# Romanian Masters of Mathematics 2011

## Bucharest, Romania
## A student's report, by Richard Freeland

## Introduction

In his parallel report on this event, James Cranch modestly suggested that his own descriptions may be lacking in humour. In an attempt to remedy this, and to allow the students of next year to gain an impression of what being at a mathematics competition is like, I have prepared this student's report. It is in the familiar diary format, and as ever, tends to focus on things that went wrong for comic effect. In reality, there were few of these, and the RMMS was an excellent competition.

As it is unlikely that Britain's success will have escaped your attention, I do not need to worry about spoilers. The team, together with scores, were:

| Team Member | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Total | Award |
|---|---|---|---|---|---|---|---|---|
| Andrew Carlotti | 6 | 1 | 1 | 7 | 0 | 4 | 19 | Silver Medal |
| Ben Elliott | 6 | 2 | 0 | 7 | 2 | 0 | 17 | Bronze Medal |
| Richard Freeland | 7 | 1 | 0 | 7 | 0 | 3 | 18 | Silver Medal |
| Edward Godfrey | 0 | 3 | 0 | 7 | 0 | 0 | 10 | Honourable Mention |
| Adam Goucher | 7 | 1 | 0 | 7 | 7 | 3 | 25 | Gold Medal |
| Jordan Millar | 5 | 1 | 0 | 7 | 7 | 3 | 23 | Silver Medal |

Cut-offs were 25 for gold, 18 for silver and 13 for bronze. Adam and I therefore achieve efficiency prizes for gaining medals with no margin of safety, whilst Ben merits sympathy for having the highest possible bronze.

The UK came joint second overall with 67, level with Hungary and behind the USA with 72, and beating Russia (66), China (65) and Serbia (62). The team scores are calculated by the sum of the top three scorers from each team. If instead all six scores are added, the UK still comes second, but this time it is Russia who take the lead by one point. If the top four or five scores are added, Britain finishes first, one point ahead of Russia.

The team leader was James Cranch and the deputy leader James Gazet.

## Student's Diary

**Wednesday 23rd February**: We assemble at Luton airport. I come across Ed and Carlotti and we discover two related problems. First, the Ritazza café where we are meeting ought to exist, but doesn't. Secondly, none of us have ever met Adam and the general suspicion is that he doesn't exist either. Ed is convinced that Geoff, the former IMO leader, posted emails under the pseudonym Adam P. Goucher to revitalise us in our attempts at the Advanced Mentoring Scheme. Can it be a coincidence that Adam Peter Goucher is an anagram of "made up, to recharge"? In this respect he is somewhat like Malcolm Granville, an equally mysterious figure from New Zealand who always manages to score one less than the highest mark in BMO.

Anyway, it soon turns out that Adam does exist, but of the Ritazza café there is no sign. We  manage to come together anyway. James Cranch claims that the meeting point did exist on the online map – we point out that generally reality is more useful. The journey is uneventful, except that it is Adam's first time on a plane, and Ed has a different type of boarding card from everyone else. James Gazet tells him it's because he's 'special'. Proof of this comes in the form of the Pret a Manger gingerbread men being named Godfrey.

We are in the same hotel as last year. Four of us are in a room together, but Ed and Carlotti are to be in a room with two Peruvians. Three try to enter, and after some discussion, realise that five people will not fit in four beds. I cannot help but feel that if the other teams are having difficulty counting, it bodes well for the competition.

**Thursday 24th February**: Ed complains that Carlotti woke him up twice in the night, once with a nosebleed, the other time because he wanted to solve a maths problem. We quickly educate Carlotti on how his normal habits may need to be changed when sharing a room with three other people, two of whom would not understand an English explanation.

We venture out into snowy Bucharest, supposedly to see the Parliament buildings. It turns out we are not allowed in without ID. Adam tries to enter with a passport photocopy and a MENSA membership card. He is rejected – it seems that MENSA requires intelligence, but not common sense. Instead, we sample Romanian culture by visiting McDonald's. We buy three drinks between the six of us, and Ed manages to connect to the Internet, despite the instructions being in Romanian, by putting 'primes' in every box.

The competition starts in the afternoon with the opening ceremony. There are speeches in which representatives of various sciences (mathematics, physics, chemistry, computing) claim their own subject is the best and that the others are inferior, and then

the teams stand up in turn. We are the only team to have any official uniform; the UKMT has provided some fetching sky-blue polo shirts. We also get a competition rucksack full of freebies: two pens, a book on Diophantine equations, and official contest T-shirts. These come in two sorts: overlarge and lurid yellow.

