The 39th International Mathematical Olympiad

The 39th IMO will be held in Taipei, Taiwan, over the dates 10–21 July 1998. The last two IMO's were held in India (1996) and Argentina (1997), for the first time in the two countries. This IMO will be Taiwan's first. In India, 75 countries took part; in Argentina, 82 countries. This year the figure may rise to 85 or more. Each country sends upto 6 students (who write the examination individually, not as a team).

For the readers' benefit, here is a brief description of how an IMO proceeds. Over March–April the host country receives proposals from participating countries (5–6 from each country). These cover the standard areas of elementary mathematics: number theory, algebra, geometry, combinatorics (calculus is excluded). In practice, not more than 30 to 35 countries send in proposals and the number of problems received rarely exceeds 125 (India got 108, Canada 112). Over May–June the Problem Selection Committee of the host country shortlists 30 problems or so, and the final paper, consisting of 6 problems, is prepared from the shortlist by the team leaders, who constitute the Jury; this is done over a 2-day period at the time of the IMO itself. The contest is held over the next 2 days (3 problems per day), with a generous time budget: 4½ hours on each day. The grading ('coordination', in IMO jargon) is done over the next 3 days. Following this is the medals-award ceremony. All told, the IMO is a tightly packed event, with little room left for organisational mishaps.

Readers may wonder about the basis on which the problems are shortlisted. The single most important criterion is originality: the problem should not have appeared in any form elsewhere. (In practice this criterion is difficult to implement.) A second criterion is suitability and general appeal. These qualities are difficult to define precisely but are important. The final paper is selected by the Jury in a highly democratic manner, with each country having a say in the matter. Sometimes it happens that the Jury totally misjudges the level of difficulty of a problem. The students are so capable that many beautiful solutions turn up, and some of these become candidates for a 'brilliancy prize'.

Coordination forms a particularly interesting part of an IMO, because of the carnival-like atmosphere that develops during the activity, with so many people milling around in the coordination rooms. Inevitably it is also a time when strong disagreements take place.

We give below a problem from IMO 1996 to illustrate the type of problem that an IMO offers. (It is a 'discrete version of the intermediate value theorem'.) (See *Resonance*, Vol.2, No.1, 60, January 1997).

Problem 6. IMO 1996

Let n, p, q be positive integers with $n>p+q$. Let $x_0, x_1, \ldots, x_n$ be integers satisfying the following two conditions: (a) $x_0 = x_n = 0$; (b) for each integer i with $1 \leq i \leq n$, either $x_i - x_{i-1} = p$ or $x_i - x_{i-1} = -q$. Show that there exists a pair (i, j) of indices with $i<j$ and $(i,j) \neq (0, n)$, such that $x_i = x_j$.

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"I would not have proposed a topic of this difficulty as a dissertation to any of my other pupils," wrote Sommerfeld. The faculty accepted the thesis and Wien accepted it for publication in the physics journal he edited, but when the mathematician Fritz Noether raised objections in 1926, the results remained in doubt for nearly a quarter century until they were finally confirmed.

Acceptance of the dissertation brought admission of the candidate to the final orals, where in this case trouble began. The examining committee consisted of Sommerfeld and Wien, along with representatives in Heisenberg's two minor subjects, mathematics and astronomy. Much was at stake, for the only grades a candidate received were those based on the dissertation and final oral: one grade for each subject and one for overall performance. The grades ranged from I (equivalent to an A) to V (an F).

As the 21-year-old Heisenberg appeared before the four professors on July 23, 1923, he easily handled Sommerfeld's questions and those in mathematics but he began to stumble on astronomy and fell flat on his face on experimental physics. In his laboratory work Heisenberg had to use a Fabry-Perot interferometer, a device for observing the interference of light waves, on which Wien had lectured extensively. But Heisenberg had no idea how to derive the resolving power of the interferometer nor, to Wien's surprise, could he derive the resolving power of such common instruments as the telescope and the microscope. When an angry Wien asked how a storage battery works, the candidate was still lost. Wien saw no reason to pass the young man, no matter how brilliant he was in other fields.

An argument broke out between Sommerfeld and Wien over the relative importance of theory and experiment. The result was that Heisenberg received the lowest of three passing grades in physics and the same overall grade (cum laude) for his doctorate, both of which were an average between Sommerfeld's highest grade and Wien's lowest grade.

Sommerfeld was shocked. Heisenberg was mortified. Accustomed to being always at the top of his class, Heisenberg found it hard to accept the lowest of three passing grades for his doctorate. Sommerfeld held a small party at his home later that evening for the new Dr Heisenberg, but Heisenberg excused himself early, packed his bag, and took the midnight train to Göttingen, showing up in Max Born's office the next morning. Born had already hired Heisenberg as his teaching assistant for the coming school year. After informing Born of the debacle of his orals, Heisenberg asked sheepishly, "I wonder if you still want to have me."

Born did not answer until he had gone over the questions Heisenberg had missed. Convincing himself that the questions were "rather tricky," Born let his employment offer stand. But that fall Heisenberg's worried father wrote to the famed Göttingen experimentalist James Franck, asking Franck to teach his boy some experimental physics. Franck did his best, but could not overcome Heisenberg's complete lack of interest and gave up the effort. If Heisenberg was going to survive at all in physics it would be purely as a theorist.

There is an interesting epilogue to this story. When Heisenberg derived the uncertainty relations several years later, he used the resolving power of the microscope to derive the uncertainty relations — and he still had difficulty with it! And again, when Bohr pointed out the error, it led to emotional difficulties for Heisenberg. Likewise, this time a positive result came of the affair: Heisenberg's reaction induced Bohr to formulate his own views on the subject, which ultimately led to the so-called Copenhagen Interpretation of quantum mechanics.

For more see: http://www.hofstra.edu/Heisenberg