52nd International Mathematical Olympiad

UK leader's report

Amsterdam, the Netherlands, 16th–24th July 2011

Introduction

The UK competed in the 52nd International Mathematical Olympiad, in Amsterdam, between the 16th and 24th of July. This is the 44th IMO in which the UK has been proud to take part. The team were:

UNK1	James Aaronson	St. Paul's School, London
UNK2	Andrew Carlotti	Sir Roger Manwood's School, Kent
UNK3	Ben Elliott	Godalming College, Surrey
UNK4	Adam Goucher	Netherthorpe School, Derbyshire
UNK5	Josh Lam	The Leys School, Cambridge
UNK6	Jordan Millar	Regent House School, County Down

The first reserve was Richard Freeland (Winchester College, Hampshire), and the second reserve was Edward Kirkby (Alton College, Hampshire).

I (Dr James Cranch, University of Leicester) led the team; Jack Shotton (formerly of Trinity College, Cambridge, and soon to be of Imperial College London) was the deputy leader.

Dr Geoff Smith (University of Bath) attended, officially in a capacity known as "Observer A", but in reality for business with the IMO Advisory Board, who are responsible for the strategic planning of successive IMOs. Sally Anne Huk (Bancroft's School, Woodford Green) came in the capacity of "Observer C": a pastoral specialist for our team. A flying visit was made by Dr Ceri Fiddes (Millfield School) to promote the European Girls' Mathematical Olympiad.

Questions

As usual, the IMO consisted of two exams on consecutive days, each with three questions and each lasting four-and-a-half hours. Each question has equal weight: seven marks.

Here are the questions (together with their submitting countries):

First day:

1. (Mexico) Given any set $A = \{a_1, a_2, a_3, a_4\}$ of four distinct positive integers, we denote the sum $a_1 + a_2 + a_3 + a_4$ by s_A. Let n_A denote the number of pairs (i, j) with $1 \leq i < j \leq 4$ for which $a_i + a_j$ divides s_A. Find all sets A of four distinct positive integers which achieve the largest possible value of n_A.

2. (UK) Let $\mathcal{S}$ be a finite set of at least two points in the plane. Assume that no three points of $\mathcal{S}$ are collinear. A *windmill* is a process that starts with a line ℓ going through a single point $P \in \mathcal{S}$. The line rotates clockwise about the *pivot* P until the first time that the line meets some other point belonging to $\mathcal{S}$. This point, Q, takes over as the new pivot, and the line now rotates clockwise about Q, until it next meets a point of $\mathcal{S}$. This process continues indefinitely.
   Show that we can choose a point P in $\mathcal{S}$ and a line ℓ going through P such that the resulting windmill uses each point of $\mathcal{S}$ as a pivot infinitely many times.

3. (Belarus) Let $f : \mathbb{R} \to \mathbb{R}$ be a real-valued function defined on the set of real numbers that satisfies

   $$f(x + y) \leq yf(x) + f(f(x))$$

   for all real numbers x and y. Prove that $f(x) = 0$ for all $x \leq 0$.

Second day:

4. (Iran) Let $n > 0$ be an integer. We are given a balance and n weights of weight $2^0, 2^1, \ldots, 2^{n-1}$. We are to place each of the n weights on the balance, one after another, in such a way that the right pan is never heavier than the left pan. At each step we choose one of the weights that has not yet been placed on the balance, and place it on either the left pan or the right pan, until all of the weights have been placed.
   Determine the number of ways in which this can be done.

5. (Iran) Let f be a function from the set of integers to the set of positive integers. Suppose that, for any two integers m and n, the difference $f(m) - f(n)$ is divisible by $f(m - n)$. Prove that, for all integers m and n with $f(m) \leq f(n)$, the number $f(n)$ is divisible by $f(m)$.

6. (Japan) Let ABC be an acute triangle with circumcircle Γ. Let ℓ be a tangent line to Γ, and let ℓ_a, ℓ_b and ℓ_c be the lines obtained by reflecting ℓ in the lines BC, CA and AB, respectively. Show that the circumcircle of the triangle determined by the lines ℓ_a, ℓ_b and ℓ_c is tangent to the circle Γ.