We retire in the evening to look at some combinatorics problems, under the scrutiny of James Gazet. Carlotti solves a 2009 IMO shortlist problem, and I translate his solution into language the rest of the team can understand. They then turn to a fiendish problem concerning the movements of an object called a 'limp rook'; I have come up against this problem before and decide to avoid a second crushing defeat.

**Friday 25th February**: We wake up at 7 for the contest and cross Bucharest in a very cramped bus. Our Romanian guides have to force the doors open so we can escape. We wait nervously in the main hall of Tudor Vianu school, surrounded by boards bearing the names of international olympiad competitors from there. Dan Schwarz, the Romanian problem setter who is in charge of the event, approaches us. He appears very uneasy, because Jordan is from Northern Ireland and might require a Gaelic version of the contest paper, and is greatly relieved that Jordan's English will suffice.

The competition is in the standard IMO format: 2 papers, each 4½ hours long and containing three questions. Question 1 is very nice and counter-intuitive, asking you to find two functions with a very unlikely property. In our various rooms, the team settle what the mysterious blob in $f \circ g$ means by suitable questions to the jury (this is allowed in the first half hour) and then generally solve it by many strange constructions. These are written up with varying degrees of rigour. Jordan solves it in the last five minute and only has time to draw some pictures of number lines. He doubts they will be accepted as a solution.

I also find what I think is a solution to question 2, but the geometric question 3 defeats me. I meet up with Ben afterwards; he claims the same as me, but I manage to dismantle his attempt at the second problem. On the other hand my solution, which uses equally flawed arguments about polynomials in a certain modulus, is accepted by the team. We reckon on 4 ½ solutions to question 1 (only Ed feels he didn't get anywhere), various interesting ideas and one solution to question 2, and what Carlotti calls non-trivial progress on problem 3. This involves making a note to himself to use circle $\omega$ and then not using it.

We meet up with James Cranch and James Gazet at lunch. They seem pleased with the morning's efforts (last year, the first day had yielded just one solution). The rest of the day is spent playing cards, the game of choice being Blind Poker.

**Saturday 26ᵗʰ February**: The second day of the contest. In the 15 minutes before the exam, I talk to a couple of American students. My attempt at problem 2 is torn to shreds, but they are amazed at the number of solutions the UK has managed in problem 1.

The exam starts well with problem 4 falling easily. It involves an unusual function measuring the parity of the number of prime factors of integers, and there are several easy ways to solve it. Question 5 is an unusual but very nice geometry problem involving a set of points with a particular distance property. It takes me a page of working to translate this property, and then I do not progress far beyond it. Question 6 is a full-blooded combinatorics problem of a fairly common type, but particularly hard.

I make little progress on either, except I guess an arrangement which will solve the last problem, without being able to prove it is optimal. However, I do make an unfortunate discovery about the food provided. It turns out that 'ROM' chocolate is not short for Romania, but actually means 'rum', and indeed that is one of the main ingredients. My pessimistic side notes that by solving question 4 but having my solution to question 2 proved wrong, I have solved 0 problems on average.

We meet up afterwards again. Everyone has solved problem 4, and there are three solutions to question 5. Ben has a Euclidean solution which he was unable to write down even after nine pages; Jordan has used physics; and Adam has used co-ordinates. He claims that he had just enough rum to think that this Olympiad 'dark art' was a good idea, but still be sober enough to do the necessary algebra. Carlotti again claims something on the hardest problem, producing 14 pages of rough to problem 6 which could be forced into a solution.

James Cranch has more good news: we are top in the world in question 1! Two of us have perfect solutions. Ben's solution has a slight flaw (he used an open interval instead of an interval closed at one end), and this tiny oversight will lose him one mark to take him down a medal boundary. Carlotti has also scored 6 out of 7. There is better news for Jordan: his function explained only by some pictures earns 5 marks. James wishes there was an Olympiad in defining daft functions, so that we could win it. He also reveals that the author of problem 5 was Luke Betts, an IMO contestant from last year. I am impressed, especially because Dan Schwarz seems to have a monopoly on RMM problems.

