69. Saddle points at $(0, 0)$ and $(-2, 2)$; local max at $(0, 2)$; local min at $(-2, 0)$ **71.** Abs. min: $-1 = f(1, 1) = f(-1, -1)$; abs. max: $49 = f(2, -2) = f(-2, 2)$

73. Abs. min: $-\frac{1}{2} = f\left(-\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}\right)$; abs. max: $\frac{1}{2} = f\left(\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}\right)$

75. Abs. min: $\frac{23}{2} = f\left(\frac{1}{3}, \frac{5}{6}\right)$ abs. max: $\frac{29}{2} = f\left(\frac{5}{3}, \frac{7}{6}\right)$;

77. Abs. min: $-\sqrt{6} = f\left(-\frac{\sqrt{6}}{6}, -\frac{\sqrt{6}}{3}, \frac{\sqrt{6}}{6}\right)$;

abs. max: $\sqrt{6} = f\left(\frac{\sqrt{6}}{6}, \frac{\sqrt{6}}{3}, -\frac{\sqrt{6}}{6}\right)$

79. $\frac{2a^2}{\sqrt{a^2 + b^2}}$ by $\frac{2b^2}{\sqrt{a^2 + b^2}}$

81. $x = \frac{1}{2} + \frac{\sqrt{10}}{20}, y = \frac{3}{2} + \frac{3\sqrt{10}}{20} = 3x, z = \frac{1}{2} + \frac{\sqrt{10}}{2} = \sqrt{10}x$

83. $(1, 2, 5)$

CHAPTER 16

Section 16.1 Exercises, pp. 1015–1017

1. $\int_0^2 \int_1^3 xy\, dy\, dx$ or $\int_1^3 \int_0^2 xy\, dx\, dy$ **3.** $\int_{-2}^4 \int_1^5 f(x, y)\, dy\, dx$ or $\int_1^5 \int_{-2}^4 f(x, y)\, dx\, dy$ **5.** 48 **7.** 4 **9.** $\frac{32}{3}$ **11.** 4 **13.** $\frac{224}{9}$

15. $10 - 2e$ **17.** $\frac{1}{2}$ **19.** $e^2 + 3$ **21.** $\frac{1}{2}$ **23.** $10\sqrt{5} - 4\sqrt{2} - 14$

25. $\frac{117}{2}$ **27.** $\frac{\pi^2}{4} + 1$ **29.** $\frac{4}{3}$ **31.** $\frac{9 - e^2}{2}$ **33.** $\frac{4}{11}$ **35.** $\frac{1}{4}$

37. 136 **39.** 3 **41.** $e^2 - 3$ **43.** $e^{16} - 17$ **45.** $\ln \frac{5}{3}$ **47.** $\frac{1}{2 \ln 2}$

49. $\frac{8}{3}$ **51. a.** True **b.** False **c.** True **53. a.** 1475 **b.** The sum of products of population densities and areas is a Riemann sum.

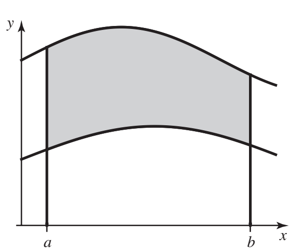
55. $\int_c^d \int_a^b f(x)\, dy\, dx = (c - d) \int_a^b f(x)\, dx$. The integral is the area of the cross section of S. **57.** $a = \pi/6, 5\pi/6$ **59.** $a = \sqrt{6}$

61. a. $\frac{1}{2}\pi^2 + \pi$ **b.** $\frac{1}{2}\pi^2 + \pi$ **c.** $\frac{1}{2}\pi^2 + 2$

63. $f(a, b) - f(a, 0) - f(0, b) + f(0, 0)$

Section 16.2 Exercises, pp. 1024–1027

1.

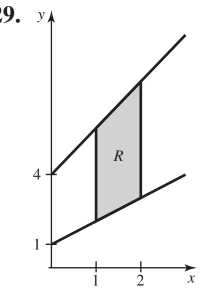


3. $dx\, dy$ **5.** $\int_0^1 \int_{x^2}^{\sqrt{x}} f(x, y)\, dy\, dx$ **7.** 4 **9.** $\int_0^2 \int_{x^3}^{4x} f(x, y)\, dy\, dx$

11. 2 **13.** $\frac{8}{3}$ **15.** 0 **17.** $e - 1$ **19.** $\frac{\ln^3 2}{6}$

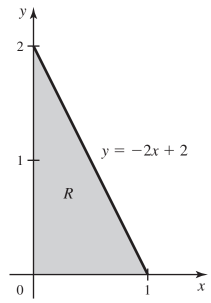
21. 2 **23.** $\frac{\pi}{2} - 1$ **25.** 0 **27.** $\pi - 1$

29.



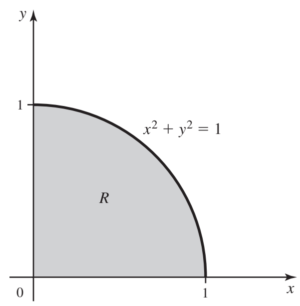
$\int_1^2 \int_{x+1}^{2x+4} f(x, y)\, dy\, dx$

31.



