"Coffins"

Here is a collection of difficult math problems with elegant solutions that possess a unique history.

The history of this collection

In the summer of 1975, while I was in a Soviet math camp preparing to compete in the International Math Olympiad on behalf of the Soviet Union, my fellow team members and I were approached for help by Valera Senderov, a math teacher in one of the best Moscow special math schools.

The Mathematics Department of Moscow State University, the most prestigious mathematics school in Russia, had at that time been actively trying to keep Jewish students (and other "undesirables") from enrolling in the department. One of the methods they used for doing this was to give the unwanted students a different set of problems on their oral exam. These problems were carefully designed to have elementary solutions (so that the Department could avoid scandals) that were nearly impossible to find. Any student who failed to answer could be easily rejected, so this system was an effective method of controlling admissions. These kinds of math problems were informally referred to as "coffins". "Coffins" is the literal translation from Russian; in English these problems are sometimes called "killer" problems.

These problems and their solutions were, of course, kept secret, but Valera Senderov and his friends had managed to collect a list. In 1975, they approached us to solve these problems, so that they could train the Jewish students in these mathematical ideas. We solved some of them. Here I present some of the "coffin" problems from my archive.

I invite people who faced "killer" problems to send them to me to add to my list.

Sample solution

Problem 31.

A quadrilateral is given in space, such that its edges are tangent to a sphere. Prove that all the points of tangency lie in one plane.

Solution. Begin by observing that each vertex of the quadrilateral is equidistant from the two points of tangency of the edges it is on. With that, put a mass into each vertex of the quadrilateral that is proportional to the inverse of the distance from that vertex

to a point of tangency (of an edge it's in). Then the center of mass for any two neighboring vertices is the point of tangency of the edge they share. Then the center of mass of all four vertices should lie on the line connecting opposite points of tangency. That means that the two lines connecting the opposite pairs of points of tangency intersect, so all four of them lie in the plane those two lines define.

Other links

- A. Shen. *Entrance examinations to the Mekh-mat*, Math. Intelligencer, **16**, 1994.
- Ilan Vardi's home page. Here you can find solutions to 25 problems published by A. Shen, Entrance Examinations to the Mekh-mat, Mathematical Intelligencer 16 (1994), 6-10.
- PDF file with Ilan Vardi's solutions.
- A. Vershik. *Admission to the mathematics faculty in Russia in the 1970s and 1980s*, Math. Intelligencer, **16**, 1994. - Historical bigraphical article supporting A. Shen's paper
- *Kerosinka: An Episode in the History of Soviet Mathematics*, *Notices of the AMS, **11***, 1999. - another historical article
- The articles by Shen, Vershik and Vardi as well as other articles are now published in a book: "You Failed Your Math Test, Comrade Einstein: Adventures and Misadventures of Young Mathematicians, Or Test Your Skills in Almost Recreational Mathematicsm", edited by M. Shifman.
- Epilogue to "Comrade Einstein".
- Bella Abramovna Subbotovskaya and the "Jewish People's University." An article in AMS Notices Vol. 54, N. 10 (2007), 1326-1330.
- A discussion on LiveJournal, in Russian.
- E. Frenkel. *The Fifth problem: math & anti-Semitism in the Soviet Union*, The New Criterion, 2012.

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