

Time limit: 15 minutes.

Instructions: This tiebreaker contains 3 short answer questions. All answers must be expressed in simplest form unless specified otherwise. You will submit answers to the problem as you solve them, and may solve problems in any order. You will not be informed whether your answer is correct until the end of the tiebreaker. You may submit multiple times for any of the problems, but **only the last submission for a given problem will be graded**. The participant who correctly answers the most problems wins the tiebreaker, with ties broken by the time of the last correct submission.

No calculators.

1. Compute the area of the polygon formed by connecting the roots of

$$x^{10} + x^9 + x^8 + x^6 + x^5 + x^4 + x^2 + x + 1$$

graphed in the complex plane with line segments in counterclockwise order.

2. $f(x)$ is a nonconstant polynomial. Given that $f(f(x)) + f(x) = f(x)^2$, compute $f(3)$.
3. Let $f(x) = x^3 - 6x^2 + \frac{25}{2}x - 7$. There is an interval $[a, b]$ such that for any real number x , the sequence $x, f(x), f(f(x)), \dots$ is bounded (i.e., has a lower and upper bound) if and only if $x \in [a, b]$. Compute $(a - b)^2$.