Question #0
Alpha Ciphering
MAΘ National Convention 2025

The determinant below can be written in reduced form $\frac{m}{n}$ for positive integers m, n:

$$\begin{vmatrix} \log_4 9 & \log_4 3 \\ \log_3 8 & \log_3 512 \end{vmatrix}$$

Find $m + n$.

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A circle has chords $\overline{AB}$ and $\overline{AC}$ with coordinates $A(-2,-1)$, $B(0,3)$, and $C(3,4)$. In terms of π, what is the exact area of the circle?

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Find the sum of all solutions on $[0, 2\pi)$ to the equation:

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Find the value of xyz that solves the system:

$$\begin{cases} \log_2 x + \log_4 y + \log_8 z = \frac{1}{6} \\ \log_4 x + \log_8 y + \log_2 z = -\frac{1}{2} \\ \log_8 x + \log_2 y + \log_4 z = \frac{13}{6} \end{cases}$$

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In ΔABC, the largest angle is twice the measure of the smallest. The ratio of the largest side length to the smallest side length is 4:3. The sine of the largest angle is of the form $\frac{m\sqrt{p}}{n}$ for relatively prime integers m, n and where p is prime. Find $m + n + p$.

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Question #5
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The four intersection points of the graphs of the curves below form a convex quadrilateral. What is the area of the quadrilateral?

$$8x^2 + 18y^2 + 36y = 118 + 16x$$
$$2x^2 = 3y^2 + 4x + 6y + 7$$

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$f(x) = x^3 + ax^2 + bx + c$ has integer roots in geometric progression, where a, b, c are integers. The product of the roots is 64. The sum of the roots is -6. Find the value of $a + b + c$.

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Question #7
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A complex number z satisfies the following, where $i = \sqrt{-1}$:

$$|z + i| = \sqrt{53}$$
$$|z + 3| = \sqrt{101}$$

Find the minimum value of $|z|$ as a simplified radical.

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Question #8
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Consider the polar curve:

$$r = 16\sin\theta\cos\theta\cos 6\theta + 4\sin 4\theta$$

Let m be the number of petals in the graph and let n be the maximum distance a point on the graph is from the origin.

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Question #9
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Alfred spins a spinner 6 times, each spin independent of the rest. The spinner has multiple, different colored regions, one being red. The probability that any spin lands on red is p. The probability that he he lands on red exactly two times is 4 times the probability that he lands on red exactly four times.

As a reduced fraction, what is the value of p?

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What is the exact value of k?

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