

30th International Mathematical Olympiad
Braunschweig, Germany

Day I
July ??, 1989

1. Prove that the set $\{1, 2, \dots, 1989\}$ can be expressed as the disjoint union of subsets A_i ($i = 1, 2, \dots, 117$) such that:
 - (i) Each A_i contains 17 elements;
 - (ii) The sum of all the elements in each A_i is the same.

2. In an acute-angled triangle ABC the internal bisector of angle A meets the circumcircle of the triangle again at A_1 . Points B_1 and C_1 are defined similarly. Let A_0 be the point of intersection of the line AA_1 with the external bisectors of angles B and C . Points B_0 and C_0 are defined similarly. Prove that:
 - (i) The area of the triangle $A_0B_0C_0$ is twice the area of the hexagon $AC_1BA_1CB_1$.
 - (ii) The area of the triangle $A_0B_0C_0$ is at least four times the area of the triangle ABC .

3. Let n and k be positive integers and let S be a set of n points in the plane such that
 - (i) No three points of S are collinear, and
 - (ii) For any point P of S there are at least k points of S equidistant from P .

Prove that:

$$k < \frac{1}{2} + \sqrt{2n}.$$

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4. Let $ABCD$ be a convex quadrilateral such that the sides AB , AD , BC satisfy $AB = AD + BC$. There exists a point P inside the quadrilateral at a distance h from the line CD such that $AP = h + AD$ and $BP = h + BC$. Show that:

$$\frac{1}{\sqrt{h}} \geq \frac{1}{\sqrt{AD}} + \frac{1}{\sqrt{BC}}.$$

5. Prove that for each positive integer n there exist n consecutive positive integers none of which is an integral power of a prime number.
6. A permutation (x_1, x_2, \dots, x_m) of the set $\{1, 2, \dots, 2n\}$, where n is a positive integer, is said to have property P if $|x_i - x_{i+1}| = n$ for at least one i in $\{1, 2, \dots, 2n - 1\}$. Show that, for each n , there are more permutations with property P than without.