$\int_0^1 \int_0^{-2x+2} f(x, y)\, dy\, dx$

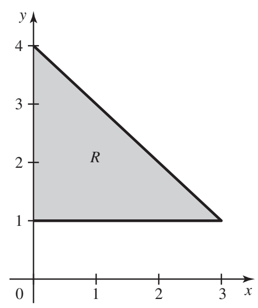
33.



$\int_0^1 \int_0^{\sqrt{1-x^2}} f(x, y)\, dy\, dx$

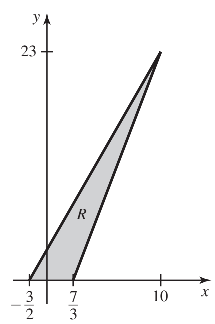
35. $\int_0^{18} \int_{y/2}^{(y+9)/3} f(x, y)\, dx\, dy$

37.



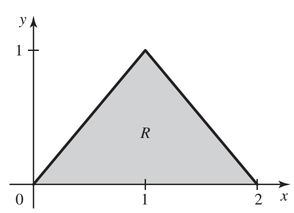
$\int_1^4 \int_0^{4-y} f(x, y)\, dx\, dy$

39.



$\int_0^{23} \int_{(y-3)/2}^{(y+7)/3} f(x, y)\, dx\, dy$

41.



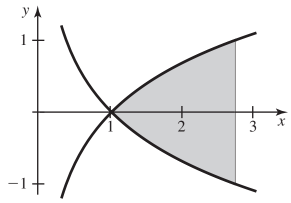
$\int_0^1 \int_y^{2-y} f(x, y)\, dx\, dy$

43. 2 **45.** 12 **47.** 5 **49.** 14 **51.** 32 **53.** $\frac{9}{8}$ **55.** $\frac{1}{4}\ln 2$

57. $\int_0^4 \int_{y/2}^{\sqrt{y}} f(x, y)\, dx\, dy$ **59.** $\int_0^{\ln 2} \int_{1/2}^{e^{-x}} f(x, y)\, dy\, dx$

61. $\int_0^{\pi/2} \int_0^{\cos x} f(x, y)\, dy\, dx$ **63.** $\frac{1}{2}(e - 1)$ **65.** 0 **67.** $\frac{2}{3}$

69.

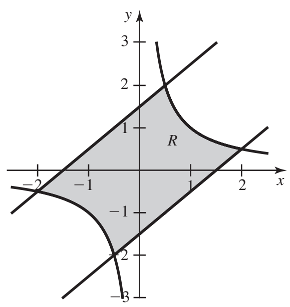


$\int_1^e \int_{-\ln x}^{\ln x} f(x, y)\, dy\, dx$

71. $\frac{11}{12}$ **73.** $\frac{32}{3}$ **75.** 12π **77.** $\frac{43}{6}$ **79.** $\frac{2}{3}$ **81.** 16 **83.** $4a\pi$

85. $\frac{32}{3}$ **87.** 1 **89.** $\frac{140}{3}$ **91. a.** False **b.** False **c.** False

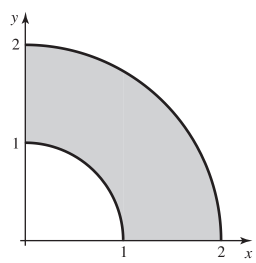
93. 30 **95.** $\frac{a}{3}$ **97. a.**



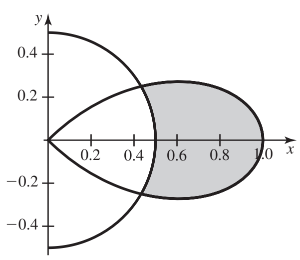
b. $\frac{15}{4} + 4\ln 2$ **c.** $2\ln 2 - \frac{5}{64}$ **99.** $\frac{3}{8e^2}$ **101.** 1

Section 16.3 Exercises, pp. 1033–1036

1. It is called a polar rectangle because r and θ vary between two constants.

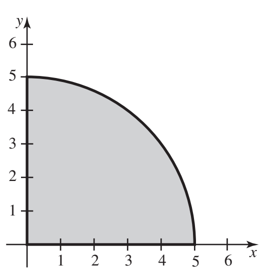


3.

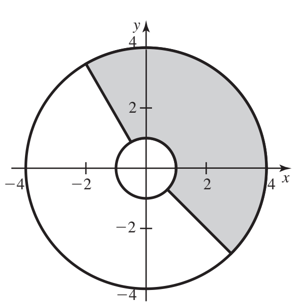


5. Evaluate the integral $\int_\alpha^\beta \int_{g(\theta)}^{h(\theta)} r\, dr\, d\theta$.

7.



9.