Results

The UK obtained 2 gold, 1 silver and 2 bronze medals and 1 honourable mention and a score of 132 out of 252, coming joint 17th out of 101 participating countries. The medal boundaries were 28 for gold, 22 for silver and 16 for bronze.

James Aaronson	7	1	7	7	7	0	29	Gold Medal
Andrew Carlotti	7	7	0	7	7	0	28	Gold Medal
Ben Elliott	7	0	2	7	7	0	23	Silver Medal
Adam Goucher	7	0	0	7	7	0	21	Bronze Medal
Josh Lam	7	1	0	1	4	0	13	Honourable Mention
Jordan Millar	7	1	1	7	2	0	18	Bronze Medal

Our team all pulled their weight to beat several extremely worthy opponents. In particular, this is the first time since 1992 that we have beaten our friends and training partners from Hungary.

The UK was fourth in the EU, behind reliable strong performers Romania, Germany and Poland. The Commonwealth of Nations was led by Singapore, with an extremely strong performance (particularly on the 'Windmill' problem 2); Canada and the UK shared joint second place.

The performance of the top end of the team was extremely impressive. The last time the UK had two students receive a gold medal was 1996. However, both are available for selection next year (as are Adam and Josh): the last time the UK had two students receive a gold medal who went on to compete the following year was 1975.

Viewing the competition from a less Anglocentric perspective, there is much to say. The top twenty nations, and their scores, were as follows:

rank	*score*	*country*	*rank*	*score*	*country*
1	189	China	12	147	Japan
2	184	USA	13	144	South Korea
3	179	Singapore	14	138	Hong Kong
4	161	Russia	15=	136	Ukraine
5	160	Thailand	15=	136	Poland
6	159	Turkey	17=	132	Canada
7	157	North Korea	17=	132	UK
8=	154	Taiwan	19	129	Italy
8=	154	Romania	20=	121	Brazil
10	151	Iran	20=	121	Bulgaria
11	150	Germany			

Only one student in the competition achieved a perfect score, Lisa Sauermann of Germany. This stunning achievement, together with her previous three gold and one silver medals, sends her to the the top of the IMO hall of fame. I understand that Lisa is now going to Bonn to study mathematics; her retirement from IMO dominance will inspire mixed feelings of sadness and relief.

That does not exhaust the good news for girls. At an IMO it is understandable that many journalists will be following the fortunes of the home team; this year the top score on the Dutch team was obtained by another girl, Madelon de Kemp. There is every sign that both Lisa and Madelon have already become role models for the next generation of IMO stars.

Leader's Diary

Saturday, 9th July

I wake up in Cambridge, having had the foresight to position myself there the night before. Today, we are starting our pre-IMO training camp at Trinity College; we are holding this jointly with the Australian team.

I have plenty of time to ablute and do a bit of maths before the Australians arrive. I greet my counterpart Ivan Guo and his deputy Graham White with a loud "g'day"; they tell me that they actually only say this to naive British people.

I mislead them into thinking that they might be able to obtain breakfast in Hall, but in fact the staff are on holiday, so this turns out to be just a good excuse to march through some of the College's grounds, which must be very invigorating after twenty-eight consecutive hours of travelling.

After they install themselves in their rooms and shower I take them to a cafe. We are joined by an early-arriving British team member, the Northern Irishman Jordan Millar. We then spend the morning walking around Cambridge. We avoid the very centre, when we discover that a small racist demonstration will be taking place. Such things really aren't normal here: Cambridge is proud to be cosmopolitan, and the demonstrators are largely football hooligans bussed in from elsewhere in the country.

Then we pass by Trinity's hall, again finding it not serving food. My kitchen connection Alan Queripel sees a fellow Guernseyman in distress and beckons my team into the staff canteen where we lunch well on pork chops and raspberries and cream.

After this the rest of our team turn up. This is very helpful: the main purpose of the day is for our team to familiarise the Australian team with various British customs which may seem quaint from an Australian perspective, such as having darkness during the daytime and sunlight during the night.

Also turning up this afternoon is my deputy, Jack Shotton, fresh from a week running around the Lake District like an idiot, and our camp's extra helpers: combinatorics expert Joseph Myers, and all-round nice guy Sean Moss.