The evening sees us visiting the theatre, to see what at first seems to be an extended game of charades. Our excellent guides inform us that it is in fact about the Communist era in Romania, and with this in mind, it is very entertaining. Going to a silent production is a good idea from the organisers. A UKMT trip to *Die Fledermaus* earlier in the year had

suffered from the singing being in German with Hungarian surtitles, and the spoken comic interludes being the other way round.

On leaving the theatre, we are confronted with a Romanian stag party, dressed up in a mind-boggling array of costumes. Several take inspiration from Sesame Street, and they are joined by Mr. Blobby and Pacman. One man with an inflatable gun tries to force us to shake his hand. We break away and head back to the hotel. It turns out we are much better off than some: the evening sees the Serbians drunk and the Hungarians lost somewhere in Bucharest. We go to bed late, distracted first by mathematics and then the potential for innuendo in the word 'function'.

**Sunday, 27th February**: The morning is spent in nervous anticipation of our results. We go for a walk to relieve the tension, but the fresh snow soon distracts us. Some of us think about making a snowman, but then consider a snow Mandelbrot set more appropriate. Carlotti throws snowballs at a wall, and we consider the Ramsey theory of nearly collinear impacts. Our musings are brought to an end by the Italian team, who simply pelt us with snowballs. We fight for a little, then beat a tactical retreat (i.e. run away) to allow our hands to return to something like 37°C.

James has our results at lunch. He gives them in increasing order and there is amazement as the team gets more and more medals. We have come first on question 1, joint first on question 4 with Italy and joint 2nd overall. I am delighted to have a silver medal, especially after scoring 5/42 in the same competition last year. Only Ed is without a medal, but he has still got as much as any Peruvian or the bottom three Americans. It is normal for UK leaders to suggest a perverse category in which we come top (such as countries including a conjunction in their full names); this year, it is not necessary.

We allow ourselves some smugness at the closing ceremony. We are the only team with a flag, and Jordan, Carlotti and I stand behind it with our silver medals. We wonder if the gold and silver used are genuine. Tests of density prove inconclusive. Someone suggests conductivity, and another aqua regia, before we realise that whilst gold is a good test for genuine aqua regia, the converse is not true.

The contest ends with a closing banquet. Faced with a shortage of places to sit, Ed and I decide the best way to get past the students to seats is by crawling under the tables of food. Adam and Carlotti walk and arrive only slightly later. Comments are made applying Occam's razor to dimensions of movement. The food is actually very good, and we retire content.

We also present the first Golden Pen award. The concept is roughly based on the Microphone d'Or from the IMO, and is awarded to the student who produced the most

unnecessarily complicated solution which was nevertheless correct. Faced with both Carlotti's problem 6 and Ben's problem 5 solutions which were too long to write down, we decide to give it to Ben out of sympathy for just missing a silver medal.

**Monday 29<sup>th</sup> February**: We wake up at 5:30 to catch a 9 o' clock flight. Bucharest airport seems to need updating by several decades to handle the number of people who want to pass through it. We return, anticipating exhaustion, but delighted with our results.

I must end this report by thanking everyone who contributed to the Romanian Masters in Mathematics. These include:

- James Cranch and James Gazet, for their excellent leadership, in everything from convincing the co-ordinators of the value of our scripts to finding enough food to keep six teenagers happy for 5 days.
- The UKMT in general, especially Mary Wimbury and Rachel Greenhalgh, for doing all the administration that made the trip possible.
- All the trainers of the UK team, especially Geoff Smith for his leadership for many years and work in setting up the training camps, but also to all the mentors on the mentoring schemes and teachers at these camps.
- The organisers of the RMMS, for an event which generally ran smoothly and without mishap. It is a pity that if the organisation is good, it tends not to be noticed. Not all competitions work as effectively (the 2010 IMO being a memorable example).
- Tudor Vianu school, for housing the competition.
- The problem setters and selectors, for what I think everyone agreed was a very interesting paper. The problems chosen were the sort we would want to try even if they weren't on a competition, purely because of their interest.
- Our guides, Andrei and Silvia, for their brilliant work in looking after the team. They made sure we were alright when we couldn't enter the Parliament buildings, battled to keep the doors of Bucharest buses open so we could enter the contest, explained the context of the play, and made sure we were fed on the way back from it. This was all done efficiently and unobtrusively. Many thanks.
- Dominic Yeo and Aled Walker, for writing student reports on the IMO which inspired this.
- The team, for providing such good company and for helping Britain to its success. I wish anyone who goes the best luck in IMO 2011.