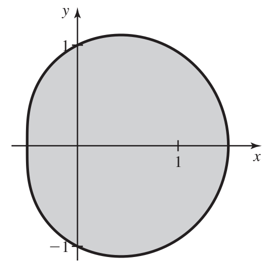


11. $\frac{64\pi}{3}$ **13.** $(8 - 24e^{-2})\pi$ **15.** $\frac{7\pi}{2}$ **17.** $\frac{9\pi}{2}$ **19.** $\frac{37\pi}{3}$

21. 128π **23.** 0 **25.** $(2 - \sqrt{3})\pi$ **27.** $2\pi/5$ **29.** $\frac{14\pi}{3}$

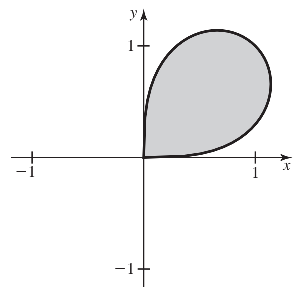
31. $\frac{81\pi}{2}$ **33.** π **35.** 8π **37.** 81π **39.** $\frac{2\pi}{3}(7\sqrt{7} - 15)$

41.



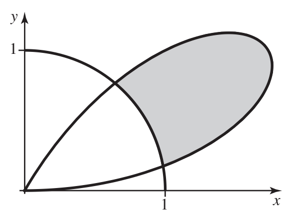
$\int_0^{2\pi} \int_0^{1+\frac{1}{2}\cos\theta} g(r, \theta) r\, dr\, d\theta$

43.



$\int_0^{\pi/2} \int_0^{\sqrt{2\sin 2\theta}} g(r, \theta) r\, dr\, d\theta$

45.



$\int_{\pi/18}^{5\pi/18} \int_1^{2\sin 3\theta} g(r, \theta) r\, dr\, d\theta$

47. $3\pi/2$ **49.** π **51.** $\frac{3\pi}{2} - 2\sqrt{2}$ **53.** $2a/3$

55. a. False **b.** True **c.** True **57.** The hyperboloid $\left(V = \frac{112\pi}{3}\right)$

59. a. $R = \{(r, \theta)\colon -\pi/4 \le \theta \le \pi/4 \text{ or } 3\pi/4 \le \theta \le 5\pi/4\}$

b. $\frac{a^4}{4}$ **61.** $\frac{32}{9}$ **63.** $2\pi\left(1 - 2\ln\frac{3}{2}\right)$ **65.** 1

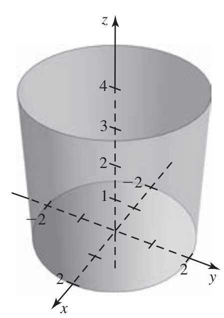
67. $\pi/4$ **69. a.** $\frac{16\pi}{3}$ **b.** 2.78 **71.** $30\pi + 42$

73. c. $\sqrt{\pi}/2$, $1/2$, and $\sqrt{\pi}/4$ **75. a.** $I = \frac{\sqrt{2}}{2}\tan^{-1}\frac{\sqrt{2}}{2}$

b. $I = \frac{\sqrt{2}}{4}\tan^{-1}\frac{\sqrt{2}a}{2} + \frac{a}{2\sqrt{a^2 + 1}}\tan^{-1}\frac{1}{\sqrt{a^2 + 1}}$ **c.** $\frac{\sqrt{2}\pi}{8}$

Section 16.4 Exercises, pp. 1043–1047

1.



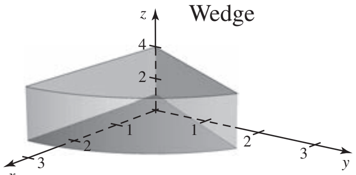
3. $\int_{-9}^{9} \int_{-\sqrt{81-x^2}}^{\sqrt{81-x^2}} \int_{-\sqrt{81-x^2-y^2}}^{\sqrt{81-x^2-y^2}} f(x, y, z)\, dz\, dy\, dx$

