ANSWERS TO EXERCISES

Pages 6, 7

1. $x = \frac{1}{2}, -2.$
2. $x = 1, -5.$
3. $x = \dfrac{-5 \pm \sqrt{13}}{6}.$
4. $x = \dfrac{-1 \pm \sqrt{-3}}{2}.$
5. $x = \pm 1, \pm\sqrt{2}.$
6. $x = \pm 1.$
7. $x = \pm 1\sqrt{3}.$
8. $x = \dfrac{3 \pm \sqrt{13}}{2}.$
9. $x = \dfrac{-1 \pm \sqrt{17}}{4}.$
10. $x = \dfrac{1 \pm \sqrt{-3}}{2}.$
11. $x = \pm 1, 2.$
12. $x = 1, \dfrac{-1 \pm \sqrt{-3}}{2}.$
13. $x = \pm 1, \pm\sqrt{-1}.$
14. $x = \dfrac{\pm\sqrt{2} \pm \sqrt{-2}}{2}.$
15. $x = \dfrac{\pm\sqrt{3} \pm \sqrt{-5}}{2}.$

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1. $x = 1, -1, 2.$
2. $x = 2, 2, -\frac{5}{3}.$
3. $x = -3, \frac{5}{2}, \frac{5}{2}.$
4. $x = \frac{1}{2}, \frac{3}{2}, \frac{3}{2}.$
5. $x = 1, \frac{1}{2}(3 \pm \sqrt{29}).$
6. $x = -3, \frac{1}{2}(-1 \pm \sqrt{-3}).$
7. $x = -1, -1, \pm\frac{1}{2}.$
8. $x = -2, 3, \frac{3}{2}, -\frac{3}{2}.$
9. $x = 2, \frac{5}{3}, 1 \pm \sqrt{-2}.$
10. $x = 4, -\frac{5}{2}, \frac{1}{2}(3 \pm \sqrt{5}).$

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1. $x = -0.53, 0.65, 2.88.$
2. $x = 1.41, -0.7 \pm 2.1\sqrt{-1}.$
3. $x = 0.54, -0.8 \pm 1.1\sqrt{-1}.$
4. $x = 1.2, 2.9.$
5. $x = 0.7, -1.2.$

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1. $x > 1$ or $x < -2.$
2. $x > 1$ or $-1 < x < 0.$
3. $x < 1.$
4. $x < -1.53$, or $-0.35 < x < 1.88.$

5. $x > 2$, $0 < x < \frac{2}{3}\sqrt{3}$, or $-2 < x < -\frac{2}{3}\sqrt{3}.$
7. $|x| < \frac{2}{3}\sqrt{3}.$
8. $|x| > \sqrt{2}.$

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1. $x = 1, y = 2.$
2. $x = 2, y = -1, z = 3.$
3. $x = 1, y = -1, z = 1.$
4. $x = 1, y = \frac{1}{2}, z = \frac{1}{3}.$
5. $x = \frac{2}{3}, y = -2, z = \frac{2}{3}.$
6. $x = -1, y = 1,$ and $x = -\frac{8}{5}, y = -\frac{4}{5}.$
7. $h = 1, k = 2, r = \pm 5,$ and $h = \frac{9}{49}, k = -\frac{26}{7}, r = \pm\frac{205}{49}.$
8. $x = 1, -1, 2, -2.$ $y = -1, 1, -\frac{1}{2}, \frac{1}{2}.$
9. $x = y = z = \pm\sqrt{2}.$
10. $x = 1, y = -1, z = 2,$ and $x = \frac{17}{13}, y = -\frac{14}{13}, z = \frac{28}{13}.$

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11. $x : y : z = 3 : 1 : 2.$
12. $x : y : z = 2 : -3 : 4.$
13. $x : y : z = 2 : -1 : 1,$ or $-1 : 2 : 1.$
14. $x : y : z = 1 : \pm 1 : 1,$ or $-2 : \pm\sqrt{-2} : 1.$

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1. $(\frac{5}{8}, 0).$
2. $(3, 8).$
3. $(5, 11), (\frac{7}{3}, 3).$
4. $AB : CD = 3 : -2.$
5. $(5, 3), (-1, -5).$

