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1 For each integer $n \geq 2,$ determine, with proof, which of the two positive real numbers a and b satisfying

$$a^n = a + 1, \qquad b^{2n} = b + 3a$$

is larger.

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2 Let $ABCD$ be a convex quadrilateral such that diagonals AC and BD intersect at right angles, and let E be their intersection. Prove that the reflections of E across AB, BC, CD, DA are concyclic.

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3 Consider functions $f : [0, 1] \to \mathbb{R}$ which satisfy
(i) $f(x) \geq 0$ for all x in $[0, 1]$,
(ii) $f(1) = 1$,
(iii) $f(x) + f(y) \leq f(x + y)$ whenever x, y, and $x + y$ are all in $[0, 1]$.

Find, with proof, the smallest constant c such that

$$f(x) \leq cx$$

for every function f satisfying (i)-(iii) and every x in $[0, 1]$.

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4 Let a, b be odd positive integers. Define the sequence (f_n) by putting $f_1 = a,$ $f_2 = b,$ and by letting f_n for $n \geq 3$ be the greatest odd divisor of $f_{n-1} + f_{n-2}$. Show that f_n is constant for n sufficiently large and determine the eventual value as a function of a and b.

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5 Let $a_0, a_1, a_2, \ldots$ be a sequence of positive real numbers satisfying $a_{i-1}a_{i+1} \leq a_i^2$ for $i = 1, 2, 3, \ldots$. (Such a sequence is said to be *log concave*.) Show that for each $n > 1$,

$$\frac{a_0 + \cdots + a_n}{n+1} \cdot \frac{a_1 + \cdots + a_{n-1}}{n-1} \geq \frac{a_0 + \cdots + a_{n-1}}{n} \cdot \frac{a_1 + \cdots + a_n}{n}.$$
