

#0 Theta Bowl
MAΘ National Convention 2026

A: Find the coefficient of x^4 in the expansion of $(x+1)^5$.

B: A diameter is drawn inside a circle, dividing the interior into two regions. A square is then inscribed in one of those two regions, with one side of the square along the diameter. Find the area enclosed by the square.

C: Secant segments $\overline{AB}$ and $\overline{AC}$ are drawn to a circle with point A lying outside the circle. Secant segment $\overline{AB}$ intersects the circle at point D (D is between A and B) and secant segment $\overline{AC}$ intersects the circle at point E (E is between A and C). If $|\overline{BD}|=7$, $|\overline{AD}|=3$, and $|\overline{AE}|=2$, find $|\overline{CE}|$.

D: Solve the equation $\sin^2 \theta = 6(\cos(-\theta) + 1)$ on the interval $0 \leq \theta < 2\pi$.

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#1 Theta Bowl
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A: Solve for x : $\log x + \log(x + 2) = \log 8$

B: Jessica has a two-gallon solution of lemonade that is 80% lemon juice and 20% water. How many quarts of water must she add to this solution in order to have the perfect lemonade, which is 65% lemon juice and 35% water? Express your answer as an improper fraction.

C: The smaller of two positive integers is $\frac{3}{5}$ of the larger. The positive difference of the two positive integers is less than 24. Find the largest possible value of the larger integer.

D: An equilateral triangle has two vertices at the points $(9, -1)$ and $(1, -1)$. Find the coordinates for the third vertex, given that it is in the first quadrant.

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#2 Theta Bowl
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Given real-valued function $f(x) = \frac{x^2 - 9}{(x^2 + 1)(x^2 - 4)}$:

A: Find the equation(s) of all vertical asymptotes of f .

B: Find the equation(s) of all horizontal asymptotes of f .

C: Find any x -intercepts of f , written as ordered pairs.

D: Find any y -intercepts of f , written as ordered pairs.

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#3 Theta Bowl
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A: Find any points of intersection of the circles defined by the equations $(x-1)^2 + y^2 = 4$ and $(x+1)^2 + y^2 = 4$.

B: A square is inscribed in a circle of radius 5. Find the area enclosed by the square.

C: Let $\odot A$ and $\odot B$ be externally tangent circles. $\odot A$ has a radius of 3 and $\odot B$ has a radius of 9. $\overline{CD}$ is a common external tangent to the circles. C is the point of tangency on $\odot A$ and D is the point of tangency on $\odot B$. Find the area enclosed by quadrilateral $ABDC$.

D: Find the product of the roots of the equation $x^2 - 4x + 1 = 0$.

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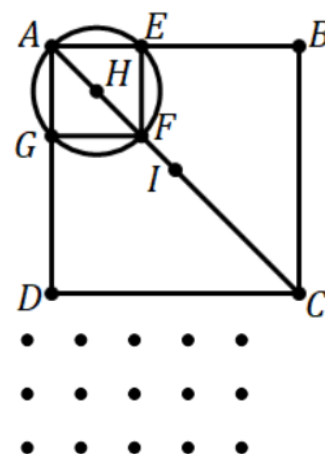
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#4 Theta Bowl
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A: Write the equation, in slope-intercept form, of the perpendicular bisector of the line segment with endpoints $(4,1)$ and $(-2,3)$.

B: In the figure, $\overline{AF}$ is the diagonal of square $AEFG$ and $\overline{AC}$ is the diagonal of square $ABCD$. Square $AEFG$ is inscribed in $\odot H$, and I is the center of square $ABCD$. The area enclosed by square $ABCD$ is 512 and $|\overline{FI}| = 2$. Find the area enclosed by $\odot H$.



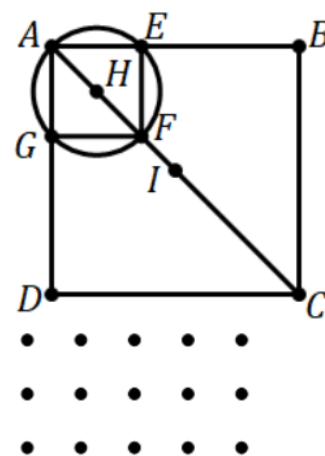
C: What is the probability that four different points chosen at random from the 15 equally-spaced points shown are the vertices of a square?

D: For vectors $\hat{u} = 3\hat{i} - 2\hat{j} + \hat{k}$ and $\hat{v} = -\hat{i} + 3\hat{j} - \hat{k}$, find $\hat{u} \times \hat{v}$, written in this same format.

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#5 Theta Bowl
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A: Ella is buying a bicycle. The regular price for the bicycle is \$500, but Ella buys it when it is on sale for 20% off the regular price. Ella is also buying a helmet. When Ella buys the helmet, it is on sale for 10% off the regular price. Ella pays \$108 for the helmet. What is the fraction of Ella's savings on her total purchase?

