}{|\vec{x}|}\vec{x}$ is a vector with length 1 unit in the opposite direction of $\vec{x}$.

12.



$m = \frac{2}{3}$

13. **a.** $-\frac{2}{3}\vec{a}$
b. $\frac{1}{3}\vec{a}$
c. $\frac{1}{3}|\vec{a}|$
d. $\frac{2}{3}|\vec{a}|$
e. $\frac{4}{3}\vec{a}$

14. $\sqrt{5}$ or 2.24, $\theta = 26.6°$ from $\vec{x}$ toward $2\vec{x} + \vec{y}$

15. 2.91, 9.9° from $\vec{x}$ toward $\vec{y}$

16. $\vec{b} = \frac{1}{|\vec{a}|}\vec{a}$

$|\vec{b}| = \left|\frac{1}{|\vec{a}|}\vec{a}\right|$

$|\vec{b}| = \frac{1}{|\vec{a}|}|\vec{a}|$

$|\vec{b}| = 1$

17. $\overrightarrow{AD} = \vec{c} + \overrightarrow{CD}$

$\overrightarrow{AD} = \vec{b} + \overrightarrow{BD}$

$2\overrightarrow{AD} = \vec{c} + \vec{b} + \overrightarrow{CD} + \overrightarrow{BD}$

But $\overrightarrow{CD} + \overrightarrow{BD} = 0$.

So, $2\overrightarrow{AD} = \vec{c} + \vec{b}$, or

$\overrightarrow{AD} = \frac{1}{2}\vec{c} + \frac{1}{2}\vec{b}$.

18. $\overrightarrow{MN} = \vec{b} - \vec{a}$

$\overrightarrow{QR} = 2\vec{b} - 2\vec{a}$

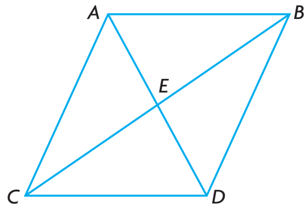
Notice that

$2\overrightarrow{MN} = 2\vec{b} - 2\vec{a}$

$= \overrightarrow{QR}$

We can conclude that $\overrightarrow{QR}$ is parallel to $\overrightarrow{MN}$ and $|\overrightarrow{QR}| = 2|\overrightarrow{MN}|$.

19.



Answers may vary. For example:

a. $\vec{u} = \overrightarrow{AB}$ and $\vec{v} = \overrightarrow{CD}$
b. $\vec{u} = \overrightarrow{AD}$ and $\vec{v} = \overrightarrow{AE}$
c. $\vec{u} = \overrightarrow{AC}$ and $\vec{v} = \overrightarrow{DB}$
d. $\vec{u} = \overrightarrow{ED}$ and $\vec{v} = \overrightarrow{AD}$

20. **a.** $|n| = 3|m|$
b. $m = 0, n = 0$

21. **a.** $\overrightarrow{CD} = \vec{b} - \vec{a}$

b. $\overrightarrow{BE} = 2\vec{b} - 2\vec{a}$

$= 2(\vec{b} - \vec{a})$

$= 2\overrightarrow{CD}$

The two are, therefore, parallel (collinear) and $\overrightarrow{BE} = 2|\overrightarrow{CD}|$.

22. Applying the triangle law for adding vectors shows that

$\overrightarrow{AC} = \overrightarrow{AD} + \overrightarrow{DC}$

The given information states that

$\overrightarrow{AB} = \frac{2}{3}\overrightarrow{DC}$

$\frac{3}{2}\overrightarrow{AB} = \overrightarrow{DC}$

By the properties of trapezoids, this gives

$\frac{3}{2}\overrightarrow{AE} = \overrightarrow{EC}$, and since

$\overrightarrow{AC} = \overrightarrow{AE} + \overrightarrow{EC}$, the original equation gives

$\overrightarrow{AE} + \frac{3}{2}\overrightarrow{AE} = \overrightarrow{AD} + \frac{3}{2}\overrightarrow{AB}$

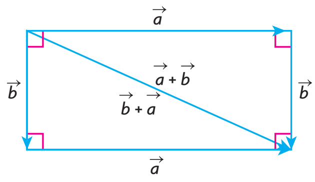
$\frac{5}{2}\overrightarrow{AE} = \overrightarrow{AD} + \frac{3}{2}\overrightarrow{AB}$

$\overrightarrow{AE} = \frac{2}{5}\overrightarrow{AD} + \frac{3}{5}\overrightarrow{AB}$

Section 6.4, pp. 306–307

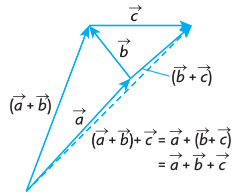
1. **a.** 0
b. 1
c. $\vec{0}$
d. 1

2.

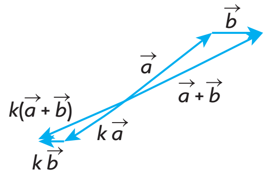


$\vec{a} + \vec{b} = \vec{b} + \vec{a}$

3.



4. Answers may vary. For example:



5. $\overrightarrow{PQ} = \overrightarrow{RQ} + \overrightarrow{SR} + \overrightarrow{TS} + \overrightarrow{PT}$

$= (\overrightarrow{RQ} + \overrightarrow{SR}) + (\overrightarrow{TS} + \overrightarrow{PT})$

$= (\overrightarrow{SR} + \overrightarrow{RQ}) + (\overrightarrow{PT} + \overrightarrow{TS})$

$= \overrightarrow{SQ} + \overrightarrow{PS}$

$= \overrightarrow{PS} + \overrightarrow{SQ}$

$= \overrightarrow{PQ}$

6. **a.** $\overrightarrow{EC}$
b. $\vec{0}$
c. Yes, the diagonals of a rectangular prism are of equal length.