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1. $5 + 3\sqrt{5}.$
7. $(2 \pm 2\sqrt{3}, 5).$
8. $(-\frac{1}{3}, 0).$
9. $(\frac{17}{18}, 3\frac{17}{18}).$
10. $(\frac{9}{10}, \frac{1}{10}).$
11. $(2\frac{1}{5}, 1\frac{2}{5}).$

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7. $(-2, 2).$
8. $[-\frac{1}{2}, -\frac{7}{2}], [4, 1], [-\frac{7}{2}, \frac{5}{2}].$
9. $(-8, 5).$
10. $(5, -1).$
12. $24\frac{1}{2}.$

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2. $(0, \frac{1}{3}), (-4, 7).$
3. $P\,(14, -13), Q\,(6, -5).$
4. $(-10, 31).$
5. $D\,(15, -3).$
8. $D\,(\frac{3}{8}, \frac{11}{8}).$
9. $P\,(1, 2\frac{2}{3}).$
12. $(2\frac{1}{5}, 4\frac{4}{5}).$

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1. $\frac{1}{2}$, -7, -2.
2. $\tan^{-1}(-0.8) = 141° 20'$.
9. $46° 51'$, $97° 8'$, $36° 2'$.
11. $7 \pm 5\sqrt{2}$.
12. $71° 34'$.
13. $\frac{5}{11}\sqrt{3} + \frac{8}{11}$.
15. $(4.933, 4.966)$, $(-6.933, -0.966)$.
16. $(-2\frac{6}{7}, -3\frac{4}{7})$.

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2. $x - 3y = 5$.
4. $y = 3x + 9$.
5. $x + 5y = 2$.
6. $y^2 = 8y - 6x - 25$.
7. $3x - 4y + 6 = 0$.
9. $x^2 + y^2 = x + y + 14$.
11. $x^2 + y^2 - 4x - 6y = 12$.

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1. $y + 3 = \sqrt{3}(x + 1)$.
2. $y = 3x - 7$.
3. $x = 2$.
4. $y = 2$.
5. $2x + 8y = 17$.
6. $y - 5 = \pm\sqrt{3}(x - 3)$.
7. $6y - 9x + 2 = 0$.
8. $x - y + 2 = 0$.
9. $y = 5x - 3$, length $= 2\sqrt{26}$.
10. $x - 2y + 3 = 0$, $x - 2y + 8 = 0$, $2x + y - 4 = 0$, $2x + y - 9 = 0$.
11. $21x + 16y = 6$, $11x + 24y = 9$.

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14. $45°$, $56° 19'$, $78° 4'$.
15. $3x - 2y = 6$.
16. $y = 5x - 4$.
17. $y = x - 4$.
18. $8x + 9y = 7$.
19. $(1\frac{8}{17}, -\frac{18}{17})$.
20. $5x + 3y = 18$.
21. 5, $\sqrt{10}$, $\sqrt{17}$.
22. $x - 5y + 8 = 0$.
23. $12x - 15y = 8$.
24. $4x - y + 9 = 0$.
25. A straight line perpendicular to the line through their centers.

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8. $x + y > 0$, $2x - 3y - 1 < 0$, $y - 2 < 0$.
9. $y + 3x - 4 > 0$, $3x - 2y - 1 > 0$, $y - 6x + 14 > 0$.
10. $\frac{1}{17}\sqrt{17}$.
11. $\frac{1}{13}\sqrt{13}$.
12. $\frac{2}{5}$.
13. $x(2\sqrt{2} - 1) - y(\sqrt{2} + 3) = \sqrt{2} - 2$.
14. $(\frac{16}{11}, \frac{2}{11})$.
15. $(y - 2x)^2 = 14x + 18y - 56$.

