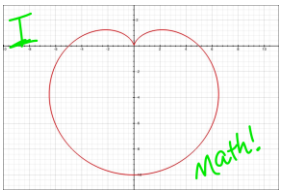
For each question, "E) NOTA" indicates that none of the above answers is correct.



1. Convert the following pair of Cartesian Coordinates to Polar Coordinates. Choose a possible correct answer below: $\left(\frac{\pi}{\sqrt{3}},\pi\right)$

A) $\left(\frac{2\pi\sqrt{3}}{3},\frac{\pi}{3}\right)$ B) $\left(\frac{2\pi}{3},\frac{\pi}{3}\right)$ C) $\left(\frac{-\pi\sqrt{3}}{3},0\right)$ D) $\left(0,\frac{-\pi\sqrt{3}}{3}\right)$ E) NOTA

2. Find the distance between the following polar points: $\left(2,45^\circ\right)$ and $\left(-4,-45^\circ\right)$.

A) 10 B) 20 C) $\sqrt{5}$ D) $2\sqrt{5}$ E) NOTA

3. Find the distance between the following polar points: $\left(-5,60^\circ\right)$ and $\left(12,-240^\circ\right)$.

A) $\sqrt{109}$ B) 13 C) $\sqrt{229}$ D) 16 E) NOTA

4. For the expression $\left(\sqrt{3}-i\right)^6$, find an equivalent polar coordinate pair for the result.

A) $(12,\pi)$ B) $(64,\pi)$ C) $(64,0)$ D) $(12,0)$ E) NOTA

5. A circle has a diameter of 10 units and a center at (-5,5). Find its equation in polar form.

A) $r^2+10r\sin\theta-10r\cos\theta+25=0$ B) $r^2+10r\cos\theta-10r\sin\theta+25=0$
C) $r=10\cos\theta$ D) $r=10\sin\theta$ E) NOTA

6. Given the following polar conic equation, find the equation of the directrix of the conic section described: $r=\frac{6}{2-2\cos\theta}$.

A) $x=-3$ B) $y=-3$ C) $x=-6$ D) $y=-6$ E) NOTA

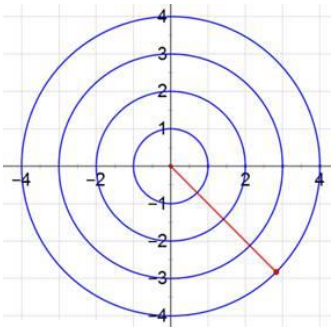
7. Find all polar coordinates (angles measured in radians and k = any integer) with positive *r* value of the Cartesian point: $(-9,9)$.

A) $\left(9\sqrt{2},3\pi/4+2k\pi\right)$ B) $\left(-9\sqrt{2},3\pi/4+2k\pi\right)$
C) $\left(9\sqrt{2},5\pi/4+2k\pi\right)$ D) $\left(-9\sqrt{2},3\pi/4-2k\pi\right)$ E) NOTA

8. In what quadrant does the polar point $(-4,-4)$ lie?

A) Quadrant 1 B) Quadrant 2 C) Quadrant 3 D) Quadrant 4 E) NOTA

9. What polar coordinates could be at the non-origin end of the radius graphed below? Assume standard position.

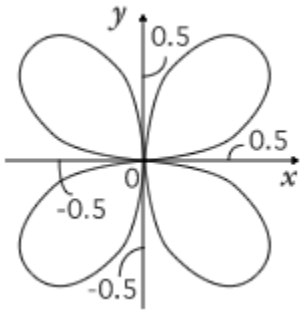


A) $\left(2\sqrt{2},-2\sqrt{2}\right)$ B) $4(\cos 315^\circ + i\sin 315^\circ)$

C) $\left(4,-1485^\circ\right)$ D) $\left(-4,-1485^\circ\right)$

E) NOTA

10. What type of polar graph is shown below?



A) Cardioid B) Rose

C) Lemniscate D) Limacon

E) NOTA

11. What kind of symmetry does this polar graph have: $r = 3 - \frac{4}{3}\cos\theta$?

A) About x-axis B) About y-axis C) About origin D) No symmetry E) NOTA

12. Find the maximum distance from the origin among all points of the following polar curve and name the type of curve: $r^2 = 4\sin(2\theta)$.