7. $-4\vec{a} + 9\vec{b} - 24\vec{c}$

8. **a.** $12\vec{i} - 17\vec{j} + 5\vec{k}$
b. $-7\vec{i} + 11\vec{j} - 4\vec{k}$
c. $= -6\vec{i} + 13\vec{j} - 7\vec{k}$

9. $\vec{x} = \frac{5}{13}\vec{a} - \frac{18}{13}\vec{b}$,

$\vec{y} = \frac{1}{13}\vec{a} + \frac{12}{13}\vec{b}$

10. $\vec{a} = \vec{x} - \vec{y}$

$= \frac{2}{3}\vec{y} + \frac{1}{3}\vec{z} - (\vec{b} + \vec{z})$

$= \frac{2}{3}\vec{y} - \frac{2}{3}\vec{z} - \vec{b}$

$= \frac{2}{3}(\vec{y} - \vec{z}) - \vec{b}$

$= \frac{2}{3}\vec{b} - \vec{b}$

$= -\frac{1}{3}\vec{b}$

11. a. $\overrightarrow{AG} = \vec{a} + \vec{b} + \vec{c}$,
$\overrightarrow{BH} = -\vec{a} + \vec{b} + \vec{c}$,
$\overrightarrow{CE} = -\vec{a} - \vec{b} + \vec{c}$,
$\overrightarrow{DF} = \vec{a} - \vec{b} + \vec{c}$

b. $|\overrightarrow{AG}|^2 = |\vec{a}|^2 + |\vec{b}|^2 + |\vec{c}|^2$
$= |-\vec{a}|^2 + |\vec{b}|^2 + |\vec{c}|^2$
$= |\overrightarrow{BH}|^2$
$\therefore |\overrightarrow{AG}| = |\overrightarrow{BH}|$

12. Applying the triangle law for adding vectors shows that
$\overrightarrow{TY} = \overrightarrow{TZ} + \overrightarrow{ZY}$
The given information states that
$\overrightarrow{TX} = 2\overrightarrow{ZY}$
$\frac{1}{2}\overrightarrow{TX} = \overrightarrow{ZY}$
By the properties of trapezoids, this gives
$\frac{1}{2}\overrightarrow{TO} = \overrightarrow{OY}$, and since
$\overrightarrow{TY} = \overrightarrow{TO} + \overrightarrow{OY}$, the original equation gives
$\overrightarrow{TO} + \frac{1}{2}\overrightarrow{TO} = \overrightarrow{TZ} + \frac{1}{2}\overrightarrow{TX}$
$\frac{3}{2}\overrightarrow{TO} = \overrightarrow{TZ} + \frac{1}{2}\overrightarrow{TX}$
$\overrightarrow{TO} = \frac{2}{3}\overrightarrow{TZ} + \frac{1}{3}\overrightarrow{TX}$

Mid-Chapter Review, pp. 308–309

1. a. $\overrightarrow{AB} = \overrightarrow{DC}$, $\overrightarrow{BA} = \overrightarrow{CD}$,
$\overrightarrow{AD} = \overrightarrow{BC}$, $\overrightarrow{CB} = \overrightarrow{DA}$
There is not enough information to determine if there is a vector equal to $\overrightarrow{AP}$.

b. $|\overrightarrow{PD}| = |\overrightarrow{DA}|$
$= |\overrightarrow{BC}|$ (parallelogram)

2. a. $\overrightarrow{RV}$ **b.** $\overrightarrow{RV}$ **c.** $\overrightarrow{PS}$ **d.** $\overrightarrow{RU}$ **e.** $\overrightarrow{PS}$ **f.** $\overrightarrow{PQ}$

3. a. $\sqrt{3}$
b. 53°

4. $t = 4$ or $t = -4$

5. In quadrilateral $PQRS$, look at $\triangle PQR$. Joining the midpoints B and C creates a vector $\overrightarrow{BC}$ that is parallel to $\overrightarrow{PR}$ and half the length of $\overrightarrow{PR}$. Look at $\triangle SPR$. Joining the midpoints A and D creates a vector $\overrightarrow{AD}$ that is parallel to $\overrightarrow{PR}$ and half the length of $\overrightarrow{PR}$. $\overrightarrow{BC}$ is parallel to $\overrightarrow{AD}$ and equal in length to $\overrightarrow{AD}$. Therefore, $ABCD$ is a parallelogram.

6. a. $2\sqrt{21}$
b. 71°
c. $\frac{1}{|\vec{u} + \vec{v}|}(\vec{u} + \vec{v}) = \frac{1}{2\sqrt{21}}(\vec{u} + \vec{v})$
d. $20\sqrt{7}$

7. 3

8. $|\vec{m} + \vec{n}| = \big||\vec{m}| - |\vec{n}|\big|$

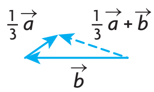
9. $\overrightarrow{BC} = -\vec{y}$, $\overrightarrow{DC} = \vec{x}$,
$\overrightarrow{BD} = -\vec{x} - \vec{y}$, $\overrightarrow{AC} = \vec{x} - \vec{y}$

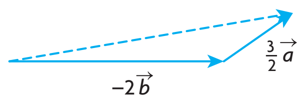
10. Construct a parallelogram with sides $\overrightarrow{OA}$ and $\overrightarrow{OC}$. Since the diagonals bisect each other, $2\overrightarrow{OB}$ is the diagonal equal to $\overrightarrow{OA} + \overrightarrow{OC}$. Or
$\overrightarrow{OB} = \overrightarrow{OA} + \overrightarrow{AB}$ and $\overrightarrow{AB} = \frac{1}{2}\overrightarrow{AC}$.
So, $\overrightarrow{OB} = \overrightarrow{OA} + \frac{1}{2}\overrightarrow{AC}$.
And $\overrightarrow{AC} = \overrightarrow{OC} - \overrightarrow{OA}$.
Now $\overrightarrow{OB} = \overrightarrow{OA} + \frac{1}{2}(\overrightarrow{OC} - \overrightarrow{OA})$,
Multiplying by 2 gives
$2\,\overrightarrow{OB} = \overrightarrow{OA} + \overrightarrow{OC}$.

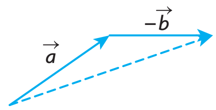
11. $\overrightarrow{BD} = 2\vec{x} + \vec{y}$
$\overrightarrow{BC} = 2\vec{x} - \vec{y}$

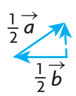
12. 460 km/h, south

13. a. $\overrightarrow{PT}$
b. $\overrightarrow{PT}$
c. $\overrightarrow{SR}$

14. a.


b.


c.


d.


15. $\overrightarrow{PS} = \overrightarrow{PQ} + \overrightarrow{QS}$
$= 3\vec{b} - \vec{a}$
$\overrightarrow{RS} = \overrightarrow{QS} - \overrightarrow{QR}$
$= -3\vec{a}$

Section 6.5, pp. 316–318

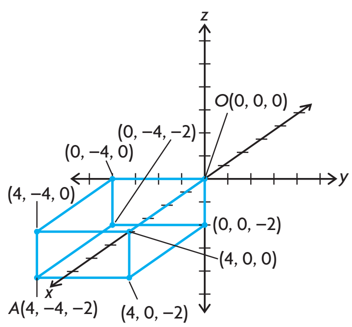
1. No, as the y-coordinate is not a real number.