B: Find the inverse of the function $f(x) = \sqrt[3]{x^5 - 2}$.

C: In $\triangle ABC$, $m\angle ACB = 90^\circ$, $|\overline{AC}| = 5$, and $|\overline{BC}| = 7$. Find the length of the altitude of this triangle to its hypotenuse.

D: In right $\triangle ABC$, $\angle C$ is the right angle, $|\overline{AC}| = 3$, and $|\overline{BC}| = 4$. Find the surface area of the figure formed by revolving $\triangle ABC$ about $\overline{BC}$.

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#6 Theta Bowl
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A: Find the center of the circle that contains the points $(-3,5)$, $(3,3)$, and $(11,19)$.

B: The lengths of the sides of a triangle are the solutions to $x^3 - 20x^2 + 127x - 252 = 0$. Find the area enclosed by the triangle.

C: Find the irrational values for x in the equation $\begin{vmatrix} -2x & 3x \\ -16 & x^2 \end{vmatrix} = 64$.

D: A parabola passes through the points $(0,2)$, $(4,5)$, and $(8,-2)$. Find the maximum value for this parabola.

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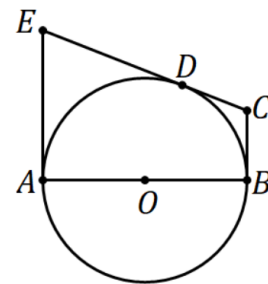
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#7 Theta Bowl
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A: If $f(x) = -x^2 + x$ and $g(x) = \frac{-x}{2}$, find $(f \circ g)(x)$.

B: Find the equation for the ellipse with eccentricity of $\frac{2}{3}$ and endpoints of minor axis $(\pm 5, 0)$, written in the form $\frac{x^2}{m} + \frac{y^2}{n} = 1$, where m and n are real numbers.

C: In the figure, $\overline{AE}$, $\overline{CE}$, and $\overline{BC}$ are tangent segments to $\odot O$. If $|\overline{AB}| = 2$ and $|\overline{AE}| = \frac{5}{4}$, find the area enclosed by trapezoid $ABCE$.



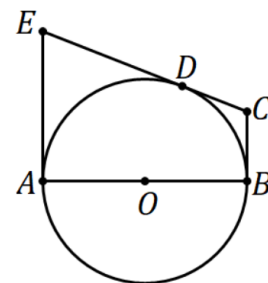
D: The length and width of a rectangle are 2 and 3, respectively. Find the circumference of the circle that circumscribes the rectangle.

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#8 Theta Bowl
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A: Evaluate $(2 - 2\sqrt{3}i)^4$. Write your answer in $a + bi$ form.

B: Evaluate $\sum_{k=1}^4 \left(\frac{1}{2}\right)^{k+1}$.

C: The hypotenuse of an isosceles right triangle is 11. If a is length of a leg of the isosceles right triangle and b is the length of the altitude of the isosceles right triangle to its hypotenuse, find the product of a and b .

D: The area enclosed by a regular hexagon is $150\sqrt{3}$. Find the length of an apothem of this hexagon.

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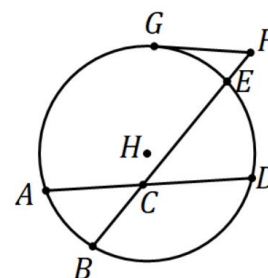
A: Determine the interval(s) over which the function $f(x) = 2x^3 + 5x^2 - 12x$ is positive. Write your answer in interval notation.

B: Find the 99th term of the arithmetic sequence with first term 7 and common difference -3 .

C: In $\triangle ABC$, D is on $\overline{AB}$ such that $\frac{|AD|}{|BD|} = \frac{3}{2}$ and E is on $\overline{BC}$ such that $\frac{|BE|}{|CE|} = \frac{3}{2}$. If $\overrightarrow{DE}$

intersects $\overline{AC}$ at F , find the value of $\frac{|DE|}{|EF|}$.

D: $\overline{FG}$ is tangent to $\odot H$. If $m\angle DE = 70^\circ$, $m\angle EG = 30^\circ$, $m\angle F = 65^\circ$, and $m\angle ACE = 125^\circ$, find $m\angle BD$.



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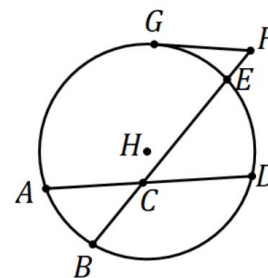
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#10 Theta Bowl
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A: Find the shortest distance between the line $y = 5x - 7$ and the point $(-1, 3)$.

B: The frustum of a right circular cone has height 6 and radii 12 and 8. Find the volume of the frustum.

