IMO Student report 2015

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Introduction

Before getting into the body of the report, there is first the necessary ridiculous over-analysing of the scores. The scores were:

	P1	P2	P3	P4	P5	P6	Σ	
Joe Benton	7	2	1	7	1	1	19	Silver Medal
Lawrence Hollom	7	1	0	1	1	0	10	Honourable Mention
Samuel Kittle	7	2	0	7	3	0	19	Silver Medal
Warren Li	7	7	1	7	3	0	25	Silver Medal
Neel Nanda	7	1	0	7	2	0	17	Bronze Medal
Harvey Yau	7	2	1	7	2	0	19	Silver Medal
Min	7	1	0	1	1	0	10	Honourable Mention
Max	7	7	1	7	3	1	26	Gold Medal

For the twenty-sixth year running, Max has scored enough for a gold, but for the second year running, only by one mark, and also only because of Joe being the only one to get a mark on a particular hard question. Min achieved an Honourable Mention because of our strong question 1, and this year the two minimums; the minimum taken over the sums, and that taken as the sum of the minimums for each question, are equal. I am responsible for the first of these two minimums, but not the second, as the removal of my marks leads to the same sum of minimums over questions. The is the first year since 2010 that Min has actually featured as part of the main body of the team, and Max very nearly made an appearance as well.

The unique quintic to describe our scores is $(5x^5 - 65x^4 + 241x^3 - 55x^2 - 918x + 1248)/24$. Extrapolating, we find that (approximately) UNKs -1.64198, 0.261715, 6.44116, $3.96955 - 1.25854i$ and $3.96955 + 1.25854i$ all achieved perfect scores of 42. Unfortunately, none of these were located within the interval of the team.

Warren has missed out on a gold by one point for the second year running, making this year his third silver. Next year, he will (probably) become the third Briton ever to attend the IMO four times, and already has the most silvers of any UNK. In 2017, Joe and Harvey will (again, probably) join him on four participations, and then in 2018, Harvey will have a chance to become the first ever UNK to go to five IMOs.

Now, some things, that are true: this is the student report on the 56th IMO, held in Chiang Mai, Thailand, and the UK-Australia pre-IMO camp held in Putrajaya, Malaysia.

Next, some things which are possibly slightly less true. This is because this report is written entirely in the UK, after the IMO. The notes I decided it would be a good idea to take while I could still remember the events were definitely a good idea to take. It would have been an even better idea to write them in a form that would make any kind of sense later, but unfortunately the real value of that idea is only just becoming apparent. The notes for July 5th, for example, read "T3. Geometry? Walk: road closed. D'fruit = 200 chips." Anyway, I'll try to make everything that follows as true as possible with the information I have, and referring to Dominic's report, which is already published, tried to at least manage consistency with the other information available.

Diary

30th June

We meet in Heathrow airport in the afternoon for our flight out to Kuala Lumpur. I am the fourth to arrive, to find Dominic with a collection of bags of assorted UKMT-branded clothes, which surprisingly, fit easily in my case, leaving room for a UK flag as well. Geoff and Jill are running late, but, as everyone else is here, after noting we've arrived in precisely the inverse order to distance from the airport, Dominic decides we should check in anyway, and let Geoff and Jill check in later, when they turn up. This is about as interesting as checking in to an airport ever is: not very.

The flight is uneventful, with everyone getting different amounts of sleep. I actually got about 8 hours, which I was surprised with seeing that I'm normally completely incapable of sleeping in buses, planes etc. On discussion afterwards, it turns out Neel had a very different approach: stay up all night, and then get through the next day with a sort of tiredness-happens-to-other-people strategy. This is surprisingly effective. The food on the plane is served at times which are wrong for both Malaysian and UK time zones, but is just about edible. Well, some of it is.

1st July

I'm not entirely sure where the join between 30th June and 1st July was (time zones are confusing...), but here works. We land in Kuala Lumpur to find a very warm evening and a minibus, which we can all fit in, but this leaves less air than person and luggage in the minibus. Thankfully, the air that hasn't been displaced by us or our luggage is air conditioned, which made the journey considerably less uncomfortable than it seemed it would be at first.