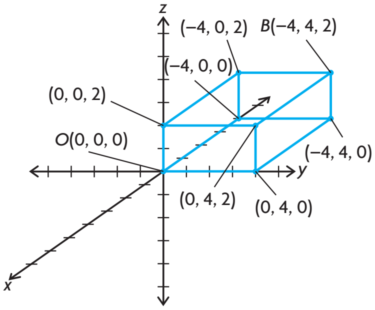
2. a. We first arrange the x-, y-, and z-axes (each a copy of the real line) in a way so that each pair of axes are perpendicular to each other (i.e., the x- and y-axes are arranged in their usual way to form the xy-plane, and the z-axis passes through the origin of the xy-plane and is perpendicular to this plane). This is easiest viewed as a "right-handed system," where, from the viewer's perspective, the positive z-axis points upward, the positive x-axis points out of the page, and the positive y-axis points rightward in the plane of the page. Then, given point $P(a, b, c)$, we locate this point's unique position by moving a units along the x-axis, then from there b units parallel to the y-axis, and finally c units parallel to the z-axis. It's associated unique position vector is determined by drawing a vector with tail at the origin $O(0, 0, 0)$ and head at P.

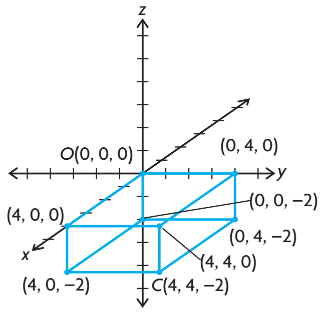
b. Since this position vector is unique, its coordinates are unique. Therefore, $a = -4$, $b = -3$, and $c = -8$.

3. a. $a = 5$, $b = -3$, and $c = 8$.
b. $(5, -3, 8)$

4. This is not an acceptable vector in I^3 as the z-coordinate is not an integer. However, since all of the coordinates are real numbers, this is acceptable as a vector in R^3.

5.






6. **a.** $A(0, -1, 0)$ is located on the y-axis. $B(0, -2, 0)$ $C(0, 2, 0)$, and $D(0, 10, 0)$ are three other points on this axis.

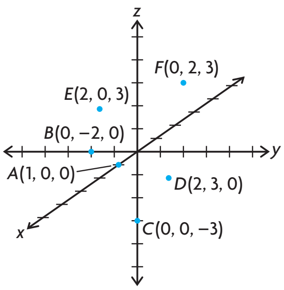
b. $\overrightarrow{OA} = (0, -1, 0)$, the vector with tail at the origin $O(0, 0, 0)$ and head at A.

7. **a.** Answers may vary. For example: $\overrightarrow{OA} = (0, 0, 1)$, $\overrightarrow{OB} = (0, 0, -1)$, $\overrightarrow{OC} = (0, 0, -5)$

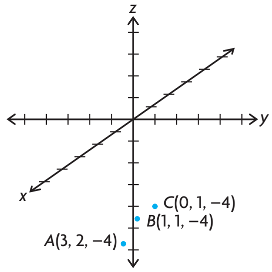
b. Yes, these vectors are collinear (parallel), as they all lie on the same line, in this case the z-axis.

c. A general vector lying on the z-axis would be of the form $\overrightarrow{OA} = (0, 0, a)$ for any real number a. Therefore, this vector would be represented by placing the tail at O and the head at the point (0, 0, a) on the z-axis.

8.

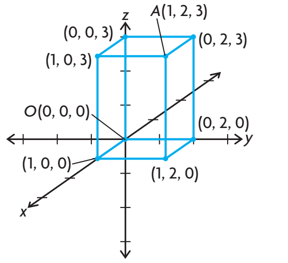


9. **a.**

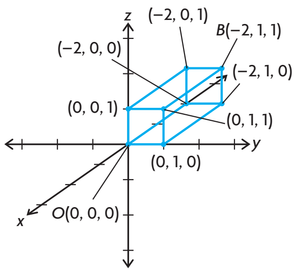


b. $z = -4$

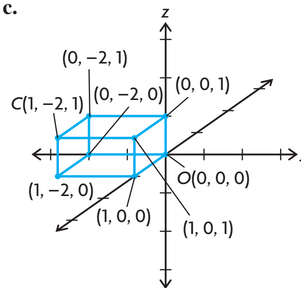
10. **a.**



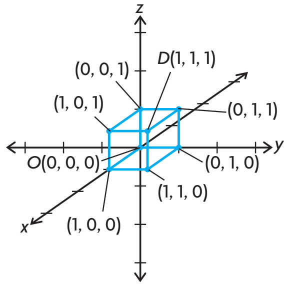
b.



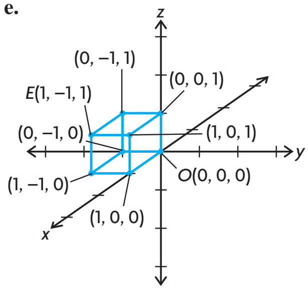
c.



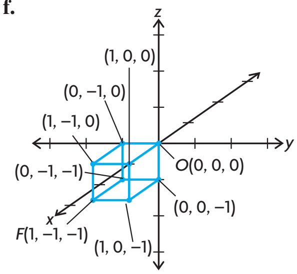
d.



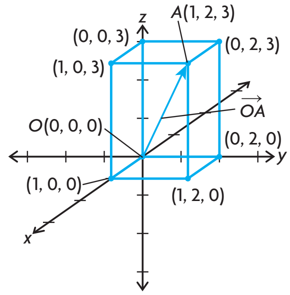
e.



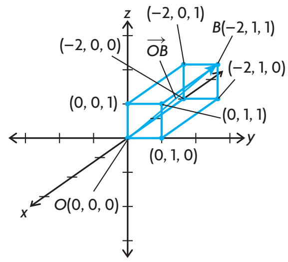
f.



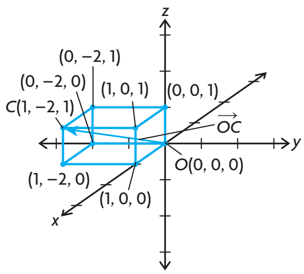
11. **a.** $\overrightarrow{OA} = (1, 2, 3)$



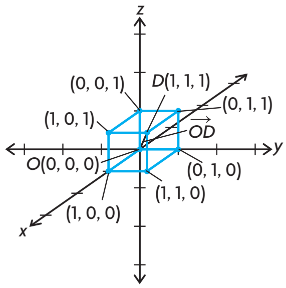
b. $\overrightarrow{OB} = (-2, 1, 1)$



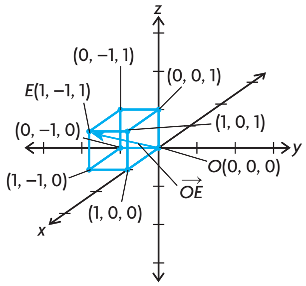
c. $\overrightarrow{OC} = (1, -2, 1)$



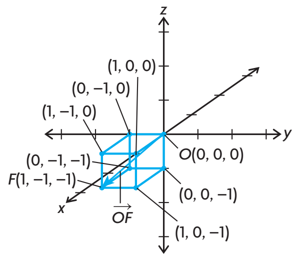
d. $\overrightarrow{OD} = (1, 1, 1)$



e. $\overrightarrow{OE} = (1, -1, 1)$



f. $\overrightarrow{OF} = (1, -1, -1)$



12. a. $a = 11$ $c = 5$

b. Since P and Q represent the same point in R^3, they will have the same associated position vector, i.e., $|\overrightarrow{OP}| = |\overrightarrow{OQ}|$. So, since these vectors are equal, they will certainly have equal magnitudes, i.e., $|\overrightarrow{OP}| = |\overrightarrow{OQ}|$.