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1. $(0, 0)$, $r = 5$.
2. $(2, 0)$, $r = 2$.
3. $(0, \frac{3}{2})$, $r = \frac{1}{2}\sqrt{7}$.
4. $(-\frac{2}{3}, 0)$, $r = \frac{1}{3}\sqrt{7}$.
5. $(\frac{1}{2}, \frac{1}{2})$, $r = \frac{1}{2}\sqrt{2}$.
6. (a, a), $r = a\sqrt{2}$.
7. $(1, -2)$, $r = \sqrt{3}$.
8. The locus is the point $(1, 0)$.
11. $x^2 + y^2 - 5x + 4y - 46 = 0$.
12. $x^2 + y^2 - 2x - 2y = 11$.
13. $x^2 + y^2 - 2x - 2y + 1 = 0$, $x^2 + y^2 - 10x - 10y + 25 = 0$.
14. $x^2 + y^2 = 9 \pm 2\sqrt{8}$.
15. $(0, 2)$, $(\frac{6}{5}, -\frac{2}{5})$.
16. $x^2 + y^2 - 3x - 3y = 0$.
17. $(x - 6)^2 + (y - 2)^2 = 25$, $(x + 1)^2 + (y + 5)^2 = 25$.
18. $2x^2 + 2y^2 + 6x + 3y = 10$.
19. $x^2 + y^2 - 16x - 12y = 0$, $x^2 + y^2 + 4y = 0$.
20. $4x^2 + 4y^2 + x - y = 3$.
21. $(x - 5)^2 + (y - 14)^2 = 4$.
22. $x^2 + y^2 + 26x + 16y = 32$.
23. $x^2 + y^2 - (2\sqrt{10} - 6)y = 2\sqrt{10} - 6$.
24. $x = 2y$.

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1. $(0, 0)$, $a = \sqrt{6}$, $b = \sqrt{3}$.
2. $(1, -2)$, $a = \frac{1}{2}$, $b = 1$.
3. $(\frac{1}{2}, \frac{1}{4})$, $a = \frac{1}{4}\sqrt{6}$, $b = \frac{1}{4}\sqrt{3}$.
4. $(1, -2)$, $a = 2$, $b = \sqrt{6}$.
5. $(-3, 1)$, $a = \sqrt{13}$, $b = \frac{1}{3}\sqrt{39}$.
6. The locus is the point $(1, -1)$.
7. $9x^2 + 4y^2 - 18x + 24y + 9 = 0$.
8. $4x^2 + y^2 + 16x - 8y + 16 = 0$.
9. $(x + y - 2)^2 + 16(x - y + 2)^2 = 32$.

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1. Axis $y = 0$, vertex $(\frac{1}{2}, 0)$.
2. $y = 0$, $(\frac{1}{2}, 0)$.
3. $x = 1$, $(1, 2)$.
4. $x = -\frac{1}{2}$, $(-\frac{1}{2}, -\frac{9}{4})$.
5. $y = \frac{3}{2}$, $(-\frac{9}{4}, \frac{3}{2})$.
6. $x = \frac{3}{2}$, $(1\frac{1}{2}, 3\frac{1}{3})$.
7. $3y^2 = 16x$.
8. $5x^2 + 20x + 9y + 2 = 0$.
9. $\frac{29}{2}\sqrt{2}$.
10. $35\frac{5}{9}$ ft.

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1. Center $(0, 2)$, $a = \sqrt{3}$, $b = 2$. Asymptotes, $y - 2 = \pm\frac{2}{3}\sqrt{3}x$.
2. Center $(0, -1)$, $a = \frac{1}{8}\sqrt{15}$, $b = \sqrt{3}$. Asymptotes, $y + 1 = \pm x\sqrt{5}$.
3. Center $(1, -1)$, $a = b = 2$. Asymptotes, $x = 1$ and $y = -1$. Axes, $x + y = 0$ and $x - y - 2 = 0$.
4. Center $(-1, 2)$, $a = \sqrt{3}$, $b = \sqrt{2}$. Asymptotes, $y - 2 = \pm\frac{2}{3}\sqrt{3}(x + 1)$.
5. The locus is two lines $x - y = 4$ and $x + y + 2 = 0$.
6. Center $(0, \frac{3}{2})$, $a = b = 2$. Asymptotes, $x = 0$ and $y = \frac{3}{2}$. Axes, $y - \frac{3}{2} = \pm x$.
7. $16(x - 2)^2 - (y + 1)^2 = \pm 16$.