5. $\int_0^1 \int_0^{\sqrt{1-z^2}} \int_0^{\sqrt{1-z^2-x^2}} f(x, y, z)\, dy\, dx\, dz$ **7.** 24 **9.** 8 **11.** $\frac{2}{\pi}$
13. 0 **15.** 8 **17.** $\frac{16}{3}$ **19.** $1 - \ln 2$
21. $\frac{2\pi(1 + 19\sqrt{19} - 20\sqrt{10})}{3}$ **23.** $\frac{27\pi}{2}$ **25.** 12π
27. $\frac{5}{12}$ **29.** 8 **31.** $\int_0^1 \int_y^1 \int_0^{2\sqrt{1-x^2}} f(x, y, z)\, dz\, dx\, dy$
33. $\int_0^1 \int_0^{2\sqrt{1-x^2}} \int_0^x f(x, y, z)\, dy\, dz\, dx$
35. $\int_0^1 \int_0^{2\sqrt{1-y^2}} \int_{y^2}^{\frac{1}{2}\sqrt{4-z^2}} f(x, y, z)\, dx\, dz\, dy$
37. $\int_0^1 \int_0^2 \int_0^{1-y} dz\, dx\, dy$, $\int_0^2 \int_0^1 \int_0^{1-z} dy\, dz\, dx$, $\int_0^1 \int_0^2 \int_0^{1-z} dy\, dx\, dz$, $\int_0^1 \int_0^{1-y} \int_0^2 dx\, dz\, dy$, $\int_0^1 \int_0^{1-z} \int_0^2 dx\, dy\, dz$ **39.** $\frac{256}{9}$ **41.** $\frac{2}{3}$
43. $(10\sqrt{10} - 1)\frac{\pi}{6}$ **45.** $\frac{3 \ln 2}{2} + \frac{e}{16} - 1$
47. $\int_0^4 \int_{y/4-1}^0 \int_0^5 dz\, dx\, dy = 10$ **49.** $\int_0^1 \int_0^{\sqrt{1-x^2}} \int_0^{\sqrt{1-x^2}} dz\, dy\, dx = \frac{2}{3}$
51. $\frac{8}{\pi}$ **53.** $\frac{10}{3}$ **55. a.** False **b.** False **c.** False **57.** 2
59. 1 **61.** $\frac{16}{3}$ **63.** $\frac{16}{3}$ **65.** $a = 2\sqrt{2}$ **67.** $V = \frac{\pi r^2 h}{3}$
69. $V = \frac{\pi h^2}{3}(3R - h)$ **71.** $V = \frac{4\pi abc}{3}$ **73.** $\frac{1}{24}$

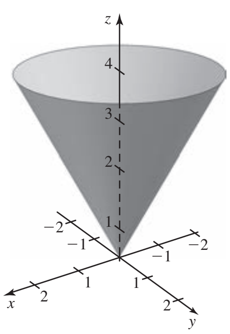
Section 16.5 Exercises, pp. 1059–1063

1. r measures the distance from the point to the z axis, θ is the angle that the segment from the point to the z-axis makes with the positive xz-plane, and z is the directed distance from the point to the xy-plane. **3.** A cone **5.** It approximates the volume of the cylindrical wedge formed by the changes Δr, $\Delta\theta$, and Δz.
7. $\int_\alpha^\beta \int_{g(\theta)}^{h(\theta)} \int_{G(r,\theta)}^{H(r,\theta)} w(r, \theta, z) r\, dz\, dr\, d\theta$ **9.** Cylindrical coordinates

11. Wedge

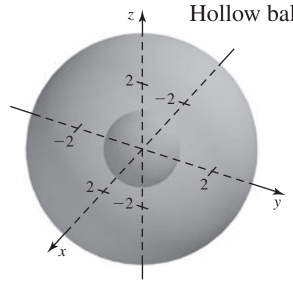


13. Solid bounded by cone and plane

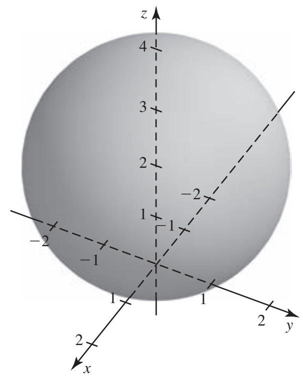


15. 2π **17.** $4\pi/5$ **19.** $\pi(1 - e^{-1})/2$ **21.** $9\pi/4$
23. 560π **25.** 396π **27.** The paraboloid ($V = 44\pi/3$)
29. $\frac{20\pi}{3}$ **31.** $\frac{(16 + 17\sqrt{29})\pi}{3}$ **33.** $\frac{1}{3}$

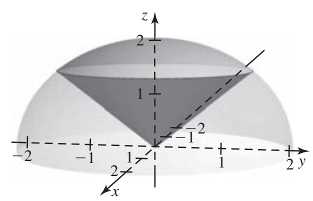
35. Hollow ball



37. Sphere of radius $r = 2$, centered at $(0, 0, 2)$



39. a. $(3960, 0.74, -2.13)$, $(-1426.85, -2257.05, 2924.28)$
b. $(3960, 0.84, 0.22)$, $(2877.61, 637.95, 2644.62)$ **c.** 5666 mi
41. $\frac{\pi}{2}$ **43.** $4\pi \ln 2$ **45.** $\pi\left(\frac{188}{9} - \frac{32\sqrt{3}}{3}\right)$ **47.** $\frac{32\pi\sqrt{3}}{9}$
49. $\frac{5\pi}{12}$ **51.** $\frac{8\pi}{3}$ **53.** $\frac{8\pi}{3}(9\sqrt{3} - 11)$ **55. a.** True **b.** True
57. $z = \sqrt{x^2 + y^2 - 1}$; upper half of a hyperboloid of one sheet
59. $\frac{8\pi}{3}(1 - e^{-512}) \approx \frac{8\pi}{3}$ **61.** 32π
63.