13. xy-plane, $z = 0$; xz-plane, $y = 0$; yz-plane, $x = 0$.

14. a. Every point on the plane containing points M, N, and P has y-coordinate equal to 0. Therefore, the equation of the plane containing these points is $y = 0$ (this is just the xz-plane).

b. The plane $y = 0$ contains the origin $O(0, 0, 0)$, and so since it also contains the points M, N, and P as well, it will contain the position vectors associated with these points joining O (tail) to the given point (head). That is, the plane $y = 0$ contains the vectors $\overrightarrow{OM}$, $\overrightarrow{ON}$, and $\overrightarrow{OP}$.

15. a. $A(-2, 0, 0)$, $B(-2, 4, 0)$, $C(0, 4, 0)$, $D(0, 0, -7)$, $E(0, 4, -7)$, $F(-2, 0, -7)$

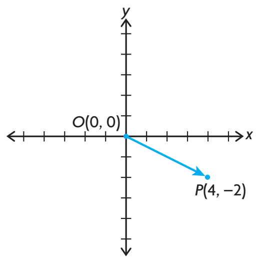
b. $\overrightarrow{OA} = (-2, 0, 0)$,
$\overrightarrow{OB} = (-2, 4, 0)$,
$\overrightarrow{OC} = (0, 4, 0)$, $\overrightarrow{OD} = (0, 0, -7)$,
$\overrightarrow{OE} = (0, 4, -7)$,
$\overrightarrow{OF} = (-2, 0, -7)$

c. 7 units

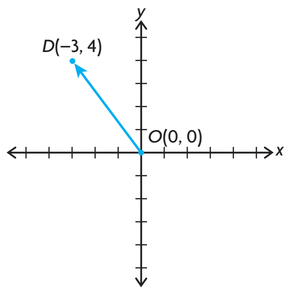
d. $y = 4$

e. Every point contained in rectangle $BCEP$ has y-coordinate equal to 4, and so is of the form $(x, 4, z)$, where x and z are real numbers such that $-2 \leq x \leq 0$ and $-7 \leq z \leq 0$.

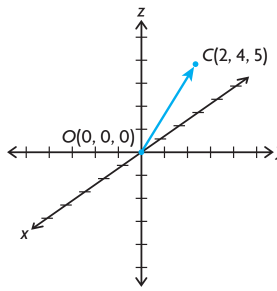
16. a.



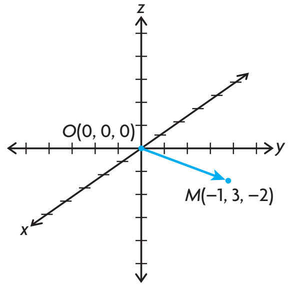
b.



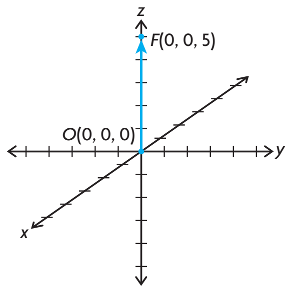
c.



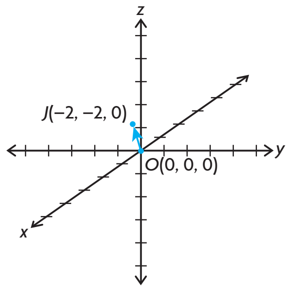
d.



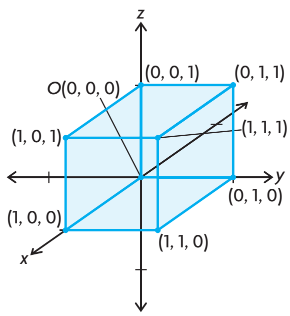
e.



f.



17.



18. First, $\overrightarrow{OP} = \overrightarrow{OA} + \overrightarrow{OB}$ by the triangle law of vector addition, where $\overrightarrow{OA} = (5, -10, 0)$, $\overrightarrow{OB} = (0, 0, -10)$, $\overrightarrow{OP}$ and $\overrightarrow{OA}$ are drawn in standard position (starting from the origin O $(0, 0, 0)$), and $\overrightarrow{OB}$ is drawn starting from the head of $\overrightarrow{OA}$. Notice that $\overrightarrow{OA}$

lies in the xy-plane, and $\overrightarrow{OB}$ is perpendicular to the xy-plane (so is perpendicular to $\overrightarrow{OA}$). So, $\overrightarrow{OP}$, $\overrightarrow{OA}$, and $\overrightarrow{OB}$ form a right triangle and, by the Pythagorean theorem,

$$|\overrightarrow{OP}|^2 = |\overrightarrow{OA}|^2 + |\overrightarrow{OB}|^2$$

Similarly, $\overrightarrow{OA} = \vec{a} + \vec{b}$ by the triangle law of vector addition, where $\vec{a} = (5, 0, 0)$ and $\vec{b} = (0, -10, 0)$, and these three vectors form a right triangle as well. So,

$$\begin{aligned}|\overrightarrow{OA}|^2 &= |\vec{a}|^2 + |\vec{b}|^2\\ &= 25 + 100\\ &= 125\end{aligned}$$

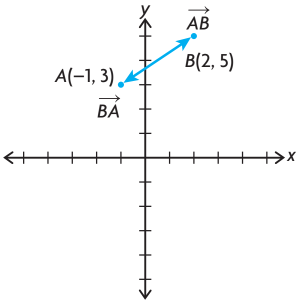
Obviously $|\overrightarrow{OB}|^2 = 100$, and so substituting gives

$$\begin{aligned}|\overrightarrow{OP}|^2 &= |\overrightarrow{OA}|^2 + |\overrightarrow{OB}|^2\\ &= 125 + 100\\ &= 225\\ |\overrightarrow{OP}| &= \sqrt{225}\\ &= 15\end{aligned}$$

19. $(6, -5, 2)$

Section 6.6, pp. 324–326

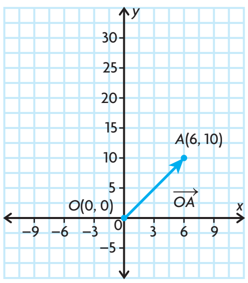
1. **a.** $\overrightarrow{AB} = (3, 2)$, $\overrightarrow{BA} = (-3, -2)$