8. $24(x+2)^2 - 5(y-1)^2 = 91$.
9. $4(3x+2y)^2 - 25(2x-3y)^2 = \pm 1300$.

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1. The circle circumscribed about the square.
2. Two parabolas having the fixed diameter as common chord and with vertices at the middle points of the perpendicular radii.
3. A rectangular hyperbola passing through A and B.
4. A circle with center at the center of the triangle.
5. The circle passing through the vertices of the base angles, and tangent to the equal sides of the triangle.
6. A hyperbola.
9. A rectangular hyperbola.
10. Two circles passing through A and B with centers at the ends of the diameter perpendicular to AB.

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1. $x = -2$.
2. $y = 3$.
3. $x - y = \sqrt{2}$.
4. $y = x\sqrt{3}$.
5. $x^2 + y^2 = 3x$.
6. $x^2 + y^2 = 4y$.
7. $x^2 + y^2 = \sqrt{2}(y - x)$.
8. $x^2 + y^2 = x - y$.
9. $x^2 + y^2 = 4$.
10. $x^2 + y^2 - 2x - 2\sqrt{3}y + 3 = 0$.
11. $x^2 + y^2 - 2x - 2y + 1 = 0$.
12. $3x^2 + 4y^2 - 4x = 4$.
13. $4y^2 - 5x^2 - 36x = 36$.
14. $y^2 = 6x + 9$.
15. $x^2 = 4y + 4$.
16. $xy = 4x + 4y - 8$.
17. $xy = 2y - 3x$.
18. $x^2 - y^2 = y$.
19. $r(2\cos\theta - \sin\theta) = 1$.
20. $r = 4\cot\theta\csc\theta$.
21. $r = 2\cos\theta$.
22. $r^2 = 14\csc 2\theta$.
23. $r^2 = \sec 2\theta$.
24. $r = 4\sqrt{2}\cos\left(\theta - \frac{\pi}{4}\right)$.
25. $r^2 + 2ar(\pm\cos\theta \pm \sin\theta) + a^2 = 0$.
26. $r\left[1 - \cos\left(\theta - \frac{\pi}{6}\right)\right] = 4$.
27. $r(3 - 2\sin\theta) = 3 - \sqrt{3}$.
28. $\sqrt{2}$.

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35. $\theta = -\frac{\pi}{24}$, $r = 3.285$.
36. $\left(a\sqrt{2}, \frac{\pi}{4}\right)$.
37. $(0, 0)$, $\left(\pm a, \frac{\pi}{2}\right)$, $\left(\pm 2^{-\frac{1}{2}}a, \frac{\pi}{4}\right)$, $\left(\pm 2^{-\frac{1}{2}}a, \frac{3}{4}\pi\right)$.
38. $(0, 0)$, $(.785\,a, \pm 25°\,52')$, $(.409\,a, \pm 102°\,4')$, $(.898\,a, \pm 148°\,3')$.
39. $\left(a, \pm\frac{\pi}{6}\right)$, $\left(a, \pm\frac{5}{6}\pi\right)$.

Pages 128, 129.

1. $r = a\cos\theta$.
2. $r = a(\sec\theta + \tan\theta)$.
3. $r(r\cos\theta - a) = k$. O is the origin and LK is perpendicular to OX at $(a, 0)$.
4. $r = a\sin 2\theta$. The length of the segment is $2a$.
5. $r = a + b\sec\theta$. The radius of the circle is $2a$ and the distance from the center to the fixed line is $2b$.
6. $r = 2a\tan\theta\sin\theta$. OA is the initial line and a the radius of circle.
7. $r = a(1 + \cos\theta)$, a cardioid.
8. $r = a(\csc\theta - 1)$.
9. $r\sin(\frac{1}{2}\theta) = a$.
10. $r = a\sec\theta + b$. The distance from O to BC is a and the constant distance is b.
11. $r = 2a\cos\theta + b$. The diameter through O is the initial line, the radius of the circle is a, and the constant distance is b.
12. $r = a\cos^2\theta$, a being the length of OA.
13. $r = a(1 - \tan^4\theta)\cos\theta$.
14. $r = \dfrac{c\sin\left(\frac{a}{b}\theta\right)}{\sin\left(\frac{c}{b}\theta\right)}$. The radii are a and b and the distance between centers is c. The origin is at the center of circle of radius a.

