

2012 Samuel Beatty Contestant Report: Matthew Brennan

43rd International Mathematics Olympiad in Mar del Plata, Argentina

Since 1959, teams of six contestants from each participating country have gathered annually to compete in the International Math Olympiad (IMO). The exam is written over two consecutive days and consists of two papers – each four and a half hours in length and comprised of three problems in algebra, combinatorics, number theory and geometry. Each of the six problems is marked out of seven points and a contestant's score on each of the six problems is determined through a process of coordination – wherein a group of markers and the team leaders identify the number of points scored by a contestant according to a pre-set marking scheme. Once all of the papers have been marked, medal boundaries are determined such that approximately the top one twelfth of the participants receives gold medals, the top one quarter of the participants receives either silver or gold medals, and the top half of the participants receives bronze, silver or gold medals. Any student who does not receive a medal but has achieved a perfect score on one or more of the problems is awarded an honourable mention.

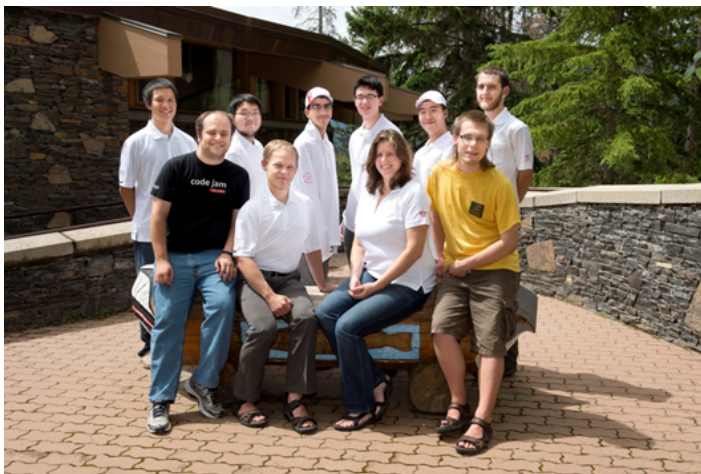


Photo: Kim Williams, Banff Centre
 Front Row (leaders and trainers) L-R: David Arthur, Ralph Furmaniak, Lindsey Shorser, Alex Fink
 Back Row (team) L-R: Calvin Deng, Alex Song, Daniel Spivak, Matthew Brennan, Kevin Zhou, James Rickards

This year, 100 countries and a total of 548 contestants participated in the 53rd International Math Olympiad held in Mar del Plata, Argentina, from July 8th to July 16th. The members of the Canadian team were: Calvin Deng (Cary NC), James Rickards (Ottawa ON), Alex Song (Waterloo ON), Kevin Zhou (Toronto ON),

Daniel Spivak (Toronto ON), and Matthew Brennan (Toronto ON). The team was selected based on the Canadian results in the Asian Pacific, USA and Canadian Math Olympiads. Three leaders travelled with the team to Argentina and helped us prepare for the exam: Team Leader Jacob Tsimmerman (Harvard University), Deputy Leader Lindsey Shorser (University of Toronto) and Deputy Leader Observer Ralph Furmaniak (Stanford University).

Prior to travelling to Argentina for the competition, the team trained at the Banff International Research Station from June 24th to July 7th. During this period, we were joined by several additional trainers: Hunter Spink from Cambridge University, Alex Fink from North Carolina State University, and David Arthur from Google. Three additional students also participated in the team's training during the first of the two weeks. These students were Leo Lai (Vancouver BC), Weilian Chu (Edmonton AB), and Kevin Sun (Naperville IL). A typical day at the training camp consisted of a morning lecture, an afternoon lecture, and an evening problem-solving seminar. Topics covered in the first week included applications of generating functions, inequalities, functional equations, induction, cyclotomic polynomials and lifting arguments with exponents, projective and inversive geometry, vectors and complex numbers. In the second week, we covered synthetic geometry, invariants and monovariants, tilings and various topics in number theory. Every two days, we wrote a mock exam consisting of three problems carefully chosen by our trainers over a four and a half hour period to emulate the conditions of the IMO. In the evenings, we often supplemented our problem-solving seminars with Bernoulli trails led by Ralph, which consisted of approximately ten true or false questions which we were given five minutes to contemplate before providing an answer.