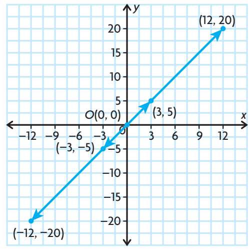
b. $|\overrightarrow{OA}| \doteq 3.16$, $|\overrightarrow{OB}| \doteq 5.39$

c. $|\overrightarrow{AB}| \doteq 3.61$, $|\overrightarrow{BA}| \doteq 3.61$

2.



a.



b. $\frac{1}{2}\overrightarrow{OA}$ and $-\frac{1}{2}\overrightarrow{OA}$, $2\overrightarrow{OA}$ and $-2\overrightarrow{OA}$

3. 5

4. **a.** $a = -3$, $b = 5$

b. 5.83

5. **a.** $|\vec{a}| = 61$, $|\vec{b}| = 41$

b. $|\vec{a} + \vec{b}| \doteq 100.02$, $|\vec{a} - \vec{b}| \doteq 28.28$

6. **a.** $(-2, 7)$

b. $(-30, 0)$

c. $(1, 11)$

7. **a.** $7\vec{i} - 8\vec{j}$

b. $3\vec{i} - 51\vec{j}$

c. $-29\vec{i} + 28\vec{j}$

8. **a.** about 4.12

b. about 6.71

c. about 18.38

d. about 18.38

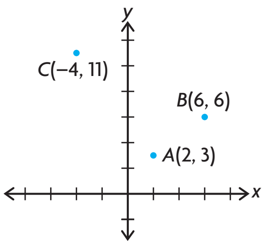
9. **a.** $\overrightarrow{AB} = (4, 2)$, $\overrightarrow{CD} = (2, 4)$, $\overrightarrow{EF} = (-6, 4)$, $\overrightarrow{GH} = (5, 0)$

b. $|\overrightarrow{AB}| \doteq 4.47$, $|\overrightarrow{CD}| \doteq 4.47$, $|\overrightarrow{EF}| \doteq 7.21$, $|\overrightarrow{GH}| = 5$

10. **a.** $\overrightarrow{OC} = (17, -3)$, $\overrightarrow{BA} = (-5, 9)$, $\overrightarrow{BC} = (6, 3)$

b. $\overrightarrow{OA} = (6, 3) = \overrightarrow{BC}$, so obviously we will have $|\overrightarrow{OA}| = |\overrightarrow{BC}|$.

11. **a.**

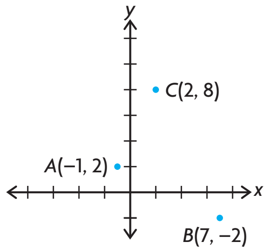


b. $\overrightarrow{AB}(4, 3)$, $|\overrightarrow{AB}| = 5$, $|\overrightarrow{AC}| = 10$, $\overrightarrow{CB} \doteq 11.18$

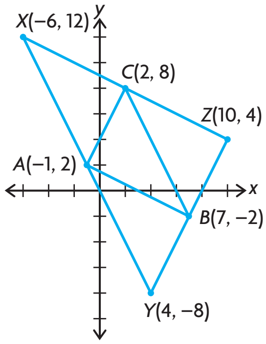
c. $|\overrightarrow{CB}|^2 = 125$, $|\overrightarrow{AC}|^2 = 100$, $|\overrightarrow{AB}|^2 = 25$

Since $|\overrightarrow{CB}|^2 = |\overrightarrow{AC}|^2 + |\overrightarrow{AB}|^2$, the triangle is a right triangle.

12. **a.**



b.

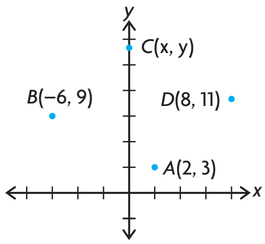


c. $X(-6, 12)$, $Y(4, -8)$, $Z(10, 4)$

13. **a.** $x = 7$, $y = -2$

b. $x = -12$, $y = 4$.

14. **a.**



b. Because $ABCD$ is a rectangle, we will have

$$\begin{aligned}\overrightarrow{BC} &= \overrightarrow{AD}\\ (x, y) - (-6, 9) &= (8, 11) - (2, 3)\\ (x + 6, y - 9) &= (6, 8)\\ x + 6 &= 6\\ y - 9 &= 8\end{aligned}$$

So, $x = 0$ and $y = 17$, i.e., $C(0, 17)$.

15. **a.** $P\left(\frac{21}{10}, 0\right)$

b. $Q\left(0, -\frac{21}{4}\right)$

16. $\left(\frac{9}{41}, \frac{40}{41}\right)$

17. **a.** about 80.9°

b. about 35.4°

Section 6.7, pp. 332–333

1. **a.** $-1\vec{i} + 2\vec{j} + 4\vec{k}$
b. about 4.58

2. $\overrightarrow{OB} = (3, 4, -4)$, $|\overrightarrow{OB}| = 6.40$

3. 3

4. **a.** $(-1, 6, 11)$
b. $|\overrightarrow{OA}| = 13$, $|\overrightarrow{OB}| = 3$,
$|\overrightarrow{OP}| \doteq 12.57$
c. $\overrightarrow{AB} = (5, -2, -13)$,
$|\overrightarrow{AB}| \doteq 14.07$,
$\overrightarrow{AB}$ represents the vector from the tip of $\overrightarrow{OA}$ to the tip of $\overrightarrow{OB}$. It is the difference between the two vectors.

5. **a.** $(1, -3, 3)$
b. $(-7, -16, 8)$
c. $\left(-\frac{13}{2}, 2, \frac{3}{2}\right)$
d. $(2, 30, -13)$

6. **a.** $\vec{i} - 2\vec{j} + 2\vec{k}$
b. $3\vec{i} + 0\vec{j} + 0\vec{k}$
c. $9\vec{i} + 3\vec{j} - 3\vec{k}$
d. $-9\vec{i} - 3\vec{j} + 3\vec{k}$

7. **a.** about 5.10
b. about 1.41
c. about 5.39
d. about 11.18

8. $\vec{x} = \vec{i} + 4\vec{j} - \vec{k}$,
$\vec{y} = -2\vec{i} - 2\vec{j} + 6\vec{k}$

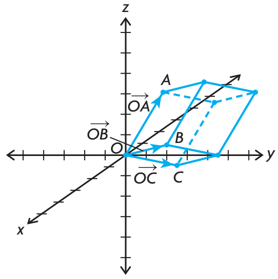
9. **a.** The vectors $\overrightarrow{OA}$, $\overrightarrow{OB}$, and $\overrightarrow{OC}$ represent the *xy*-plane, *xz*-plane, and *yz*-plane, respectively. They are also the vector from the origin to points $(a, b, 0)$, $(a, 0, c)$, and $(0, b, c)$, respectively.
b. $\overrightarrow{OA} = a\vec{i} + b\vec{j} + 0\vec{k}$,
$\overrightarrow{OB} = a\vec{i} + 0\vec{j} + c\vec{k}$,
$\overrightarrow{OC} = 0\vec{i} + b\vec{j} + c\vec{k}$
c. $|\overrightarrow{OA}| = \sqrt{a^2 + b^2}$,
$|\overrightarrow{OB}| = \sqrt{a^2 + c^2}$,
$|\overrightarrow{OB}| = \sqrt{b^2 + c^2}$
d. $(0, -b, c)$, $\overrightarrow{AB}$ is a direction vector from *A* to *B*.