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2. $x = a(1 + \tan\phi)$, $y = a\tan\phi$, $x - y = a$.
3. $x = a(1 + 2\sin^2\phi)$, $y = 2a\tan\phi\sin^2\phi$, $y^2(3a - x) = (x - a)^3$.
4. $x = 1 + \frac{1}{2}\cot\phi$, $y = \frac{1}{2} + \tan\phi$. $2xy = x + 2y$.
5. $r = a\sqrt{1 + \phi^2}$, $\theta = \phi - \tan^{-1}\phi$. $\theta = \frac{1}{a}\sqrt{r^2 - a^2} - \cos^{-1}\left(\frac{a}{r}\right)$.

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3. $x^2 - y^2 = 4$.
4. $(y - x)^3 = 2(x + y)^2$.
5. $xy + x = 3y - 1$.
6. $4x^2 - 4\sqrt{3}xy + 4y^2 = 1$.
7. $x^2 - y^2 = 1$.
8. $\sqrt{x^2 + y^2} = \tan^{-1}\left(\frac{x}{y}\right)$.
9. $r = 1 - 2\theta^2$.
12. $x = a\cos^{-1}\left(\frac{a - y}{a}\right) - \sqrt{2ay - y^2}$.
13. $\theta^2(1 + r^2)^3 = r^2(3 - r^2)^2$.
14. $x^{\frac{2}{3}} + y^{\frac{2}{3}} = (4a)^{\frac{2}{3}}$.
16. $r = \theta = t$.
17. $x = t^2\cos(1 + t)$, $y = t^2\sin(1 + t)$.
21. $(4, 4)$.

22. $(3, 4), (-4, -3)$.
23. $(\pm 0.5404\,a, 0.8414\,a)$.
24. $(\frac{1}{2}a, \pm\frac{1}{2}a\sqrt{2})$.
25. $x = a(1+\cos 2\theta)$, $y = a\sin 2\theta$.
26. $x = \dfrac{4}{m^2}$, $y = \dfrac{4}{m}$.
27. $x = a\cos\phi$, $y = b\sin\phi$.
28. $x = a\sec\phi$, $y = b\tan\phi$.
29. $x = a\sin^3\phi$, $y = a\cos^3\phi$.
30. $x = m^2$, $y = m^3 - m - 2$.

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1. $x = b\tan\phi \mp a\sin\phi$, $y = \pm a\cos\phi$, the fixed point on the y-axis being $(0, b)$.
2. $x = k(1 + \cos^2\phi)$, $y = k(\tan\phi + \sin\phi\cos\phi)$.
3. $x = 2a\cot\phi$, $y = 2a\sin^2\phi$. $(x^2 + 4a^2)\,y = 8a^3$.
4. $x = \dfrac{a}{2}(1 + \cos\phi)$, $y = \dfrac{a}{2}(\sin\phi + \tan\frac{1}{2}\phi)$.
   $4xy^2 = (a - x)(a + 2x)^2$.
5. $x = (a - c\tan\phi)\sin^2\phi$, $y = (a - c\tan\phi)\sin\phi\cos\phi$.
   $x(ay - cx) = y(x^2 + y^2)$. $r = (a - c\cot\theta)\cos\theta$.
6. $x = a\tan\phi$, $y = a\cos 2\phi$. $y(a^2 + x^2) = a^3 - ax^2$.
7. $x = a(\tan\phi + \sin\phi\cos\phi)$, $y = a(1 + \cos^2\phi)$.
   $y(x^2 + y^2) = a(x^2 + 2y^2)$. $r = a(\csc\theta + \sin\theta)$.
8. $x = 2a\cos^2\phi$, $y = 2a\sec\phi$. $xy^2 = 8a^3$, $x \gtreqless 2a$.
   O is the origin, OA the x-axis, and $\phi = AOC$.
9. $r = a\sec^3\theta$.
10. $(x^2 + y^2 - 2a^2)^2 = a^2(5a \pm 4y)$. The fixed diameter is x-axis and the center of circle is origin.
11. $x = c\cos 2\phi - a\sin\phi + b\cos\phi$, $y = c\sin 2\phi + a\cos\phi + b\sin\phi$. The radii are a and b and the distance between centers is $2c$. The x-axis passes through the centers and the origin is midway between them.
12. A rectangular hyperbola.
13. $x = -a\sin(\phi + B)$, $y = b\sin(\phi - A)$. The curve is an ellipse.
14. $r = a\csc\phi$, $\theta = \csc\phi + \cot\phi + \phi - \dfrac{\pi}{2} - 1$.
    The origin is at the center of circle, the initial line passes through the intersection of curve and circle, and ϕ is the angle formed at the pencil by the string.
15. $x = a\phi - b\sin\phi$, $y = a - b\cos\phi$.
16. $x = \dfrac{a}{4}(3\cos\phi + \cos 3\phi)$, $y = \dfrac{a}{4}(3\sin\phi - \sin 3\phi)$. $x^{\frac{2}{3}} + y^{\frac{2}{3}} = a^{\frac{2}{3}}$.
    The radius of the fixed circle is a.
17. $y + 1 = 0$.