We explain the logistics of the camp, order takeaway pizza and eat it outdoors in the sunshine, and then after a few games of cards we mercifully allow the Australians to sleep.

Sunday, 10th July

The day begins with a makeshift breakfast, then continues with a practice paper. Then we finally gain access to Trinity College's hall for substantial refreshment. We are joined by the Australian Maths Trust's head honcho Peter Taylor, who is in transit from Lincolnshire to London in the middle of a short holiday practising industrial espionage and visiting relatives.

It turns out that the Australians beat us marginally in the practice paper (by the margin of 84 to 82); their top individual score is 21 to our 20. This does not bode well for the Ashes, which are to be contested on Tuesday.

Paul Russell arrives to give a session, entitled *How to find (and keep) a husband*. He was a member of our IMO team last time the UK beat China, in 1996.

Several games are produced. These include *Set*, which inexplicably enough is the only game I know based around combinatorial lines in a four-dimensional hypercube of side-length three (this game is also a favourite of the Hungarian team, and we first learned it from them). We also played the anarchic

We Didn't Playtest This at All, which shows strong signs of having been playtested.

I am happy to report that we have an excellent class of parent this year; Josh's father arrives to donate a bottle of champagne to the cause.

Someone passes comment on the similarities in names among the Australian team. Indeed, four of them have two-letter surnames ending in 'u': Fu, Lu, Xu and Yu. Joseph points out that there is a story among the British delegation: half of the students have first names beginning with 'J', and also half of the adults travelling out on the 12th, and also half of the adults travelling out on the 16th, and also half of the extra pre-IMO camp staff (Joseph vs Sean). It's exactly like the Belgian system, which chooses a half-Flemish, half-Walloon team each year.

Monday, 11th July

After breakfast in hall, it is clear that the teams are settling comfortably into the idea of getting up in the morning and doing a four-and-a-half-hour exam. This is a good habit to get into, when preparing to sit an IMO.

We decide to take the students punting. For foreign readers, this is a popular student pastime in Oxford and Cambridge, where a small heavy-bottomed wooden boat is propelled along an inland waterway by the expedient method of repeatedly poking the riverbed with a long pole. Jack and I are old-time masters at riverbed-poking; some of the students (and Australian adults) take to it better than others.

Then we are visited by Prof Tim Gowers FRS, nowadays better known for his Fields Medal than for his IMO perfect score from 1981. His decision is to ensure that the teams are well-versed in the basics, by teaching them how to multiply and divide: it is much appreciated.

We mark the morning's paper. The UK's combinatorial supremacy has caused them to comfortably outpoint the Aussies on the crucial Q2. Several contestants have produced nasty recursive arguments with dubious notation but the underlying ideas are first-rate.

Adam's script goes further and makes the inspired move of working in two dimensions where things are much clearer and admit a commonsense geometric interpretation; the downside is the use of some baroque terminology he must have found on Wikipedia one sleepless night. We both praise him and encourage him not to assume his readers have an intimate familiarity with tabloid mathematics.

Then there is a smart dinner in Hall, kindly organised by my predecessor Imre Leader, and equally kindly hosted by Tim Gowers. The UK team's

uniform has not arrived yet, so they must make do with chinos and polo-shirts; the Australians are resplendent in their green blazers.

All the students march in. Naturally they clump together, UNKs at one end and AUSes at the other, to engage in mutual distrust and enmity. We protest, finding an algorithm to permute them, and the dinner is a much more pleasant affair for it; I enjoy the company of Adam, Jordan and an Australian, Angel.

After this we have a quick debrief of the morning paper, in which Joseph explains that, just before he sat his first IMO in 1994, he had been corresponding with Paul Erdős on the content of Q1. He exhibits a letter from the great Hungarian which begins "Dear Dr Myers...".

I wish my team well for the IMO and explain what I expect of them. I will be leaving the next morning and things will be hurried then.

Tuesday, 12th July

After breakfast, the Ashes begin. This is our annual contest against the Australian team, decided on the basis of a single IMO-style paper.

I remain long enough to see the students knuckle down to it, give the IMO first aid kit and a few euros to Jack, and leave for the IMO.