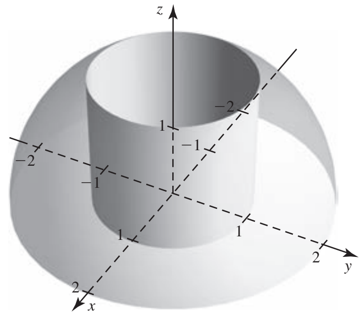
$$\int_0^{2\pi} \int_0^{\sqrt{2}} \int_r^{\sqrt{4-r^2}} g(r, \theta, z)\, r\, dz\, dr\, d\theta,$$

$$\int_0^{2\pi} \int_0^{\sqrt{2}} \int_0^z g(r, \theta, z)\, r\, dr\, dz\, d\theta$$

$$+ \int_0^{2\pi} \int_{\sqrt{2}}^2 \int_0^{\sqrt{4-z^2}} g(r, \theta, z)\, r\, dr\, dz\, d\theta,$$

$$\int_0^{\sqrt{2}} \int_r^{\sqrt{4-r^2}} \int_0^{2\pi} g(r, \theta, z)\, r\, d\theta\, dz\, dr$$

65.



$\int_{\pi/6}^{\pi/2}\int_0^{2\pi}\int_{\csc\varphi}^{2} g(\rho,\varphi,\theta)\rho^2\sin\varphi\,d\rho\,d\theta\,d\varphi,$

$\int_{\pi/6}^{\pi/2}\int_{\csc\varphi}^{2}\int_0^{2\pi} g(\rho,\varphi,\theta)\rho^2\sin\varphi\,d\theta\,d\rho\,d\varphi$

67. $32\sqrt{3}\pi/9$ **69.** $2\sqrt{2}/3$ **71.** $7\pi/2$ **73.** 95.6036

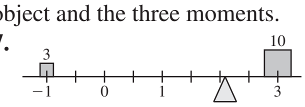
77. $V = \dfrac{\pi r^2 h}{3}$ **79.** $V = \dfrac{\pi}{3}(R^2 + rR + r^2)h$

81. $V = \dfrac{\pi R^3(8r - 3R)}{12r}$

Section 16.6 Exercises, pp. 1070–1072

1. The pivot should be located at the center of mass of the system. **3.** Use a double integral. Integrate the density function over the region occupied by the plate. **5.** Use a triple integral to find the mass of the object and the three moments.

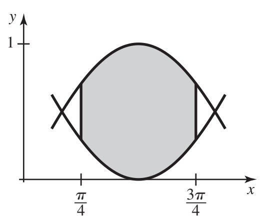
7.



$\frac{27}{13}$ **9.** Mass is $2 + \pi$; $\bar{x} = \frac{\pi}{2}$

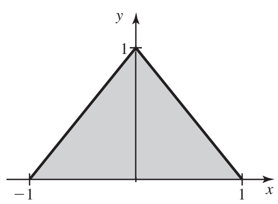
11. Mass is $\frac{20}{3}$; $\bar{x} = \frac{9}{5}$ **13.** Mass is 10; $\bar{x} = \frac{8}{3}$

15.



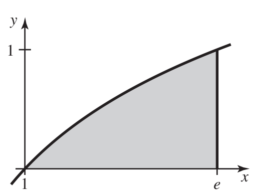
$\left(\dfrac{\pi}{2}, \dfrac{1}{2}\right)$

17.



$\left(0, \dfrac{1}{3}\right)$

19.

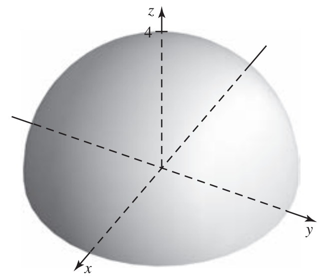


$\left(\dfrac{1}{4}(e^2 + 1), \dfrac{e}{2} - 1\right) \approx (2.10, 0.36)$

21. $\left(\frac{7}{3}, 1\right)$; density increases to the right. **23.** $\left(\frac{16}{11}, \frac{16}{11}\right)$; density increases toward the hypotenuse of the triangle.

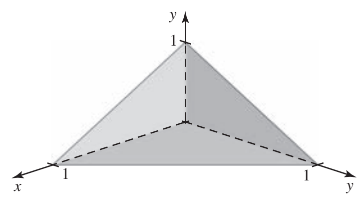
25. $\left(0, \frac{16 + 3\pi}{16 + 12\pi}\right) \approx (0, 0.4735)$; density increases away from the x-axis.

27.



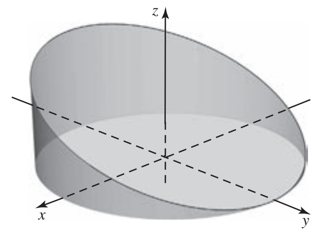
$\left(0, 0, \frac{3}{2}\right)$

29.



$\left(\frac{1}{4}, \frac{1}{4}, \frac{1}{4}\right)$

31.