On July 3rd, Jacob departed for Argentina. Between July 5th and July 8th, as a member of the jury at the IMO, he voted for and against the shortlisted problems to ultimately determine the six that appeared on the exam. Lindsey, Ralph and the Canadian Team left Banff for the contest on July 7th. After thirty four hours of airplane and bus rides, we arrived at the contestant hotel in Mar del Plata on Sunday July 8th. Unlike at IMO 2011 in the Netherlands, all of the events related to the contest,

with the exception of the opening ceremony, were held in the large halls of the hotel. We were greeted by our guide Luis Ferroni who gave us a tour of the hotel. After exploring the hotel briefly, we seized the opportunity to catch up on some much needed sleep. On the next day, we attended the opening ceremony at a nearby theatre. The chairman of the IMO Advisory Board, Nazar Agakhanov, and the representative of Argentina on the Board, Patricia Fauring, officially launched IMO 2012. Then the teams paraded across the stage carrying their respective flags. The rest of the day was spent relaxing and preparing mentally for the first day of the contest.

On Tuesday, we wrote the contest between 9:00 a.m. and 1:30 p.m. in one of the hotel's large halls. The problems on the first day produced a very unorthodox contest. Although the first problem was a synthetic geometry requiring one key insight and typical of the IMO, the second was a very non-standard inequality problem. It requires a surprisingly short solution for problem two and gives an aesthetically appealing lower bound which is significantly lower than the minimum of the function for large values of n . The third problem was a very difficult one and the first with two parts since 2008. Although three of us solved the first part, no Canadian made any significant progress on the second part. Later that day, we found out that the problem was proposed by David Arthur and created in conjunction with Jacob. We spent the rest of the day resting for the second day of the exam and discussing the problems with other teams. Many strong countries completely solved the first problem and partially solved the second. Most countries found the third problem very difficult. The one exception was the U.S. team, many members of which were expecting a perfect score on the first day.

On Wednesday, we again wrote the contest between 9:00 a.m. and 1:30 p.m. in the same large hall. The problems again were unorthodox. The fourth problem was significantly harder and longer than in previous years. While the first problem had taken most of us between a quarter and three quarters of an hour, the fourth problem consumed between one and two and a half hours of our time. When we discussed the problems with other teams, we found that they had similar difficulties. As a result, many contestants did not have sufficient time to fully attempt the fifth and sixth problems. Despite this difficulty, Alex had solved the three problems completely and Calvin had nearly solved all three, with several steps missing in his solution to the sixth problem. The rest of the day was spent in the rec room, where we relaxed

with the exam behind us. Lindsey, Ralph and Jacob read our solutions to prepare for the three days of coordination to follow.



L-R: Luis Ferroni, Kevin Zhou, James Rickards, Calvin Deng, Daniel Spivak, Matthew Brennan, Alex Song, Ralph Furmaniak

The next morning, we met with Jacob after he had reviewed our solutions. The team had six complete solutions to the first problem, four to the second, three to the first part of the third, six to the fourth, three to the fifth, and one to the sixth. We also had two partial solutions to the second problem, one partial solution to the fifth, and two partial solutions to the sixth. Unfortunately, the marking scheme for the fourth problem deducts up to two points for not checking the solutions found to the given functional equation, which is typically deemed a detail minute enough detail to be omitted without penalty. As a result, it appeared as though two of our solutions to the fourth problem would be penalized. After Jacob left for Canada's first session of coordination, the rest of the team alternated between playing cards and participating in activities in the rec room.

On day two of the coordination, the contestants were taken to the aquarium in Mar del Plata. To our surprise, the aquarium was outdoors and when a rainstorm hit, most of us were unprepared. When we returned to the hotel, we continued to play cards and try various activities in the rec room, while keeping an eye on the scoreboard. After a third day of coordination, the rankings of the top countries became clearer. The next day, the medal cut-offs, individual rankings and country rankings were announced. The Canadian team had earned three gold medals, one silver medal and two bronze medals. We had placed fifth, tying with Thailand,

behind South Korea, China, the U.S. and Russia. The details of our placement are summarized in the table below.

Name	P1	P2	P3	P4	P5	P6	Total	Rank
Calvin Deng	7	7	3	7	7	4	35	11
James Rickards	7	7	3	5	0	0	22	96
Alex Song	7	7	3	7	7	7	38	4
Kevin Zhou	7	3	0	6	3	0	19	151
Daniel Spivak	7	1	0	7	0	2	17	183
Matthew Brennan	7	7	0	7	7	0	28	33

IMO 2012 marks Canada's highest overall rank to date and the largest number of gold medals achieved by Canada at any IMO. Alex's result makes him the first Canadian to rank in the top five since Jacob ranked first in 2004 with a perfect score. This is also one of the few times that Canada has had two students rank in the top twelve.



Alex receiving his gold medal

After the closing ceremony and presentation of medals, we spent the night packing and participating in the final activities in the rec room. The next morning, we began the trip to Toronto. Once in Toronto, Kevin, Daniel, Alex, Lindsey and I returned home and Jacob, Calvin, Ralph and James transferred to additional flights.