The railway network carries me to London Gatwick airport uneventfully. On the plane I get chatting to an intensive care nurse who frequently visits Amsterdam. Upon entering the arrivals area she ushers me away from the vast hordes of easyJet customers we flew in with, through several cafes' worth of seating, to an apparently secret, entirely empty passport control room. This gives way immediately to the baggage reclaim area, from which I can see the long queues at our intended passport control desks. Thanks, whoever you are!

My good luck continues when my holdall is the first bag onto the carousel. I grab it and step out to be met by two beaming Dutch helpers. They fix me up with a bottle of Schweppes Bitter Lemon, the taste of the Netherlands, and we mass together at a meeting point where about six volunteers are hanging around and smiling.

There I meet the Irish delegation: the leader Bernd Kreussler whom I know from past IMOs, and his observer Mark Flanagan.

There is a bus journey of about ninety minutes, to somewhere in the vicinity of Eindhoven, in the south of the Netherlands. We arrive at a hotel of vast proportions: even though it has been divided into coloured zones to aid navigation, it still seems certain to bewilder for days.

After this I manage to lay my hand on the object which has brought me so far: the shortlist. There are thirty problems. Shortlists are usually good,

but this one is extraordinarily exciting, particularly in the combinatorics department.

I then hang around for a while waiting for my observer, the Advisory Board member Geoff Smith, to arrive. This means I unwittingly miss dinner (my mind is still on UK time) but the hotel provides a fully functional packed meal.

From Geoff I learn the results of the Ashes. It has been a tie, and so the urn and cup are retained by the British team. Geoff is pleased with this: the Australians expended the maximum possible effort to not win back the Ashes. By now, the team will be relaxing with a talk by Bryn Garrod on the Rado graph.

After some time spent attempting the shortlist, Geoff and I go and socialise. Old friends come and go, including the local *capo di capi* Wim Berkelmans, the IMO computing expert Matjaž Željko, and the newly-promoted Swiss leader Julian Kellerhals.

Wednesday, 13th July

I get up early and swim 2^5 lengths of the hotel's convenient pool.

At lunch I sit with some of the Dutch organising staff: onetime deputy leader Birgit van Dalen is about to be in charge of the student experience, and Rozemarijn Schalkx has been running the office. I complain at the large amount of time I have wasted in recent weeks while exchanging emails with the Dutch IMO organisation, in attempting to spell the latter's name.

The model solutions are released. I wait a valiant four hours before picking them up, and another hour before giving up and looking at them. Some heavy study is warranted.

My brain becomes confused eventually, and I go for another swim. Unfortunately, about five minutes in, a gang of middle-aged Dutch ladies put a divider across the middle of the pool to prevent me doing lengths, and begin wiggling around to dance music in the deep end. So I hop out and go to dinner instead.

Afterwards there is a small amount of experimentation with the beers of the Netherlands and of the neighbouring countries. The Belgian leader Bart Windels is present, as always with his wife Ria van Huffel; both are experts in these matters. Bart claims that it is cheaper to bring Ria to the IMO than it would be to hire a private detective to watch her for the same period.

Thursday, 14th July

The morning begins with the first jury meeting, at 9am. The chair of the jury, Professor Hans van Duijn, welcomes us.

In his opening speech he tells us that Eindhoven is thought of as the country's "Brainport" (in contrast with Rotterdam, the seaport, and Amsterdam Schiphol, the airport); also that it was recently named the smartest area in the world.

We then prepare for the annual bonfire of questions: countries are expected to declare if any problems are similar to problems they have seen in the literature. This year is unusually violent: four of the thirty questions end up discarded for their similarities to others. Later on, the Indian leader will get carried away and attempt to destroy the eventual Problem 4, but he won't succeed.

I find myself with a little while to spare, so get in the pool again. I am pleased with my 40 lengths, but then discover that the pool is only 12.5m long. Not so virtuous after all.

We have been invited to a reception and buffet dinner at the Technical University of Eindhoven, a short bus journey away. We arrive and are given a drink.

The rector of the university, a certain Professor Hans van Duijn, gives a short welcoming speech. Firstly he tells us that Eindhoven is thought of as the country's "Brainport" (in contrast with Rotterdam, the major seaport, and Amsterdam Schiphol, the major airport); also that it was recently named the smartest area in the world. Secondly, he then gives way to a second speaker.