C: Let $f(x)$ be a function such that, for every real number x , $f(-x) + 2f(x) = \cos x$. Find $f\left(\frac{\pi}{4}\right)$.

D: Winston and Nick play a game in which each independently throws a dart at a target. On any given turn, Winston hits the target with probability 0.6 and Nick hits the target with probability 0.3. Winston wins the game if he hits the target and Nick misses on the same turn. Nick wins the game if he hits the target and Winston misses on the same turn. Otherwise, the game is a tie. Find the probability that the game is a tie. Give your answer in decimal form.

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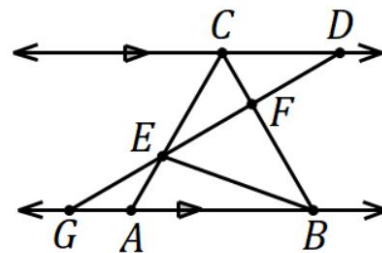
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#11 Theta Bowl
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A: The lengths of two sides of a triangle are 6 and 11. Give all possible values for the length of the third side of the triangle. Write your answer in interval notation.

B: $\triangle ABC$ is an equilateral triangle in which the sides have length 6. If $\overrightarrow{AB} \parallel \overrightarrow{CD}$ and $|\overline{DF}| = |\overline{FE}| = |\overline{EG}|$, find $|\overline{BE}|$.



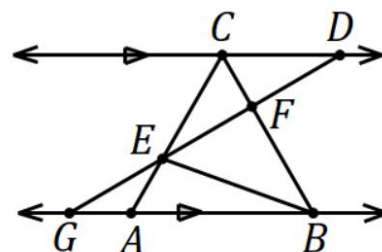
C: When $\sqrt{4-2\sqrt{3}}$ is expressed in the form $\sqrt{a}-b$, where a and b are integers, find $a+b$.

D: If $A = \begin{bmatrix} 3 & 2 \\ -5 & 4 \end{bmatrix}$, find A^{-1} . Do not include any scalars outside the matrix in your answer.

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#12 Theta Bowl
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A: Calculate $x + y + z$ in the system:
$$\begin{cases} 2x + y + 3z = 12 \\ 3x - 2y - 5z = 7 \\ x + 3y + 4z = 1 \end{cases}$$

B: When $(2+k)x^2 + 3x - k$ is divided by $x + 4$, the remainder is 3. Find k .

C: A regular polygon has an exterior angle that measures 8° . How many diagonals does this polygon have?

D: Two polygons are similar to each other. The areas of the polygons are 50 and 75. If the length of the shortest side of the smaller polygon is 5, find the length of the shortest side of the larger polygon.

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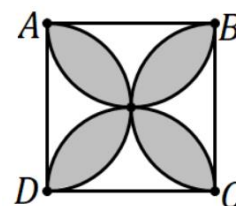
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#13 Theta Bowl
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A: One solution of the equation $5x^2 + kx = 4$ is $x = 2$. Find the other solution.

B: The lengths of the diagonals of a rhombus are in the ratio 2:1. If the perimeter of the rhombus is 20, find the sum of the lengths of the diagonals.

C: Quadrilateral $ABCD$ is a square. The petals within the square are formed by four intersecting semicircles. If $|\overline{AB}| = 4$, find the probability that a point selected at random lies in the shaded region.



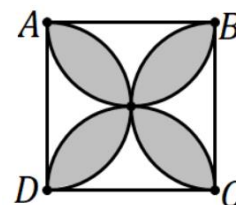
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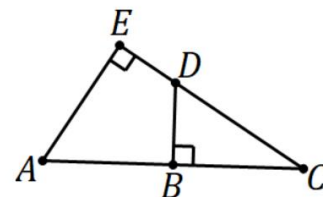


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#14 Theta Bowl
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A: A solid sphere and a solid right circular cone both sit on the same horizontal surface. The cone sits on its circular base. Both the sphere and the cone's base have a radius of 5 mm, and the cone has a height of 10 mm. A horizontal plane intersects both the sphere and cone in circular cross-sections that have the same area. How far, in mm, above the horizontal surface is this plane?

B: In the figure to the right, B is the midpoint of $\overline{AC}$, $|\overline{AC}| = 20$, and $|\overline{AE}| = 12$. Find the area of quadrilateral $ABDE$.



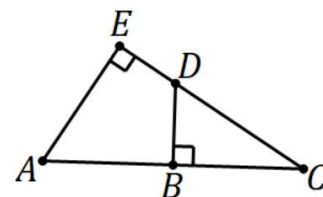
C: Simplify the expression for integer $n \geq 2$: $\frac{n(n+1)!}{(n-1)!} \cdot \frac{n!}{n^3(n^2-1)}$

D: If $\frac{x^2 - 3x - 10}{x^2 - 1} \leq 0$, solve for x . Write your answer in interval notation.

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