After a journey that was neither notably long nor notably short, we arrive at Nexus international school, Putrajaya. My first impression was: "I wonder if

it has air conditioning". My second impression was "those look like air conditioning units", and upon getting inside, after having spent a very small amount of time outside sorting out luggage, my third impression was "yes, there is lots of air conditioning. Air conditioning is good." In respects other than the air, its inside and outside temperatures, and the difference between these, the school seems very nice, and well equipped. We are taken up to the second floor, where the UK students and staff will be staying, through a door that requires the combination 222 to open. Neel claims that this must mean the code for the next floor up, which we assume will be the Australian's floor, will have the code 333, by geographical induction[1]. Nobody actually cares enough to walk up to check, so we decide to just investigate our floor. The floor appears to have been designed with about 50 people in mind, judging by the number of cubicles in the bathroom, with 20 people in mind, judging by the number of rooms, and with 6 people in mind, judging by the number of sofas round the table. This suits us perfectly.

We go out to a restaurant for dinner, where we decide to try and order a mixture of things for the table. This ends up with a long debate about how big the different dishes are, and how many we want to order. We come to a decision after Geoff's food has arrived, and it turns out we get this largely right, and actually end up with a good meal (eventually).

2nd July

I'm the last person to wake up, to Joe saying that everyone else is going down to breakfast. When I come down a few minutes later, I find the rest of the team investigating the array of breakfast things. The actual content was different each day, and I have no idea what food was on which day, but the theme was always international with a Malaysian twist. This consisted of a proper subset of a cooked English breakfast, some cereal, and some other more Malaysian dishes, some of which, while probably nice at some time of day, didn't really seem like the kind of thing to have at breakfast (the spicy fish-head soup is a prime example of this). Anyway, there is more than enough for us all.

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[1]This is just like normal induction, but you don't actually do the inductive step. Just complete the base case, or 'Case Study' as geographers like to call it, and then the result must hold in all cases.

After breakfast, and trying out some of the games on the ground floor (pool and table-tennis), we head out on a small excursion. This excursion is a boat trip around Putrajaya, and turns out to include some making friends with a parrot beforehand, while waiting for the boat. The boat trip has constant commentary about the surrounding things. This commentary consists of many words. Of these words, very few are actually understood by any of us, but everything is fairly self-explanatory. There's a bridge that looks like the golden gate bridge, other than that it connects to neither side of the artificial lake both us and it are in, and it's concrete-grey, rather than orange/red. The further down the river we go, the less complete the buildings seem to be. One team photo and return trip later, we attempt to visit a giant pink mosque. However, it turns out that this is closed for visitors at the moment, so we instead head to a Chinese restaurant for our lunch. We ask for a set menu for everyone, which appears to involve food being brought out continually at intervals until we stop eating it. After this point is reached, we go for a walk around a neighbouring botanical gardens, which apart from us, some gardeners and an obelisk-sundial thing appears to be completely deserted.

The rest of the day is taken up partially by card games, partially having the long requested talk from Geoff about the wonders of power of a point and the radical axis, and partially meeting the Australians. The Australian team this year is very strong: Alex Gunning is returning for his fourth IMO, having scored full marks last year, and Seyoon Ragavan, returning for his third. He has two bronzes so far, but apparently last year could have gone much better for him. The Ashes look set to be a very closely fought competition. We also settle the question of what the code to floor 3 is: it's 222 as well.

3rd July

Today is the first of the five IMO practise exams we do over the course of the week. When we arrive at the exam room, it appears the room has far

greater ambitions than housing us, and seems to be planning some kind of deep space exploration to challenge New Horizons: it appears to be trying to take off, with the fans and air conditioning all working at full force, leading to a slightly breezier than expected environment. There are equally interesting exam refreshments: some only slightly strange apple and aloe vera juice, and some slightly more strange brightly coloured swiss rolls, which have a colour that would be completely fine if the object with said colour was not expected to be edible.

Geoff heads off to Thailand to be part of the process in deciding what questions we'll end up doing on the actual IMO, and Dominic is busy marking our scripts, so we spend the afternoon relaxing: cards and mafia with the Australians. (They insist it's M-are-fia, but this is incorrect).

