2025 MAΘ National Convention
Mu Ciphering
Problem 0

Compute the maximum value of $x(1-x)^2$ over all $0 \leq x \leq 1$.

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Problem 1

Legosi gets thrown off a roof by Gouhin, and falls such that his distance from the ground is modeled by the function $h(t) = at^2 + bt + c$ for some real a, b, c.

If $h(0) = 20$, $h(2) = 14$, and $h(4) = 0$, find the average value of $h'(t)$ over $0 \leq t \leq 4$.

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Problem 2

Evaluate

$$\lim_{x \to 0^+} \frac{x^{2x} - 1}{x \ln(x)}.$$

If the limit does not exist, submit "DNE."

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Problem 3

The graphs of $y = 2\sqrt{x}$ and $y = 3\sqrt[3]{x}$ have a unique common tangent line with positive slope. Compute the x-intercept of this common tangent (express your answer as just the x-coordinate, not a point).

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Problem 4

Compute the slope of the tangent line to the ellipse given by $x^2 + xy + y^2 = 7$ at the point $(1, 2)$.

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Problem 5

Evaluate

$$\int_{1/3}^{3} \frac{3}{\sqrt{x}+\frac{1}{\sqrt{x}}}\,\mathrm{d}x.$$

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Problem 6

Let $ABCDA'B'C'D'$ be a right rectangular prism with opposite faces $ABCD$ and $A'B'C'D'$ and connecting edges AA', BB', CC', and DD'.

The lengths AB, AD, and AA' change at rates 1, 2, and 1 units per second respectively, while everything else changes in such a way as to keep $ABCDA'B'C'D'$ a right rectangular prism.

At the moment $AB = 1$, $AD = 1$, and $AA' = 2$, compute the rate of change of the area of triangle $BA'D$.

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Problem 7

Let R be the region bounded between the x-axis, $y = \sqrt[3]{x}$, $x = 1$, and $x = 8$. Compute the volume of the region formed by revolving R about the x-axis.

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Problem 8

Suppose $\{a_n\}_{n=1}^{\infty}$ is a sequence of real numbers such that for all $1 < x < 3$

$$\sum_{n=1}^{\infty} a_n \left(\frac{x-1}{2}\right)^{n-1} = \sqrt{x}.$$

Compute $\sum_{n=1}^{\infty} \frac{a_n}{n \cdot 6^n}$.

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Problem 9

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Problem 10

There exists a unique function $f(x)$ such that for all $x \geq 1$,

$$xf(x)f'(x) = (f(x))^2 + 1,$$

and $f(1) = 1$. Compute $f(5)$.

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