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3. $x^2 + 4y^2 = 4$.
4. $y^3 + 3x^2 + 16 = 0$.
5. $r = 2$.
6. $r = 4p\cot\theta\csc\theta$.
7. $2x - 3y = 0$.
8. $\dfrac{(x-a)^2}{a^2} + \dfrac{y^2}{b^2} = 1$.
9. $(x^2 + 4a^2)y + 2ax^2 = 0$.
10. $xy^2 = (x - a)^2(2a - x)$.
11. $x = a(\phi' + \sin\phi')$, $y = a(\cos\phi' - 1)$, where $\phi' = \phi - \pi$.
12. $x = \dfrac{a}{2}(2\cos\theta + \cos 2\theta)$, $y = \dfrac{a}{2}(2\sin\theta + \sin 2\theta)$.
13. $x + y = 0$, $2x - 3y = 0$.
14. $x^2 + y^2 = 11$.
20. $3x^2 + y^2 = 2$.
21. $r^2\cos 2\theta = 2$.
22. $x^2 - y^2 = 8$.
23. $\dfrac{x^2}{4(\sqrt{2}-1)} - \dfrac{y^2}{4(\sqrt{2}+1)} = 1$.

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4. Distance from the x-axis $\sqrt{y^2 + z^2}$, distance from the origin $\sqrt{x^2 + y^2 + z^2}$.
5. In the xy-plane $(1, 2, 0)$, on the x-axis $(1, 0, 0)$.
6. The projections on the y-axis are $1, -2, 1$.
7. $76° 22', 76° 22', 19° 28'$.
8. $5, -4$, and 3.
9. $(\frac{5}{2}, -\frac{1}{2}, \frac{3}{2})$.

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3. $(1, 2, 3)$.
4. $(\frac{11}{3}, 3, -2)$, $(\frac{3}{2}, -\frac{1}{4}, \frac{5}{4})$.
5. The projection on the xy-plane is $[2, 2, 0]$.
7. $(5, 2, 5)$.

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3. $\frac{2}{7}, \frac{3}{7}, \frac{6}{7}$.
4. $45°$ and $135°$.
5. $\frac{1}{2}\sqrt{2}, \frac{1}{2}\sqrt{2}, 0$.
6. $54° 44'$.
7. $\frac{1}{9}, \frac{4}{9}, \frac{8}{9}$.
8. $70° 32', 48° 12', 48° 12'$.
9. $71° 34', 71° 34', 36° 52'$.
11. $56° 1'$.

Pages 166, 167.

1. $\cos\alpha = \dfrac{1}{\pm\sqrt{21}}$, $\cos\beta = \dfrac{2}{\pm\sqrt{21}}$, $\cos\gamma = \dfrac{4}{\pm\sqrt{21}}$.
   The positive square roots correspond to one direction along the normal, the negative to the other. If a particular direction is desired, the proper sign is easily determined. In the following answers only one set of cosines is given.