That second speaker tells us that Eindhoven is thought of as the country's "Brainport" (in contrast with Rotterdam, the major seaport, and Amsterdam Schiphol, the major airport); also that it was recently named the smartest area in the world. Only now does Ivan express his surprise to me at learning that you can travel by brain.

Over dinner we are treated to a fine medley of Andrew Lloyd Webber and Elton John tunes, and also a string quartet. I chat to the leaders of several English-speaking countries such as Norway and Finland.

Then it is back to the jury. We must decide the two easy questions tonight.

An interesting and unusual situation arises. Most years, at the IMO, there are two geometry problems: one easy, one medium or hard: it's become more-or-less expected.

This year there are some extremely pleasant and perfectly approachable questions in algebra, geometry and number theory. But, this year, the easy

geometry questions seem not to be much loved, and the much-loved geometry questions seem not to be easy.

There are various impassioned pleas in favour of geometry, which is perfectly reasonable. However, the shortlist seems to be screaming at us to do otherwise, and there is evidence that the crowd are in favour.

A tea break is taken in order to ponder it for a while before a final decision. The mood is tense.

Then Claude Deschamps, the French leader, approaches me in a rush. His observer, Johan Yebbou, has found the exact statement of G2, together with a proof similar to the shortlist proof, in a published paper in French from 1918.

The Brazilian leader suggests that a student who is familiar with the French literature from the era of the First World War fully deserves seven free IMO points. However, the IMO intends to generate novel and ingenious problems, and it has done so very successfully in the past, and so the jury votes to squash G2.

The opinion of the problem selection committee is sought; they state that they consider A1 and C1 to be too easy. The jury accordingly back exactly those two questions. We have a paper without any easy geometry!

Friday, 15th July

The next day we start by picking the hard problems. The geometry lobby gets their way rapidly, and we end up with A6, a nasty functional inequality, and G8, asking for a proof of a rather elegant but fearsomely hard theorem in pure geometry.

Then it is time for the medium problems. It is observed that no number theory is on the paper yet, so a motion passes easily that we should select one, and the unusual-looking N5 makes it fairly easily.

Then there is a fight. There is a pro-geometry lobby who think that one geometry problem in six is not nearly enough and that having two geometry problems is vital. There is another group who think that a medium geometry problem will test the same skills as a hard geometry problem, so will skew the paper. Yet more people feel that the quality of the combinatorics shortlist questions are exceptionally good and it would be a shame not to use another. An anti-combinatorics coalition suggest that almost all of the questions chosen so far have some kind of combinatorial flavour already.

The choice is whittled down to G4 and C3. There are impassioned speeches on both sides, and eventually C3 is chosen by the remarkable margin of 47 votes to 46.

After this, the authors of the papers are revealed. It turns out that we must blame Geoff for C3.

Then it is time to produce the official English language versions of the papers. The UK leader is *ex officio* chair of the committee; I do not relish this task, but things look a lot better after I recruit Chris Tuffley of New Zealand as my secretary.

Chairing the English language committee is a bit like wrestling crocodiles. The demands of the English language purists are different from the demands of the people from countries where it is spoken freely but usually as a second or third language, and both of these are different from the demands of the foreign-language nations who wish for a version which is easy to translate.

I observe the law of conservation of commas, removing three from one question but immediately finding a home for them in another question.

In the event, a couple of changes will be made later on, causing much work down the line. I should apologise publicly, either for my weak performance during the meeting, or for failing to restrain the enthusiasts later: I don't know which.

Saturday, 16th July

There is a debate on the marking schemes for problems 1, 2 and 3. The discussion is extremely thorough, and the whole affair does not lend itself to diarisation.

Sunday, 17th July

The marking schemes for problems 4, 5 and 6 are discussed, and then the marking scheme to problem 2 is revisited.

The Dutch problem captains have by now perfected an ingenious strategy: they discuss the marking schemes in such painstaking detail that the leaders are asleep during the subsequent discussion, and then Van Duijn wakes them just before the approval vote.