This evening's dinner turns out to be a western option at the local mall. After getting to the mall, which I am fairly sure involved making strictly more than one complete lap of the building, we realise we have absolutely no idea where the restaurant is. We eventually find it after no small amount of randomly walking round the surprisingly crowded mall (this appears to be the only place in Putrajaya that could hope to be described as 'crowded'). It turns out to be a rib house, which not only offers stereotypical American style food, but also in stereotypical American sized portions, with a full rack of ribs ending up amounting to about half a fully grown pig. Gunning is the only person who actually managed to finish a rack of ribs, and I end up stealing almost half of Warren's. Jill orders a drink that is theoretically the same size as those ordered by everyone else, but turns up in a glass that looks as though it should hold a litre rather than a pint. This turns out to be caused by glass that looked thick, but was in reality very thick.

4th July

Somebody who knows how to operate the air conditioning in our exam room has been through at some point, as today the room is not trying to escape the confines of Earth's atmosphere. There's a bit of confusion as question 3 on today's paper was also question 3 on one of our selection tests, but a replacement is quickly found, and the rest of the morning passes without any issues.

Once we leave the exam, Neel quickly discovers an article in the Guardian about Joe, featuring a photo of Joe staring into the top-left middle distance we find very entertaining, along with an equally entertaining cameo from Warren: his only contribution to the article is the phrase "there's not much romance", in response to a question about whether any X+Y-esque moments ever actually happen at the IMO.

The other main notable event today is when Dominic returns from the mall after trying to find some slightly less dubious exam refreshments. He fails, and Harvey's suggestion of grapes turns into kedondong, which are like grapes in that they are green and vaguely grape shaped. They also turn out to have a texture and taste almost entirely unlike grape: a texture somewhere between apple and tree, and a taste which is like a very sharp apple, but considerably

more powerful, and much more bitter. We also at first believe them to be called d'fruit, but this turns out to be the name of the company after some searching the internet. It also turns out that when ripe they turn 'golden-yellow', but are currently the colour of limes. We keep the rest of them in case they do indeed ripen, or just turn out to provide some later entertainment.

5th July

Today's exam passes without incident. There's nothing planned for the afternoon, so, leaving the rest of the UK team to enjoy the IMO shortlists of 2000 and 2001, Sam, Dominic and I go for a walk. The area around the school is the 'diplomatic area' of Putrajaya, where other countries are encouraged to build their embassies. Only Iraq has actually got round to this, and so the area feels somewhat empty. There are many roads we can walk straight down the middle of due to the complete lack of cars.

Tomorrow, the Australians will sit an exam with questions chosen by us and vice-versa. We finalise the questions we are setting this afternoon. Instead of the usual easy-medium-hard layout of a paper, we've gone for the novel idea of medium-medium-medium, after deciding not to attempt a Gunning-trap, as it would (a) probably fail and (b) use up one of our three questions with Gunning having the only significant possibility of solving it. The problems do have a progression though: they go pleasant, unpleasant, horrible in terms of how nice they are to solve. Marking question 3 is looking like it will turn out to be almost as tedious as attempting to solve this problem.

The kedondong also made a reappearance: After Warren and I both ran out of money in poker after a string of bad luck (obviously skill had nothing to do with this. . .), our generous teammates decided that we could simply re-join with a considerable amount of money. On the condition that we ate half a kedondong each. It turns out that the deeper into a kedondong you go, the less of the unpleasant flavour there is. However, by some kind of conservation of pleasantness, the flavour was replaced with a texture that is best described as fresh, shredded wood (but slightly tougher). I successfully re-joined, and then proceeded to lose nearly all my money again very quickly.

6th July

We sit the paper that the Australians selected for us in the morning. We have been told in advance that it is a nice paper, and that Gunning independently discovered the result that question 3 requires a proof of. The paper turns out to be very nice, with question three being a reasonably natural geometry result, to which my first reaction is "kill it with areals![2]" I try, and fail to do this. On discussion afterwards, Joe has succeeded in areal-bashing the problem, using a clever trick to remove any trig from the expressions.