2. $\cos\alpha = \frac{1}{\sqrt{11}}$, $\cos\beta = -\frac{1}{\sqrt{11}}$, $\cos\gamma = \frac{3}{\sqrt{11}}$.
3. $\cos\alpha = \cos\beta = \cos\gamma = \frac{1}{3}\sqrt{3}$.
4. $\cos\alpha = \frac{2}{\sqrt{13}}$, $\cos\beta = -\frac{3}{\sqrt{13}}$, $\cos\gamma = 0$.
5. $\cos\alpha = \frac{2}{3}$, $\cos\beta = 0$, $\cos\gamma = \frac{1}{3}$.
6. $\cos\alpha = \cos\beta = 0$, $\cos\gamma = 1$.
7. $x + y\sqrt{2} + z = 0$.
8. $3x - 5y + 4z + 2 = 0$.
9. $\frac{x}{1} + \frac{y}{2} + \frac{z}{3} = 1$.
12. 70° 32′.
13. 29° 40′.

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17. $x^2 + y^2 + z^2 = a^2$, $r^2 + z^2 = a^2$, $\rho = a$.
18. $x^2 + y^2 + z^2 = 2az$, $r^2 + z^2 = 2az$, $\rho = 2a\cos\phi$.
19. $x^2 + y^2 = a^2$, $r = a$, $\rho = a\csc\phi$.
20. $x^2 + y^2 = z^2$, $r = z$, $\phi = \frac{\pi}{4}$.
21. $y^2 + z^2 = 2az$.
22. $x^2 = az$.
23. $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$.
24. $\frac{x^2}{a^2} + \frac{y^2 + z^2}{b^2} = 1$.
25. $\frac{x^2}{a^2} - \frac{y^2 + z^2}{b^2} = 1$, or $\frac{x^2 + z^2}{a^2} - \frac{y^2}{b^2} = 1$.
26. $y^2 + z^2 = ax$.
27. $(\sqrt{x^2 + z^2} - b)^2 + y^2 = a^2$. A circle with center on the x-axis is rotated about the y-axis.

Pages 177, 178.

1. There are two sets of direction cosines differing in algebraic sign. One set is:
$$\cos\alpha = -\tfrac{2}{3},\ \cos\beta = \tfrac{2}{3},\ \cos\gamma = \tfrac{1}{3}.$$
2. $\cos\alpha = \frac{1}{\sqrt{6}}$, $\cos\beta = -\frac{1}{\sqrt{6}}$, $\cos\gamma = \frac{2}{\sqrt{6}}$.
3. $\cos\alpha = -\frac{7}{\sqrt{78}}$, $\cos\beta = \frac{2}{\sqrt{78}}$, $\cos\gamma = \frac{5}{\sqrt{78}}$.
4. $\cos\alpha = \cos\beta = 0$, $\cos\gamma = 1$.
5. $\frac{x-2}{1} = \frac{y-3}{1} = \frac{z+1}{3}$.
6. $\frac{x}{3} = \frac{y-1}{1} = \frac{z-2}{5}$.
7. $\frac{x-1}{1} = \frac{y-1}{2} = \frac{z-1}{-1}$.
8. 60°.
9. 58° 31′.

Page 180.

1. The projection on the xy-plane is
$$x^2 + y^2 + xy - x - y = 0,\ z = 0.$$
2. The projection on the yz-plane is
$$z = \pm a,\ x = 0.$$

3. The projection on the xz-plane is
$$z^2 = 2x^2 - 2x + 1,\ y = 0.$$
11. $(-1, 1, 2)$, $(-\frac{1}{3}, \frac{1}{3}, \frac{4}{3})$.

Pages 181, 182.

1. The projection on the xy-plane is $x + y = 3$, $z = 0$.
2. The projection on the yz-plane is $y = \sin(\frac{1}{2}z)$, $x = 0$.
3. The projection on the xz-plane is $x = z\sin z$, $y = 0$.
5. $x = a\theta\cos\theta$, $y = a\theta\sin\theta$, $z = k\theta$.
6. $z = k\theta$.
7. $y = x\sqrt{2}$, $z = x - .000064x^2$, $z = .7071y - .000032y^2$.