$\left(0, -\frac{1}{4}, \frac{5}{8}\right)$

33. $\left(\frac{7}{3}, \frac{1}{2}, \frac{1}{2}\right)$ **35.** $\left(0, 0, \frac{198}{85}\right)$ **37.** $\left(\frac{2}{3}, \frac{7}{3}, \frac{1}{3}\right)$ **39. a.** False **b.** True **c.** False **d.** False **41.** $\bar{x} = \dfrac{\ln(1 + L^2)}{2\tan^{-1} L}$, $\lim_{L\to\infty} \bar{x} = \infty$

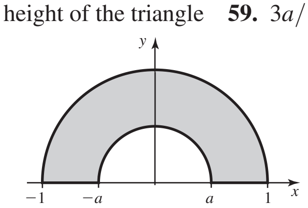
43. $\left(0, \dfrac{8}{9}\right)$ **45.** $\left(0, \dfrac{8}{3\pi}\right)$ **47.** $\left(\dfrac{5}{6}, 0\right)$ **49.** $\left(\dfrac{128}{105\pi}, \dfrac{128}{105\pi}\right)$

51. On the line of symmetry, $2a/\pi$ units above the diameter

53. $\left(\dfrac{2a}{3(4 - \pi)}, \dfrac{2a}{3(4 - \pi)}\right)$ **55.** $h/4$ units

57. $h/3$ units, where h is the height of the triangle **59.** $3a/8$ units

61. a. $\left(0, \dfrac{4(1 + a + a^2)}{3(1 + a)\pi}\right)$



b. $a = \dfrac{1}{2}\left(-1 + \sqrt{1 + \dfrac{16}{3\pi - 4}}\right) \approx 0.4937$

63. Depth $= \dfrac{40\sqrt{10} - 4}{333}$ cm ≈ 0.3678 cm

65. a. $(\bar{x}, \bar{y}) = \left(\dfrac{-r^2}{R + r}, 0\right)$ (origin at center of large circle);

$(\bar{x}, \bar{y}) = \left(\dfrac{R^2 + Rr + r^2}{R + r}, 0\right)$ (origin at common point of the circles)

b. *Hint:* Solve $\bar{x} = R - 2r$.

Section 16.7 Exercises, pp. 1082–1084

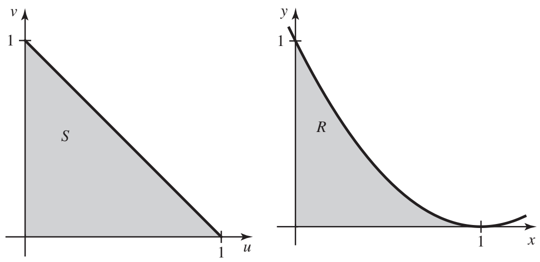
1. The image of S is the 2×2 square with vertices at $(0, 0)$, $(2, 0)$, $(2, 2)$, and $(0, 2)$. **3.** $\int_0^1\int_0^1 f(u + v, u - v)\,2\,du\,dv$

5. The rectangle with vertices at $(0, 0)$, $(2, 0)$, $\left(2, \frac{1}{2}\right)$, and $\left(0, \frac{1}{2}\right)$

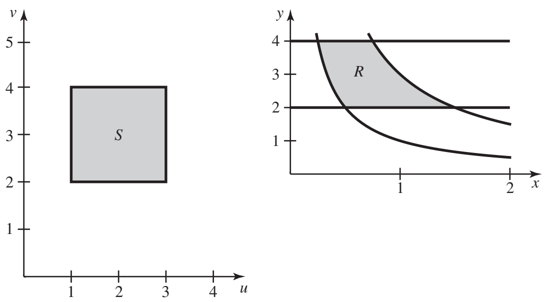
7. The square with vertices at $(0, 0)$, $\left(\frac{1}{2}, \frac{1}{2}\right)$, $(1, 0)$, and $\left(\frac{1}{2}, -\frac{1}{2}\right)$

9. The region above the x-axis and bounded by the curves $y^2 = 4 \pm 4x$ **11.** The upper half of the unit circle

13.



15.

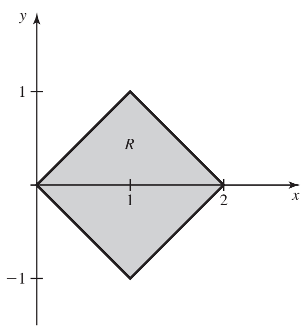


17. -9 **19.** $-4(u^2 + v^2)$ **21.** -1

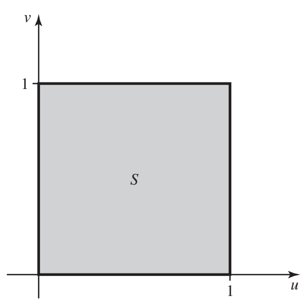
23. $x = (u + v)/3, y = (2u - v)/3; -1/3$

25. $x = -(u + 3v), y = -(u + 2v); -1$

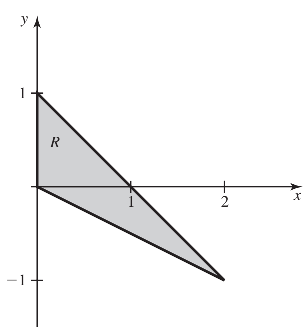
27. a.