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[2]A brief description of areal coordinates: "undoubtedly the best way of solving geometry problems. The height of elegance and succinctness, surpassing even Cartesian coordinates in terms of beauty." As said by no-one, ever.

The reason for us setting each other questions is primarily for what happens now: marking each others' scripts. while a little tedious, this is a very good exercise in reminding us that the person reading your script probably doesn't already know your solution. It also makes us appreciate just how much work the leaders do. Warren and I get the fun of marking question 3. Thankfully for us, Gunning is the only person to actually submit a complete solution for this problem, with only small parts of solutions from everyone else, as this is easily enough for us to fully benefit from this task. We still take the longest to finish, and Gunning gets 21, which nobody is particularly surprised with.

7th July

Today, there is the second most important event of the entire IMO trip: the Mathematical Ashes. After an issue involving the room we normally do exams in being rearranged is resolved, by moving into a different room, the competition gets underway. The paper this year contains an approachable number theory, a medium geometry, and a hard combinatorics. This is obviously selected to favour the Australians and their medium geometrical skills, to break our winning streak in the Ashes. I find an impressively inefficient solution to question 1, in the form an algorithm which, if run, would result in a solution consisting of integers probably several billion digits in length, but this isn't the IOI, and the solution works, so it doesn't matter.

After the exam is over, there is some tense adding up of solutions. Unfortunately, Sam and I both failed to solve the medium geometry, so it looks like the Australians' ploy is going to pay off, with them appearing to be almost a whole solution in the lead. Further disappointment comes later, when it's discovered that Warren's question 1 has fallen apart. With all of this in mind, we aren't really that nervous when the results are announced: we're almost certain we've lost. The results are announced: the UK has scored 84, and Australia have scored... 84. For the second time ever, the Ashes are tied, so the UK retains the urn (which is a good thing, seeing nobody could find it until after we left...)

To resolve this ending, Jill has organised for us to go to the local mall for the most important event of the entire IMO trip: the UNK v AUS bowling competition. Here, we set off to a much better start: I get an early game strike, Joe scores consistently well. Harvey and Neel appear to have similar levels of experience, but while Harvey almost scores a strike in the next lane, Neel's strategy of run at the lane and throw the ball in the air is unbelievably effective, with the ball going in an almost perfect straight line every time. It's not even particularly close: we win by about 20 points. We can now relax and enjoy the rest of our time in Malaysia, and Thailand, safe in the knowledge that everything important has already been done.

8th July

We're travelling to Thailand today, and our flight isn't until the afternoon, and so we have time to sleep in, an opportunity which we do not let pass (except

for Neel). We don't really do much other than pack and sort out the impressive quantity of paper that has been used over the week. Over the whole course of the journey, we try to attack last year's C9 as a group. This problem is extremely hard, and so we don't really make any progress. However, it's the kind of question that lends itself well to spending a long time just drawing multiple pictures of it and not really achieving anything, so it passes the time.

In the airport in Malaysia, we stop off in Nando's for lunch. Harvey takes a photo of us, and uploads it to Facebook with the disappointing caption of "today's lunch". The first test of the Wi-Fi in Thailand will be to correct this. The most interesting thing that happens on the flight is filling in an immigration card for Thailand, which isn't very interesting.

We are met at the airport by several large IMO signs, and a considerable number of people who insist on giving us garlands, and taking a lot of photographs. We meet our guide, Gorn, who introduces himself, informs us that we don't need to try and pronounce his last name (Buranasampatanon), and leads us to a minibus that we can all fit in comfortably enough. When we arrive at the hotel, we discover it appears to be on loan from David Hilbert, having rooms for all IMO contestants (in pairs), an entire shopping complex, and a single room big enough to hold the entire exam. IMO check in is a surprisingly speedy process, without any of the errors and misspellings we have been warned of from previous years. We are presented with a bag containing a T-shirt and a small assortment of other things, and head up to our rooms. These are also very impressive, with Wi-Fi and air conditioning. And beds and other things equally unimportant by comparison.

