

EXERCISE SET 11.1  Graphing Utility**1–2** Plot the points in polar coordinates.

1. (a)  $(3, \pi/4)$       (b)  $(5, 2\pi/3)$       (c)  $(1, \pi/2)$   
     (d)  $(4, 7\pi/6)$       (e)  $(-6, -\pi)$       (f)  $(-1, 9\pi/4)$
2. (a)  $(2, -\pi/3)$       (b)  $(3/2, -7\pi/4)$       (c)  $(-3, 3\pi/2)$   
     (d)  $(-5, -\pi/6)$       (e)  $(2, 4\pi/3)$       (f)  $(0, \pi)$

**3–4** Find the rectangular coordinates of the points whose polar coordinates are given.

3. (a)  $(6, \pi/6)$       (b)  $(7, 2\pi/3)$       (c)  $(-6, -5\pi/6)$   
     (d)  $(0, -\pi)$       (e)  $(7, 17\pi/6)$       (f)  $(-5, 0)$
4. (a)  $(-2, \pi/4)$       (b)  $(6, -\pi/4)$       (c)  $(4, 9\pi/4)$   
     (d)  $(3, 0)$       (e)  $(-4, -3\pi/2)$       (f)  $(0, 3\pi)$

5. In each part, a point is given in rectangular coordinates. Find two pairs of polar coordinates for the point, one pair satisfying  $r \geq 0$  and  $0 \leq \theta < 2\pi$ , and the second pair satisfying  $r \geq 0$  and  $-2\pi < \theta \leq 0$ .
- (a)  $(-5, 0)$       (b)  $(2\sqrt{3}, -2)$       (c)  $(0, -2)$   
     (d)  $(-8, -8)$       (e)  $(-3, 3\sqrt{3})$       (f)  $(1, 1)$

6. In each part, find polar coordinates satisfying the stated conditions for the point whose rectangular coordinates are  $(-\sqrt{3}, 1)$ .
- (a)  $r \geq 0$  and  $0 \leq \theta < 2\pi$   
     (b)  $r \leq 0$  and  $0 \leq \theta < 2\pi$   
     (c)  $r \geq 0$  and  $-2\pi < \theta \leq 0$   
     (d)  $r \leq 0$  and  $-\pi < \theta \leq \pi$

**7–8** Use a calculating utility, where needed, to approximate the polar coordinates of the points whose rectangular coordinates are given.

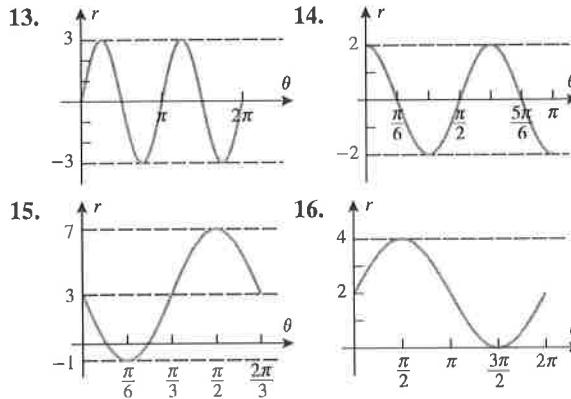
7. (a)  $(3, 4)$       (b)  $(6, -8)$       (c)  $(-1, \tan^{-1} 1)$
8. (a)  $(-3, 4)$       (b)  $(-3, 1.7)$       (c)  $(2, \sin^{-1} \frac{1}{2})$

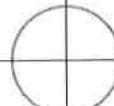
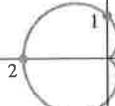
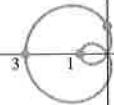
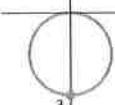
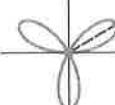
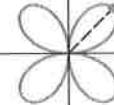
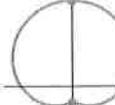
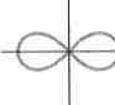
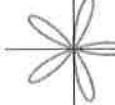
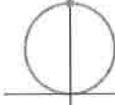
**9–10** Identify the curve by transforming the given polar equation to rectangular coordinates.

9. (a)  $r = 2$       (b)  $r \sin \theta = 4$   
     (c)  $r = 3 \cos \theta$       (d)  $r = \frac{6}{3 \cos \theta + 2 \sin \theta}$
10. (a)  $r = 5 \sec \theta$       (b)  $r = 2 \sin \theta$   
     (c)  $r = 4 \cos \theta + 4 \sin \theta$       (d)  $r = \sec \theta \tan \theta$

**11–12** Express the given equations in polar coordinates.

11. (a)  $x = 3$       (b)  $x^2 + y^2 = 7$   
     (c)  $x^2 + y^2 + 6y = 0$       (d)  $9xy = 4$
12. (a)  $y = -3$       (b)  $x^2 + y^2 = 5$   
     (c)  $x^2 + y^2 + 4x = 0$       (d)  $x^2(x^2 + y^2) = y^2$

**FOCUS ON CONCEPTS****13–16** A graph is given in a rectangular  $\theta r$ -coordinate system. Sketch the corresponding graph in polar coordinates.**17–20** Find an equation for the given polar graph.