10. **a.** 7
b. 13
c. $(5, 2, 9)$
d. 10.49
e. $(-5, -2, -9)$
f. 10.49

11. In order to show that *ABCD* is a parallelogram, we must show that $\overrightarrow{AB} = \overrightarrow{DC}$ or $\overrightarrow{BC} = \overrightarrow{AD}$. This will show they have the same direction, thus the opposite sides are parallel.
$\overrightarrow{AB} = (3, -4, 12)$
$\overrightarrow{DC} = (3, -4, 12)$
We have shown $\overrightarrow{AB} = \overrightarrow{DC}$ and $\overrightarrow{BC} = \overrightarrow{AD}$, so *ABCD* is a parallelogram.

12. $a = \frac{2}{3}$, $b = 7$, $c = 0$

13. **a.**



b. $V_1 = (0, 0, 0)$,
$V_2 = (-2, 2, 5)$,
$V_3 = (0, 4, 1)$,
$V_4 = (0, 5, -1)$,
$V_5 = (-2, 6, 6)$,
$V_6 = (-2, 7, 4)$,
$V_7 = (0, 9, 0)$,
$V_8 = (-2, 11, 5)$

14. $(1, 0, 0)$

15. 4.36

Section 6.8, pp. 340–341

1. They are collinear, thus a linear combination is not applicable.

2. It is not possible to use $\vec{0}$ in a spanning set. Therefore, the remaining vectors only span R^2.

3. The set of vectors spanned by $(0, 1)$ is $m(0, 1)$. If we let $m = -1$, then $m(0, 1) = (0, -1)$.

4. $\vec{i}$ spans the set $m(1, 0, 0)$. This is any vector along the *x*-axis. Examples: $(2, 0, 0)$, $(-21, 0, 0)$.

5. As in question 2, it isn't possible to use $\vec{0}$ in a spanning set.

6. $\{(-1, 2), (-1, 1)\}$, $\{(2, -4), (-1, 1)\}$, $\{(-1, 1), (-3, 6)\}$ are all the possible spanning sets for R^2 with 2 vectors.

7. **a.** $14\vec{i} - 43\vec{j} + 40\vec{k}$
b. $-7\vec{i} + 23\vec{j} - 14\vec{k}$

8. $\{(1, 0, 0), (0, 1, 0)\}$:
$(-1, 2, 0) = -1(1, 0, 0) + 2(0, 1, 0)$
$(3, 4, 0) = 3(1, 0, 0) + 4(0, 1, 0)$
$\{(1, 1, 0), (0, 1, 0)\}$
$(-1, 2, 0) = -1(1, 1, 0) + 3(0, 1, 0)$
$(3, 4, 0) = 3(1, 1, 0) + (0, 1, 0)$

9. **a.** It is the set of vectors in the *xy*-plane.
b. $-2(1, 0, 0) + 4(0, 1, 0)$
c. By part a., the vector is not in the *xy*-plane. There is no combination that would produce a number other than 0 for the *z*-component.
d. It would still only span the *xy*-plane. There would be no need for that vector.

10. $a = -2$, $b = 24$, $c = 3$

11. $(-10, -34) = 2(-1, 3) - 8(1, 5)$

12. **a.** $a = x + y$,
$b = x + 2y$
b. $(2, -3) = -1(2, -1) - 4(-1, 1)$
$(124, -5) = 119(2, 1) + 114(-1, 1)$
$(4, -11) = -7(2, 1) - 18(-1, 1)$

13. **a.** The statement $a(-1, 2, 3) + b(4, 1, -2) = (-14, -1, 16)$ does not have a consistent solution.
b. $3(-1, 3, 4) - 5(0, -1, 1) = (-3, 14, 7)$

14. -7

15. $m = 2$, $n = 3$; Non-parallel vectors cannot be equal, unless their magnitudes equal 0.

16. Answers may vary. For example:
$p = -6$ and $q = 1$,
$p = 25$ and $q = 0$,
$p = \frac{13}{3}$ and $q = \frac{2}{3}$

17. As in question 15, non-parallel vectors. Their magnitudes must be 0 again to make the equality true.
$m^2 + 2m - 3 = (m - 1)(m + 3)$
$m = 1, -3$
$m^2 + m - 6 = (m - 2)(m + 3)$
$m = 2, -3$
So, when $m = -3$, their sum will be 0.

Review Exercise, pp. 344–347

1. **a.** false; Let $\vec{b} = -\vec{a} \neq 0$, then:
$|\vec{a} + \vec{b}| = |\vec{a} + (-\vec{a})|$
$= |0|$
$= 0 < |\vec{a}|$
b. true; $|\vec{a} + \vec{b}|$ and $|\vec{a} + \vec{c}|$ both represent the lengths of the diagonal of a parallelogram, the first with sides $\vec{a}$ and $\vec{b}$ and the second with sides $\vec{a}$ and $\vec{c}$; since both parallelograms have $\vec{a}$ as a side and diagonals of equal length $|\vec{b}| = |\vec{c}|$.
c. true; Subtracting $\vec{a}$ from both sides shows that $\vec{b} = \vec{c}$.

d. true; Draw the parallelogram formed by $\vec{RF}$ and $\vec{SW}$. $\vec{FW}$ and $\vec{RS}$ are the opposite sides of a parallelogram and must be equal.

e. true; the distributive law for scalars

f. false; Let $\vec{b} = -\vec{a}$ and let $\vec{c} = \vec{d} \neq 0$. Then, $|\vec{a}| = |-\vec{a}| = |\vec{b}|$ and $|\vec{c}| = |\vec{d}|$ but $|\vec{a} + \vec{b}| = |\vec{a} + (-\vec{a})| = 0$