In the afternoon it is time for the opening ceremony: we are bussed all the way into Amsterdam and taken to a balcony in a large auditorium. My students are below me; I am permitted to wave and make the customary thumbs-up sign to them.

The ceremony itself is a fine thing. The speeches are mercifully short. In the past, the "parade of nations", where each team comes onto the stage in turn, has become rather long. This year, the organisers have decided to break it into groups by continent (Europe, Asia, the Americas, and Africa/Oceania)

with other things in between, the teams' movement across the stage is facilitated by a lithe and acrobatic troupe of performance artists, and the (thoroughly British) Chemical Brothers' electronic piece *Galvanize* alternates with a folksy Dutch string band playing variations on the IMO hymn. I hope that similar improvements become standard.

Afterwards the leaders are removed downtown to the Royal Netherlands Academy of Arts and Sciences, known as KNAW. There is a pleasant wine-and-sandwich buffet which prepares us for the drive back to Eindhoven.

Monday, 18th July

This morning is the first exam for the students, and for the jury there is a joint meeting with the IMO Advisory Board. Today is a tough one: we are discussing a proposed reform of the IMO. This is a subject which inspires much controversy.

The afternoon is a much more lighthearted affair. Four different excursions have been organised; I have signed up for a bike ride and mathematical art visit.

Familiarising myself with Dutch bikes is not immediate. The brakes are activated by backpedalling, and so it turns out to be unwise to attempt to avoid collision by gripping the handlebars rhythmically. Also, the rider's stance is much more upright than on my bike at home; I deal with this by leaning back as far as I can and humming the soundtrack to *Easy Rider*.

The mathematical art visit turns out to be a visit to the house of the jury secretary Tom Verhoeff's father Koos. Some forty years ago, as a mathematician and computer scientist, he was engaged by an artist to advise on the complicated problems of making closed paths from straight lengths of beams connected by mitre joins; he eventually took over the problem and used it as a leitmotif for a life of sculpture.

The family serve us a pleasant tea in small groups, and then Tom and Koos show us around, explaining the mathematics and design philosophy that lies behind the artwork.

Back at the ranch, Rozemarijn brings me a couple of post-prandial cups of tea, and I am happy to exchange gossip. She tells me that Quintijn Puite is hurtling down a motorway with the scripts. They arrive slightly earlier than expected.

Our scripts in Problem 1 are pretty strong, and I form an ambition to receive 42 points for them. My heart sinks when I see UNK2 Carlotti's script. He has noticed that it is a problem about integers, and apparently he has some perverse moral code which causes him to disapprove of this. So he has translated it into an equivalent problem about rationals. I am surprised and

relieved to find that he then solves it in a sensible fashion, unencumbered by his own obfuscatory techniques.

It is clear that Problem 2, the Windmill, has been found very hard indeed. Carlotti has produced a very pleasant solution, of a sort known to the jury; there is another attempted solution by another candidate but, heartbreakingly, it contains nothing of value. Several other students have observed that if you can guarantee to visit points once, then you can deduce they will be visited infinitely many times: this should be worth a mark.

We have also made heavy weather of Problem 3. UNK1 Aaronson has produced a nice script. UNK3 Elliott has a messy attempt which appears to have some value; nothing else is worth talking about.

Tuesday, 19th July

I pack and check out, then pop in to the Day 2 question-and-answer session. We are bombarded by nearly 190 questions, mostly asking if the order of the weights matters in Problem 4. It's a grave scene: more than sixty leaders are seen queueing up simultaneously to answer questions.

After this we are bussed to Amsterdam. I arrive shortly before the students arrive; we are one big bustling family for lunch.

Five of the students claim Q4; a miscalculation has sent UNK5 Lam on a wild goose chase, leading to a disappointing day for him. However, he has many part marks and there is no cause for embarrassment.

Four of the students claim Q5, and there is no progress at all on Q6.

After a relaxed late afternoon, the team go bowling while Jack and I settle down together to read their scripts. Everything is nicely written, and we feel confident we can get lots of nice points for all of them.

Wednesday, 20th July

Today is the start of coordination: the process where leaders agree scores with teams of experts from the host nation.