A) 2; rose B) 2; limacon C) 4; rose D) 4; lemniscate E) NOTA

13. Fill in the blanks: _____ is an example of an equation for a *Spiral of* _____.

A) $r = \sin\left(\pi/4\right)$; Archimedes

B) $r = \sin\theta$; Aristotle

C) $r = \pi/4$; Aristotle

D) $r = 4\theta$; Archimedes

E) NOTA

14. Which of the following is a polar equation of a line going through the pole with a slope of $\frac{-1}{\sqrt{2}}$?

A) $r = \pi/4$ B) $r = \frac{-\sqrt{2}}{2}$ C) $\theta = \frac{-\sqrt{2}}{2}$ D) $\theta = \frac{-\pi}{4}$ E) NOTA

15. Classify the polar conic section and find the rectangular coordinates of its vertex/vertices: $r = \frac{12}{4 - 3\cos\theta}$.

A) Ellipse; $(12,0),\left(12/7,\pi\right)$ B) Ellipse; $(12,0),\left(-12/7,0\right)$

C) Hyperbola; $(12,0),\left(12/7,\pi\right)$ D) Hyperbola; $(12,0),\left(-12/7,0\right)$ E) NOTA

16. How many of the following are graphed at the same "location" on a plane? (give the largest possible answer)

$\left(-2, 2\sqrt{3}\right)$ $(-4, 60^\circ)$ $-2+2\sqrt{3}i$ $4\left(\cos 2\pi/3 + i\sin 2\pi/3\right)$

A) 0 B) 1 C) 2 D) 3 E) NOTA

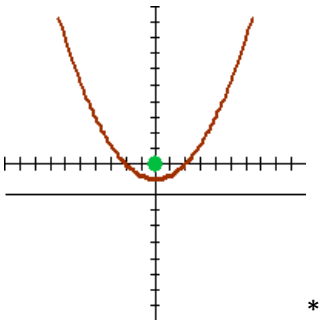
17. A vector is formed with tail at Cartesian point $(-1, 4)$ and head at Cartesian point $(6, 28)$. Find the component form of the vector. Using the magnitude and direction of the vector, give the polar coordinate pair that would be equivalent to the standard position vector.

A) $\left(25, \tan^{-1}\frac{24}{7}\right)$ B) $\left(-25, \tan^{-1}\frac{24}{7}\right)$ C) $\left(25, \tan^{-1}\frac{-24}{7}\right)$ D) $\left(25/2, \tan^{-1}\frac{-24}{7}\right)$ E) NOTA

18. Convert the polar point $\left(-5, \frac{5\pi}{6}\right)$ to a point *z* at the same location in the Argand plane, then find the value of z^4, giving your final answer in the standard form of a complex number.

A) $\frac{-625}{2}+\frac{625\sqrt{3}}{2}i$ B) $\frac{-625}{2}+\frac{-625\sqrt{3}}{2}i$ C) $-10-\left(10\sqrt{3}\right)i$ D) $-10+\left(10\sqrt{3}\right)i$ E) NOTA

19. Find the polar equation of the parabola with given focus and directrix from the graph:



** Assume the scale is 1 unit for both axes

A) $r=\frac{2}{1-2\cos\theta}$ B) $r=\frac{2}{2-\cos\theta}$ C) $r=\frac{2}{1-2\sin\theta}$ D) $r=\frac{2}{1-\sin\theta}$ E) NOTA

20. Everett was taking a jog along the path of the curve $r=12\sin\theta$ from his starting value of $\theta=\pi/6$ to his terminal value of $\theta=2\pi/3$. What distance did Everett travel?