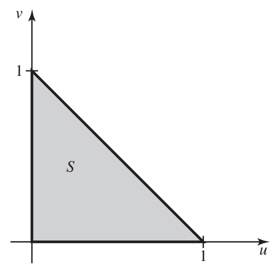
b. $0 \le u \le 1, 0 \le v \le 1$ **c.** $J(u, v) = -2$ **d.** 0



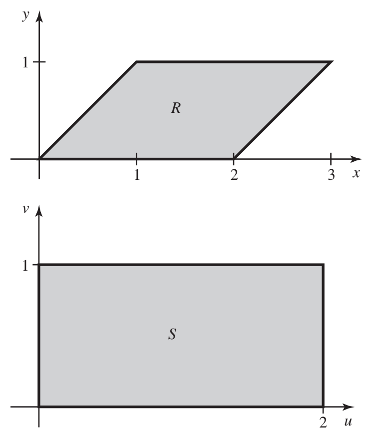
29. a.



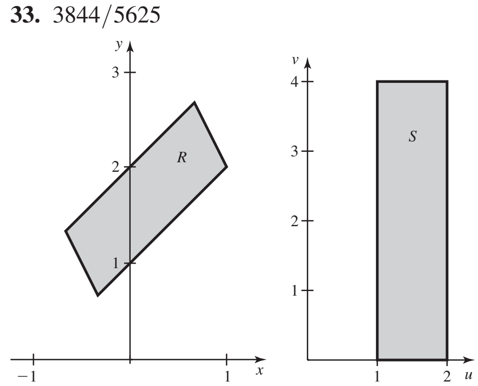
b. $0 \le u \le 1, 0 \le v \le 1 - u$ **c.** $J(u, v) = 2$ **d.** $256\sqrt{2}/945$



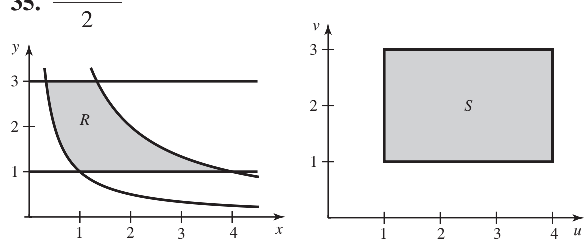
31. $4\sqrt{2}/3$



33. $3844/5625$



35. $\dfrac{15 \ln 3}{2}$



37. 2 **39.** $2w(u^2 - v^2)$ **41.** 5 **43.** $1024\pi/3$

45. a. True **b.** True **c.** True

47. *Hint:* $J(\rho, \varphi, \theta) = \begin{vmatrix} \sin\varphi\cos\theta & \rho\cos\varphi\cos\theta & -\rho\sin\varphi\sin\theta \\ \sin\varphi\sin\theta & \rho\cos\varphi\sin\theta & \rho\sin\varphi\cos\theta \\ \cos\varphi & -\rho\sin\varphi & 0 \end{vmatrix}$

49. $a^2b^2/2$ **51.** $(a^2 + b^2)/4$ **53.** $4\pi abc/3$

55. $(\bar{x}, \bar{y}, \bar{z}) = \left(0, 0, \dfrac{3c}{8}\right)$ **57. a.** $x = a^2 - \dfrac{y^2}{4a^2}$

b. $x = \dfrac{y^2}{4b^2} - b^2$ **c.** $J(u, v) = 4(u^2 + v^2)$ **d.** $\dfrac{80}{3}$ **e.** 160

f. Vertical lines become parabolas opening downward with vertices on the positive y-axis, and horizontal lines become parabolas opening upward with vertices on the negative y-axis. **59. a.** S is stretched in the positive u- and v-directions but not in the w-direction. The amount of stretching increases with u and v. **b.** $J(u, v, w) = ad$

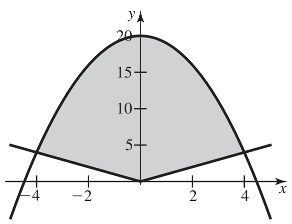
c. Volume $= ad$ **d.** $\left(\frac{a+b+c}{2}, \frac{d+e}{2}, \frac{1}{2}\right)$

Chapter 16 Review Exercises, pp. 1084–1088

1. a. False **b.** True **c.** False **d.** False **3.** $\frac{26}{3}$

5. $\int_0^1 \int_{-\sqrt{y}}^{\sqrt{y}} f(x, y)\, dx\, dy$ **7.** $\int_0^1 \int_0^{\sqrt{1-x^2}} f(x, y)\, dy\, dx$

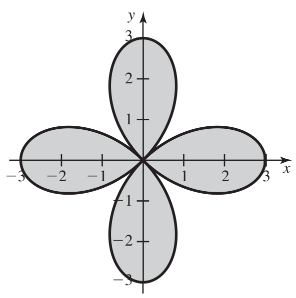
9. $\frac{304}{3}$



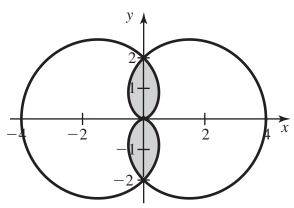
11. $\frac{\sqrt{17} - \sqrt{2}}{2}$

13. 8π **15.** $\frac{2}{7\pi^2}$ **17.** $\frac{1}{5}$

19. $\frac{9\pi}{2}$



21. $6\pi - 16$



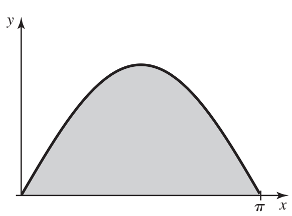
23. 2 **25.** $\int_0^1 \int_{2y}^{2} \int_0^{\sqrt{z^2-4y^2}/2} f(x, y, z)\, dx\, dz\, dy$ **27.** $\pi - \frac{4}{3}$