$|\vec{c} + \vec{b}| = |\vec{c} + \vec{c}| = |2\vec{c}|$

so $|\vec{a} + \vec{b}| \neq |\vec{c} + \vec{d}|$

2. **a.** $20\vec{a} - 30\vec{b} + 8\vec{c}$

b. $\vec{a} - 3\vec{b} - 3\vec{c}$

3. **a.** $\vec{XY} = (-2, 3, 6)$, $|\vec{XY}| = 7$

b. $\left(-\frac{2}{7}, \frac{3}{7}, \frac{6}{7}\right)$

4. **a.** $(-6, -3, -6)$

b. $\left(-\frac{2}{3}, -\frac{1}{3}, -\frac{2}{3}\right)$

5. $\left(-\frac{6}{7}, \frac{2}{7}, \frac{3}{7}\right)$

6. **a.** $\vec{OA} + \vec{OB} = (-3, 8, -8)$, $\vec{OA} - \vec{OB} = (9, -4, -4)$

b. $\theta \doteq 84.4°$

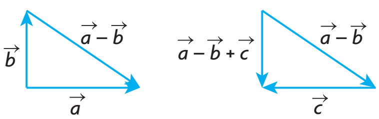
7. **a.** $|\vec{AB}| = \sqrt{14}$, $|\vec{BC}| = \sqrt{59}$, $|\vec{CA}| = \sqrt{45}$

b. 12.5

c. 18.13

d. $(6, 2, -2)$

8. **a.**



b. 5

9. $\frac{1}{2}(-11, 7) + \left(-\frac{3}{2}\right)(-3, 1) = (-1, 2)$,

$\frac{1}{3}(-11, 7) + \left(-\frac{2}{3}\right)(-1, 2) = (-3, 1)$,

$3(-3, 1) + 2(-1, 2) = (-11, 7)$

10. **a.** $x - 3y + 6z = 0$ where $P(x, y, z)$ is the point.

b. $(0, 0, 0)$ and $\left(1, \frac{1}{3}, 0\right)$

11. **a.** $a = -3, b = 26.5, c = 10$

b. $a = 8, b = \frac{7}{3}, c = -10$

12. **a.** yes

b. yes

13. **a.** $|\vec{AB}|^2 = 9$, $|\vec{AC}|^2 = 3$, $|\vec{BC}|^2 = 6$

Since $|\vec{AB}|^2 = |\vec{AC}|^2 + |\vec{BC}|^2$ the triangle is right-angled

b. $\frac{\sqrt{6}}{3}$

14. **a.** $\vec{DA}, \vec{BC}$ and $\vec{EB}, \vec{ED}$

b. $\vec{DC}, \vec{AB}$ and $\vec{CE}, \vec{EA}$

c. $|\vec{AD}|^2 + |\vec{DC}|^2 = |\vec{AC}|^2$

But $|\vec{AC}|^2 = |\vec{DB}|^2$

Therefore, $|\vec{AD}|^2 + |\vec{DC}|^2 = |\vec{DB}|^2$

15. **a.** $C(3, 0, 5)$, $P(3, 4, 5)$, $E(0, 4, 5)$, $F(0, 4, 0)$

b. $\vec{DB} = (3, 4, -5)$, $\vec{CF} = (-3, 4, -5)$

c. 90°

d. 50.2°

16. **a.** 7.74

b. 2.83

c. 2.83

17. **a.** 1236.9 km

b. S14.0°W

18. **a.** Any pair of nonzero, noncollinear vectors will span R^2. To show that (2, 3) and (3, 5) are noncollinear, show that there does not exist any number k such that $k(2, 3) = (3, 5)$. Solve the system of equations:

$2k = 3$

$3k = 5$

Solving both equations gives two different values for k, $\frac{3}{2}$ and $\frac{5}{3}$, so (2, 3) and (3, 5) are noncollinear and thus span R^2.

b. $m = -770, n = 621$

19. **a.** Find a and b such that

$(5, 9, 14) = a(-2, 3, 1) + b(3, 1, 4)$

$(5, 9, 14) = (-2a, 3a, a) + (3b, b, 4b)$

$(5, 9, 14) = (-2a + 3b, 3a + b, a + 4b)$

i. $5 = -2a + 3b$

ii. $9 = 3a + b$

iii. $14 = a + 4b$

Use the method of elimination with i. and iii.

$2(14) = 2(a + 4b)$

$28 = 2a + 8b$

$+\ \ 5 = -2a + 3b$

$33 = 11b$

$3 = b$

By substitution, $a = 2$.

$\vec{a}$ lies in the plane determined by $\vec{b}$ and $\vec{c}$ because it can be written as a linear combination of $\vec{b}$ and $\vec{c}$.

b. If vector $\vec{a}$ is in the span of $\vec{b}$ and $\vec{c}$, then $\vec{a}$ can be written as a linear combination of $\vec{b}$ and $\vec{c}$. Find m and n such that

$(-13, 36, 23) = m(-2, 3, 1) + n(3, 1, 4)$

$= (-2m, 3m, m) + (3n, n, 4n)$

$= (-2m + 3n, 3m + n, m + 4n)$

Solve the system of equations:

$-13 = -2m + 3n$

$36 = 3m + n$

$23 = m + 4n$

Use the method of elimination:

$2(23) = 2(m + 4n)$

$46 = 2m + 8n$

$+\ -13 = -2m + 3n$

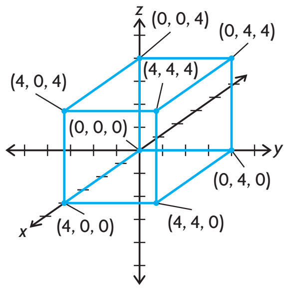
$33 = 11n$

$3 = n$

By substitution, $m = 11$.

So, vector $\vec{a}$ is in the span of $\vec{b}$ and $\vec{c}$.

20. **a.**



b. $(-4, -4, -4)$

c. $(-4, 0, -4)$

d. $(4, 4, 0)$

21. 7

22. **a.** $|\vec{AB}| = 10$, $|\vec{BC}| = 2\sqrt{5} = 4.47$, $|\vec{CA}| = \sqrt{80} = 8.94$

b. If A, B, and C are vertices of a right triangle, then

$|\vec{BC}|^2 + |\vec{CA}|^2 = |\vec{AB}|^2$

$|\vec{BC}|^2 + |\vec{CA}|^2 = (2\sqrt{5})^2 + (\sqrt{80})^2$

$= 20 + 80$

$= 100$

$|\vec{AB}|^2 = 10^2$

$= 100$

So, triangle ABC is a right triangle.

23. **a.** $\vec{a} + \vec{b} + \vec{c}$

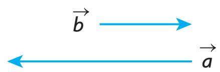
b. $\vec{a} - \vec{b}$

c. $-\vec{b} - \vec{a} + \vec{c}$

d. $\vec{0}$

e. $\vec{b} + \vec{c}$

24.