A) 2π B) 3π C) 4π D) 6π E) NOTA

21. Stephen is playing *Polar Battleship* with Brandi. The goal of the game is to locate your opponent's polar coordinates of their battleships on the game board. Stephen and Brandi are having a heated debate about whether or not Stephen correctly located Brandi's battleship with polar coordinates $\left(-5, \pi/3\right)$. If he did correctly locate the battleship at that point, what is another way he could have named it?

A) $(\pi/3, -5)$ B) $\left(5, 2\pi/3\right)$ C) $\left(5, -2\pi/3\right)$ D) $\left(-5, 5\pi/3\right)$ E) NOTA

22. Find the area enclosed by the following set of parametric equations: $\begin{aligned} x &= 4\cos\theta \\ y &= 12\sin\theta \end{aligned}$.

A) 24π B) 36π C) 48π D) 64π E) NOTA

23. What is the modulus of the following simplified expression: $\dfrac{\left(4cis\,\pi/3\right)^{-3}\left(5cis\,\pi/6\right)^{4}}{cis\,\pi}$?

A) $625/64$ B) $-64/625$ C) 8 D) Cannot Be Determined E) NOTA

24. Find the distance between vertices on the graph of the following polar conic: $r = \dfrac{16}{2-8\sin\theta}$.

A) $\frac{4}{5}$ B) $\frac{16}{15}$ C) $\frac{2}{3}$ D) $\frac{14}{15}$ E) NOTA

25. Among the following limacons, all of which have an inner loop, the point on the inner loop that is farthest from the pole is found, and the distance from that point to the pole is found. For which limacon is that distance the greatest?

A) $r = 3-4\cos\theta$ B) $r = 4+5\sin\theta$ C) $r = 5+6\sin\theta$ D) $r = 3-5\sin\theta$ E) NOTA

26. Which of the polar linear equations has the largest magnitude slope?

A) $\theta = 7\pi/4$ B) $\theta = -3\pi/4$ C) $r = \dfrac{\pi}{4}\csc\theta$ D) $\theta = -2\pi/3$ E) NOTA

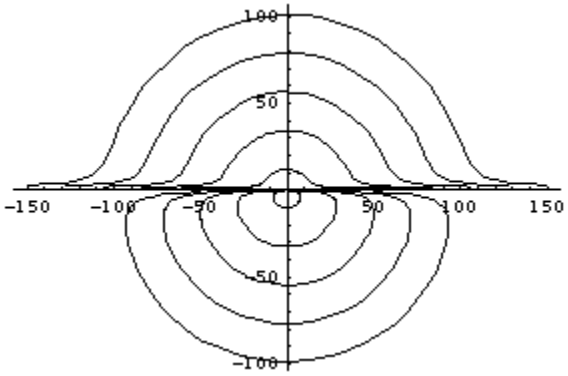
27. At what angle measures (in degrees) would the tip of each rose petal $r = 6\cos(3\theta)$ intersect with the tip of each "propeller" on the lemniscate $r^2 = 36\sin(2\theta)$?

A) 0° and 180° B) 30° and 210° C) 45° and 225° D) They never meet E) NOTA

28. This polar graph is made by taking one cardioid and rolling over another cardioid of the same size. Its equation is $r = 4a\cos^3\left(\theta/3\right)$. It is sometimes also known as a sinusoidal spiral.

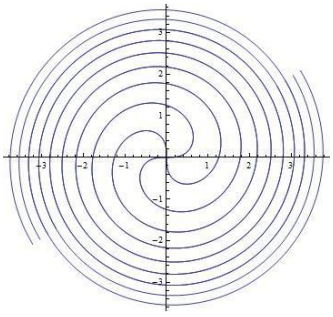
A) Hayley's Comet B) Cayley's Sextic
C) Cassinian Oval D) Cissoid of Diocles E) NOTA

29. This polar curve (seen in the image) got its name from what common object?



A) Apple B) Balloon C) Conch Shell D) Dew Drops E) NOTA

30. This may be the last question, but it is not the Last Theorem. Which of the following equations generates Fermat's Spiral?



A) $r = a^2\theta$
B) $r^2 = a\theta$
C) $r^2 = a^2\cos\theta$
D) $r^2 = a^2\theta$
E) NOTA