29. $8 \sin^2 2 = 4(1 - \cos 4)$ **31.** $\frac{848}{9}$ **33.** $\frac{8}{15}$ **35.** $\frac{16}{3}$

37. $\frac{128}{3}$ **39.** $\frac{\pi}{6} - \frac{\sqrt{3}}{2} + \frac{1}{2}$ **41.** $\frac{1}{3}$ **43.** $\frac{1}{3}$ **45.** π

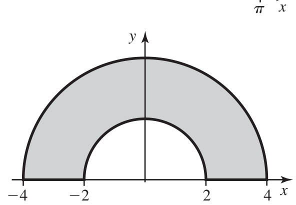
47. 4π **49.** $\frac{28\pi}{3}$ **51.** $\frac{2048\pi}{105}$

53.



$(\bar{x}, \bar{y}) = \left(\frac{\pi}{2}, \frac{\pi}{8}\right)$

55.



$(\bar{x}, \bar{y}) = \left(0, \frac{56}{9\pi}\right)$

57. $(\bar{x}, \bar{y}, \bar{z}) = (0, 0, 24)$ **59.** $(\bar{x}, \bar{y}, \bar{z}) = \left(0, 0, \frac{63}{10}\right)$

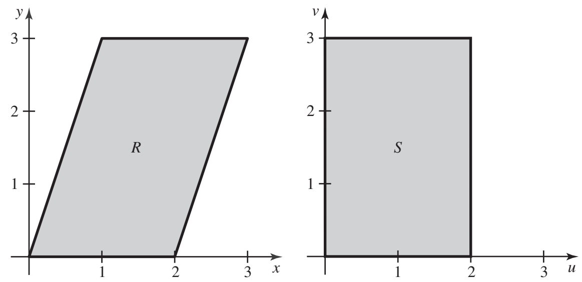
61. $\frac{h}{3}$ **63.** $\left(\frac{4\sqrt{2}a}{3\pi}, \frac{4(2 - \sqrt{2})a}{3\pi}\right)$ **65. a.** $\frac{4\pi}{3}$ **b.** $\frac{16Q}{3}$

67. $R = \{(x, y): 0 \le x \le 1, 0 \le y \le 1\}$

69. The parallelogram with vertices $(0, 0)$, $(3, 1)$, $(4, 4)$, and $(1, 3)$

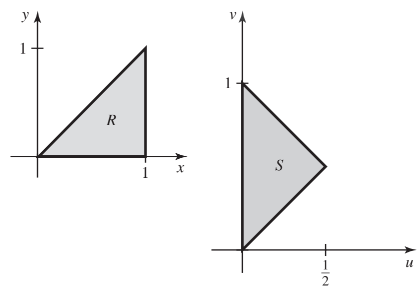
71. 10 **73.** 6

75. a.



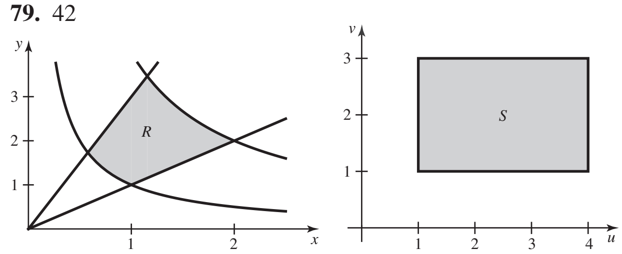
b. $0 \le u \le 2, 0 \le v \le 3$ **c.** $J(u, v) = 1$ **d.** $\frac{63}{2}$

77. a.



b. $u \le v \le 1 - u, 0 \le u \le \frac{1}{2}$ **c.** $J(u, v) = 2$ **d.** $\frac{1}{60}$

79. 42



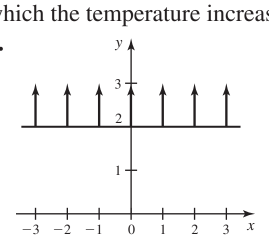
81. $-\frac{7}{16}$

CHAPTER 17

Section 17.1 Exercises, pp. 1096–1098

1. $\mathbf{F} = \langle f, g, h \rangle$ evaluated at (x, y, z) is the velocity vector of an air particle at (x, y, z) at a fixed point in time. **3.** At selected points (a, b), plot the vector $\langle f(a, b), g(a, b) \rangle$. **5.** It shows the direction in which the temperature increases the fastest and the amount of increase.

7.



9.