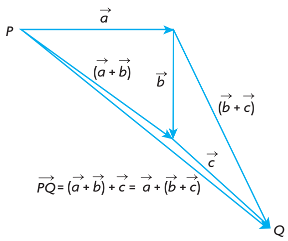


25. **a.** $\sqrt{|\vec{a}|^2 + |\vec{b}|^2}$
b. $\sqrt{|\vec{a}|^2 + |\vec{b}|^2}$
c. $\sqrt{4|\vec{a}|^2 + 9|\vec{b}|^2}$

26. **Case 1** If $\vec{b}$ and $\vec{c}$ are collinear, then $2\vec{b} + 4\vec{c}$ is also collinear with both $\vec{b}$ and $\vec{c}$. But $\vec{a}$ is perpendicular to $\vec{b}$ and $\vec{c}$, so $\vec{a}$ is perpendicular to $2\vec{b} + 4\vec{c}$.
Case 2 If $\vec{b}$ and $\vec{c}$ are not collinear, then by spanning sets, $\vec{b}$ and $\vec{c}$ span a plane in R^3, and $2\vec{b} + 4\vec{c}$ is in that plane. If $\vec{a}$ is perpendicular to $\vec{b}$ and $\vec{c}$, then it is perpendicular to the plane and all vectors in the plane. So, $\vec{a}$ is perpendicular to $2\vec{b} + 4\vec{c}$.

Chapter 6 Test, p. 348

1. Let P be the tail of $\vec{a}$ and let Q be the head of $\vec{c}$. The vector sums $[\vec{a} + (\vec{b} + \vec{c})]$ and $[(\vec{a} + \vec{b}) + \vec{c}]$ can be depicted as in the diagram below, using the triangle law of addition.
We see that $\overrightarrow{PQ} = \vec{a} + (\vec{b} + \vec{c}) = (\vec{a} + \vec{b}) + \vec{c}$. This is the associative property for vector addition.



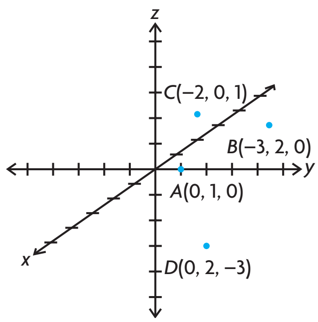
2. **a.** (8, 4, 8)
b. 12
c. $\left(-\frac{2}{3}, -\frac{1}{3}, -\frac{2}{3}\right)$
3. $\sqrt{19}$
4. **a.** $\vec{x} = 2\vec{b} - 3\vec{a}, \vec{y} = 3\vec{b} - 5\vec{a}$
b. $a = 1, b = 5, c = -11$
5. **a.** $\vec{a}$ and $\vec{b}$ span R^2, because any vector (x, y) in R^2 can be written as a linear combination of $\vec{a}$ and $\vec{b}$. These two vectors are not multiples of each other.
b. $p = -2, q = 3$
6. **a.** $(1, 12, -29) = -2(3, 1, 4) + 7(1, 2, -3)$
b. $\vec{r}$ cannot be written as a linear combination of $\vec{p}$ and $\vec{q}$. In other words, $\vec{r}$ does not lie in the plane determined by $\vec{p}$ and $\vec{q}$.
7. $\sqrt{13}, \theta \doteq 3.61$; 73.9° relative to x

8. $\overrightarrow{DE} = \overrightarrow{CE} - \overrightarrow{CD}$
$\overrightarrow{DE} = \vec{b} - \vec{a}$
Also,
$\overrightarrow{BA} = \overrightarrow{CA} - \overrightarrow{CB}$
$\overrightarrow{BA} = 2\vec{b} - 2\vec{a}$
Thus,
$\overrightarrow{DE} = \frac{1}{2}\overrightarrow{BA}$

Chapter 7

Review of Prerequisite Skills, p. 350

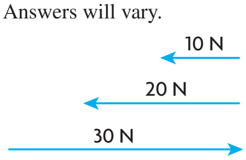
1. $v \doteq 806$ km/h N 7.1° E
2. 15.93 units W 32.2° N
3.



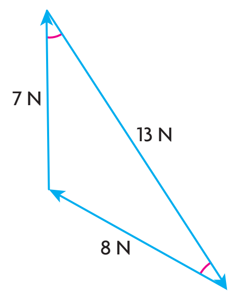
4. **a.** $(3, -2, 7); l \doteq 7.87$
b. $(-9, 3, 14); l \doteq 16.91$
c. $(1, 1, 0); l \doteq 1.41$
d. $(2, 0, -9); l \doteq 9.22$
5. **a.** $(x, y, 0)$
b. $(x, 0, z)$
c. $(0, y, z)$
6. **a.** $\vec{i} - 7\vec{j}$
b. $6\vec{i} - 2\vec{j}$
c. $-8\vec{i} + 11\vec{j} + 3\vec{k}$
d. $4\vec{i} - 6\vec{j} + 8\vec{k}$
7. **a.** $\vec{i} + 3\vec{j} - \vec{k}$
b. $5\vec{i} + \vec{j} - \vec{k}$
c. $12\vec{i} + \vec{j} - 2\vec{k}$

Section 7.1, pp. 362–364

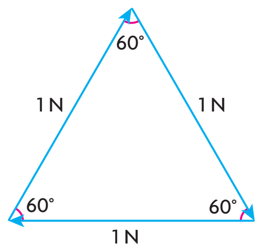
1. **a.** 10 N is a melon, 50 N is a chair, 100 N is a computer
b. Answers will vary.
2. **a.**



b. 180°
3. a line along the same direction
4. For three forces to be in equilibrium, they must form a triangle, which is a planar figure.
5. **a.** The resultant is 13 N at an angle of N 22.6° W. The equilibrant is 13 N at an angle of S 22.6° W.
b. The resultant is 15 N at an angle of S 36.9° W. The equilibrant is 15 N at N 36.9° E.
6. **a.** yes **b.** yes **c.** no **d.** yes
7. Arms 90 cm apart will yield a resultant with a smaller magnitude than at 30 cm apart. A resultant with a smaller magnitude means less force to counter your weight, hence a harder chin-up.
8. The resultant would be 12.17 N at 34.7° from the 6 N force toward the 8 N force. The equilibrant would be 12.17 N at 145.3° from the 6 N force away from the 8 N force.
9. 9.66 N 15° from given force, 2.95 N perpendicular to 9.66 N force
10. 49 N directed up the ramp
11. **a.**



b. 60°
12. approximately 7.1 N 45° south of east
13. **a.** 7
b. The angle between f_1 and the resultant is 16.3°. The angle between $\vec{f}_1$ and the equilibrant is 163.7°.
14. **a.**



For these three equal forces to be in equilibrium, they must form an equilateral triangle. Since the resultant will lie along one of these lines, and since all angles of an equilateral triangle are 60°, the resultant will be at a 60° angle with the other two vectors.