This seems fated to be smooth. The coordinators have clearly done their homework well, constructing nuanced and intelligent marking schemes, and studying the strengths and weaknesses of the scripts minutely.

In fact, it is so smooth that, when we go in for Problem 1 and one of the organising crew accidentally delivers us to the correct table for Problem 2, we can't find any reason not to coordinate anyway. After a short battle we get what we ask for, and are then returned to the intended Problem 1 table. They too give us our 42 marks.

Later on, Problem 4 also does not cause a serious problem; the students' work is tidy and little disagreement is possible.

Pleased with a good day's work, the UK staff retire to the bar, where I meet a couple of friendly members of the local staff.

Thursday, 21th July

Today is another day of coordination. Quite the most exciting part of the day is that, as is traditional, we must act as coordinators for the Dutch team's scripts on Problem 2, which was a British proposal (it is felt that having Dutch coordinators deal with the Dutch team would be insecure). Dion Gijswijt, the capable problem captain, will be on hand to offer advice.

Jack and I had looked at the scripts (in Dutch, obviously), but had made no preparation for tackling Johan and Sietske. But, in the event, we fall naturally into a good cop/bad cop routine. I humour them into thinking a mark is appropriate, and then Jack tells them it isn't worth one. In the end they get a 6 for a very pleasant solution, and a 1.

Then we return to our own problems, in the most literal of senses.

Problem 3 is quite involved. Ben Elliott's script, which should be worth two marks, is a mess: the good stuff is buried in among a bit of bad, and the coordinators have gone off the rails thanks to misreading some dodgy handwriting. Jack explains the script carefully, and we are sent away so they can think about it in peace. We are ushered back a few minutes later: they agree, and we pick up the points.

Problem 6 is an easy coordination. We ask boldly for six zeroes, and the coordinators give way and agree immediately.

Lastly we coordinate Problem 5. Four 7s and a 2 for UNK6 Millar are uncontroversial. We observe that a score of 4 for Lam is an immediate consequence of the marking scheme. This point appears to be recondite, but eventually we get the 4.

Jack then disappears for a post-coordination snooze, and I loiter in the lobby to pick up gossip and rumours about our relative performance. Things seem all right.

Friday, 22th July

The morning begins with the final jury meeting. This one is theatre, and deputies and observers are invited. The first part of the business consists of hearing reports from the chief invigilator and chief coordinator.

The former report is studded with statistics: it's good to know that the organisers were paying close attention. Next year I expect to be told the

maximum variation in desk thickness, and the standard deviation in the times elapsed before the first toilet visit by each team.

Then comes the choice of medal boundaries. The organisers' proposal is a nice surprise for us: it gets Andrew his gold. Adam will feel bad about not being able to scrape together another mark for a silver, but I'm sure he'll be in fighting condition for next year's IMO. All other medals were as suspected.

After this is an excursion to central Amsterdam. Our guide Vicky wishes to take us walking around the parks; Geoff chooses a less ambulatory option and sits in a cafe for an hour and a half. Then we pick him up for a canal boat trip, which does a good job of explaining the history of Amsterdam; Messrs. Aaronson, Carlotti, Elliott, and Shotton sleep through a large chunk of it.

From there we walk to the Dam, the large square in the centre of the city. Vicky expertly avoids the red light district to take us to the science museum NEMO, where there is a hot buffet dinner and a party.

It turns out that having a party in a science museum is a very good idea.

There is a rock band, comprising the motlier parts of the IMO staff. They finish up with the timeless Metallica classic *Enter Sandman*, and I feel the urge to go and jump up and down with the students. Jordan and Josh walk in, and Jack greets them, "James is on the dancefloor. He's a complete metalhead!" They spend a while looking disbelievingly for James Aaronson before coming to their senses.

Afterwards I notice I have become warm and go sit outside, enjoying a commanding twilight view of Amsterdam.

Saturday, 23th July

In the morning there is another meeting: a joint jury meeting with the IMO Advisory Board. This is to finish discussion of IMO reform. It is clear that the majority mood is currently against any radical change, but there is a vote to create an "ethics committee". This will be the IMO police, with the job of investigating any suggestions of dodgy behaviour at the IMO.