17. (a)  (b)  (c) 
18. (a)  (b)  (c) 
19. (a)  (b)  (c) 
20. (a)  (b)  (c) 

**21–50** Sketch the curve in polar coordinates.

21.  $\theta = \frac{\pi}{3}$       22.  $\theta = -\frac{3\pi}{4}$       23.  $r = 3$   
     24.  $r = 4 \cos \theta$       25.  $r = 6 \sin \theta$       26.  $r = 1 + \sin \theta$   
     27.  $2r = \cos \theta$       28.  $r - 2 = 2 \cos \theta$

29.  $r = 3(1 + \sin \theta)$

31.  $r = 4 - 4 \cos \theta$

33.  $r = -1 - \cos \theta$

35.  $r = 2 + \cos \theta$

37.  $r = 3 + 4 \cos \theta$

39.  $r = 5 - 2 \cos \theta$

41.  $r^2 = \cos 2\theta$

43.  $r^2 = 16 \sin 2\theta$

45.  $r = 4\theta \quad (\theta \leq 0)$

47.  $r = -2 \cos 2\theta$

49.  $r = 9 \sin 4\theta$

30.  $r = 5 - 5 \sin \theta$

32.  $r = 1 + 2 \sin \theta$

34.  $r = 4 + 3 \cos \theta$

36.  $r = 3 - \sin \theta$

38.  $r = 5 - 3 \sin \theta$

40.  $r = -3 - 4 \sin \theta$

42.  $r^2 = 9 \sin 2\theta$

44.  $r = 4\theta \quad (\theta \geq 0)$

46.  $r = 4\theta$

48.  $r = 3 \sin 2\theta$

50.  $r = 2 \cos 3\theta$

**51–55** Use a graphing utility to generate the polar graph. Be sure to choose the parameter interval so that a complete graph is generated.

51.  $r = \cos \frac{\theta}{2}$

52.  $r = \sin \frac{\theta}{2}$

53.  $r = 1 - 2 \sin \frac{\theta}{4}$

54.  $r = 0.5 + \cos \frac{\theta}{3}$

55.  $r = \cos \frac{\theta}{5}$

56. The accompanying figure shows the graph of the “butterfly curve”

$$r = e^{\cos \theta} - 2 \cos 4\theta + \sin^3 \frac{\theta}{4}$$

Generate the complete butterfly with a graphing utility, and state the parameter interval you used.

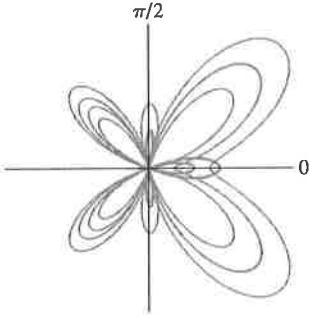
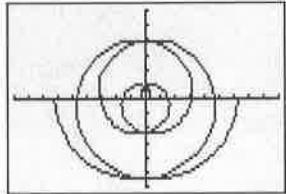


Figure Ex-56

57. The accompanying figure shows the Archimedean spiral  $r = \theta/2$  produced with a graphing calculator.

(a) What interval of values for  $\theta$  do you think was used to generate the graph?

(b) Duplicate the graph with your own graphing utility.



[-9, 9] × [-6, 6]

xScl = 1, yScl = 1

Figure Ex-57

58. Find equations for the two families of circles in the accompanying figure.

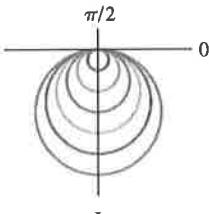
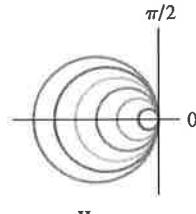


Figure Ex-58



59. (a) Show that if  $a$  varies, then the polar equation

$$r = a \sec \theta \quad (-\pi/2 < \theta < \pi/2)$$

describes a family of lines perpendicular to the polar axis.

(b) Show that if  $b$  varies, then the polar equation

$$r = b \csc \theta \quad (0 < \theta < \pi)$$

describes a family of lines parallel to the polar axis.

#### FOCUS ON CONCEPTS

60. The accompanying figure shows graphs of the Archimedean spiral  $r = \theta$  and the parabolic spiral  $r = \sqrt{\theta}$ . Which is which? Explain your reasoning.

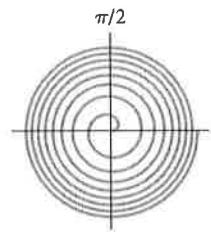
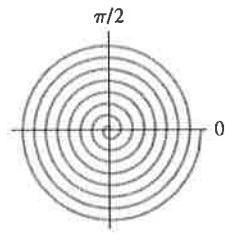


Figure Ex-60



61. The accompanying figure shows the polar graph of the equation  $r = f(\theta)$ . Sketch the graph of

- (a)  $r = f(-\theta)$
- (b)  $r = f\left(\theta - \frac{\pi}{2}\right)$
- (c)  $r = f\left(\theta + \frac{\pi}{2}\right)$
- (d)  $r = -f(\theta)$
- (e)  $r = f(\theta) + 1$ .

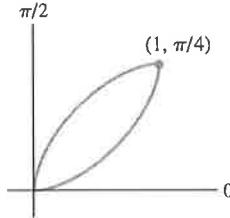


Figure Ex-61