

3rd United States of America Junior Mathematical Olympiad

Day I 12:30 PM – 5 PM EDT

April 24, 2012

Note: For any geometry problem, the first page of the solution must be a large, in-scale, clearly labeled diagram made with drawing instruments (ruler, compass, protractor, graph paper, carbon paper). Failure to meet any of these requirements will result in a 1-point automatic deduction.

JMO 1. Given a triangle ABC , let P and Q be points on segments \overline{AB} and \overline{AC} , respectively, such that $AP = AQ$. Let S and R be distinct points on segment \overline{BC} such that S lies between B and R , $\angle BPS = \angle PRS$, and $\angle CQR = \angle QSR$. Prove that P, Q, R, S are concyclic (in other words, these four points lie on a circle).

JMO 2. Find all integers $n \geq 3$ such that among any n positive real numbers a_1, a_2, \dots, a_n with

$$\max(a_1, a_2, \dots, a_n) \leq n \cdot \min(a_1, a_2, \dots, a_n),$$

there exist three that are the side lengths of an acute triangle.

JMO 3. Let a, b, c be positive real numbers. Prove that

$$\frac{a^3 + 3b^3}{5a + b} + \frac{b^3 + 3c^3}{5b + c} + \frac{c^3 + 3a^3}{5c + a} \geq \frac{2}{3}(a^2 + b^2 + c^2).$$