The other, much more pleasant, piece of business is to accept proposals from the Advisory Board on future IMO hosts. We had long since been planning IMO 2012 in Argentina, but had not had any more hosts lined up. However, this year we agree on three more: IMO 2013 in Colombia, IMO 2014 in South Africa, and IMO 2015 in Thailand.

The meeting gives way to lunch, and a little later we walk to the closing ceremony.

The closing ceremony does not suffer from the disadvantages of over-preparation. The compère, apparently a Dutch televisual national treasure

from the same mould as Valerie Singleton, confirms common suspicion by announcing at one point that she has no idea what she is doing. Nevertheless, the students do: the medals are all awarded, and apparently all to the correct people.

The closing ceremony gives way to the afterparty next door. The most important piece of business here is the multilingual presentation of the *Golden Microphone*, for the leader who has given the most speeches in the jury meetings. This year it is won by the Brazilian leader: an amazingly loquacious performance. I was told that I was third; I consider this not bad for a first attempt.

Despite the rain, the atmosphere is rather good. Jack and I are even persuaded to dance; our failings are carefully insulated from the students by a barrier of guides and organisers.

Sunday, 24th July

I am woken up early by Adam Goucher's knocking upon my door. He tells me to get up in -5 minutes. It seems I mis-set my alarm clock: it is lucky that my students are less incompetent.

We must get to Schiphol for a morning flight, but there is time for two final presentations.

The first is my jury voting stick, the *Sceptre of Unk*, a device with mystical powers including (but not limited to) preventing its wielder from making false statements. I give this to Josh, so that he may use it for the next eleven months and two weeks.

There is also the *Golden Pen* donated by the students: this is given to the student with the nastiest script that ends up obtaining seven marks. Rewarding such people with extra writing implements seems like playing with fire, but I am nonetheless pleased to bestow it upon Ben.

Our final farewells and the repatriation of team UNK, by a short flight to Gatwick, are uneventful.

Thanks

For a nation to successfully participate in the IMO requires vast effort, and the staff actually present at an IMO are at best the tip of the iceberg.

Except for a skeleton staff in Leeds, all the olympiad work in the UK is entirely voluntary, and many of our volunteers are stoically insensitive to the damage caused to their careers, studies and relationships by the heavy expenditure of time.

I would like to mention many of the people and groups to whom I owe thanks:

- James, Andrew, Ben, Adam, Josh and Jordan, for making me proud;
- Jack, for being an excellent deputy and a good friend;
- Vicky Simon-Akerboom, our wonderful guide;
- Sally Anne, for being there for the students;
- Joseph Myers and Sean Moss, for helping run a pleasant and informative pre-IMO camp;
- Paul Russell, Tim Gowers and Bryn Garrod, for getting our students excited by mathematics at a crucial time;
- Bev Detoeuf and Rachel Greenhalgh, for their solid logistical work in the UKMT office;
- Richard Freeland and Ed Kirkby, for raising the standards of the training from within;
- My predecessors Tony Gardiner, Adam McBride and Imre Leader, for providing invaluable advice on what constitutes good education;
- The students' families and schools, for putting up with the disruption of a serious IMO campaign;
- All the mathematicians and UKMT volunteers who have helped train the students over the course of the year;
- The IMO organisation and students of Australia and Hungary for showing warmth and good mathematics to our students;
- Tom Lovering, (Luke) Alexander Betts, and the international problem submissions group for managing that side of the British IMO effort;
- All the other leaders for making me, a rank novice, feel welcome among them: I'm particularly grateful for the wisdom and experience of Zuming Feng, Indra Haraksingh, József Pelikán and Paul Vaderlind;
- Geoff Smith MBE, for constant energetic support, advice and help of all sorts throughout the year;

- Most pointedly, the staff of IMO 2011: they did a fantastic job. We were particularly impressed by Rozemarijn Schalkx, Ronald van Luijk, Tom Verhoeff, Birgit van Dalen, Matjaž Željko, Wim Berkelmans, Quintijn Puite, and Hans van Duijn. However, the friendly and personable nature of the senior organisers can serve to mislead, by hiding the vast amount of work done by a multitude of largely invisible guides, IT specialists, journalists and crew members.

James Cranch (jdc41@cam.ac.uk), 27th July 2011.