Dominic informs us that the continued contact with the BBC over a possible interview, which Neel has volunteered for, has taken an interesting turn: the latest piece of communication includes the phrase "seeing as Neel is a girl...", and seemed very keen to get "her" opinion on why there were so many more boys than girls at the IMO. Dominic decides to gently break the news to them at the end of the next conversation, in passing. Neel is quick to embrace his new found feminism, and, looking at his official IMO photo, we can kind of see why they've gone wrong. For some odd reason that none of us can work out, Dominic has said that doing an interview in drag would be a very bad idea. The reason was something like this would completely contradict the message we would want to put across in this kind of interview.

9th July

Waking up at six for the opening ceremony isn't as bad as it sounds (but still isn't good) due to the time difference between Malaysia and Thailand. We are transported to the venue of the opening ceremony in a huge convoy of what we are told (and will subsequently find out for ourselves) are the main form of public transport in Chiang Mai: red taxis. The police actually stop traffic as we drive through, and so we arrive at the location for the opening ceremony in a reasonably short amount of time. There are the obligatory official photographs, and after this we have to go through airport style security, because there will

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be royalty at the ceremony. We find our seats, and pass the time by attempting C8, which is easier than C9, and we manage to make some progress, but we don't manage to finish.

We are instructed on the procession, with a demonstration of how we should process. It seems straightforward enough (we still manage to get the timings wrong). HRH Princess Maha Sirindhorn arrives, with much fanfare. Speeches are given, including one by Geoff, which unfortunately had to be formal, so couldn't include anything more entertaining than a small joke about elephants. We process, more speeches are given, and the princess leaves. We are informed that we are now allowed to take photographs, but cannot stand on the red carpet where the princess stood. As we must wait for the leaders to leave before we can, there is about half an hour of free-for-all photography. Jill is armed with her smartphone, and before long, we've had group photos with just about every country we can think of and find. There is also a spontaneous entire-IMO photo on stage, when a few countries start a group, and before long, everyone has joined in. We keep up the tradition of Joe being carried around on people's shoulders, and are quickly copied by several other countries near the back of the crowd who want to be seen.

The Australians seem especially keen to have photos taken with everyone they meet, and it becomes clear why after we discover an assortment small koalas and kangaroos hanging off the back of our blazers. This starts the first of what ends up being several putting-things-on-people's-backs-without-them-realising competitions.

After photos and attaching miniature marsupials to people are complete, we head back to the hotel. When we get outside the opening ceremony hall, we find

a lot of teams and a few red taxis waiting around. There are also a reasonable number of official looking people doing official looking things that also happen to give nobody any information about who should be getting in a taxi when. We decide to just get in a taxi, and this turns out to be very effective, as nobody questions our uninstructed actions, and the taxi takes us back to the hotel.

In the afternoon we head out to visit a temple along with some people from various other teams. In what becomes a recurring theme for temples, bells are rung, pagodas and statues are photographed and karma is discussed. We also visit a café for ice cream (or similar). The ice-cream is good, and the mysterious giant (as in 5 metres tall) pink plastic almost-dog with sunglasses is mysterious. We also get stuck out in a rainstorm, which Neel is very pleased about.

The theme for karma continues in the evening with the discovery of a book in our room entirely devoted to the explanation of this concept. We spend a good portion of the evening attempting to understand the difference between merit and karma, and fail. We search the internet for help, and discover that there was, predictably, a WikiHow (with pictures) titled "how to boost your karma: 12 steps". Reading this, along with an obviously entirely factual and academic article on Glamour.com, leaves us feeling much more proficient and understanding of this system. Warren takes this information to heart, but before we can discuss the details of exactly how to maximise our Karma-function over the set of possible actions, we turn the television on, and the first thing that appears on the screen is us! (In the opening ceremony, on stage). We were as out of time as we feared. Discussion of karma continues a bit longer, before we decide that, with an exam the next day, we ought to get as much sleep as we can.

10th July

Exam day one. I've slept surprisingly well, but Neel and Warren haven't been quite so fortunate, with their 1960's-idea-of-the-1980s room control system giving them a phone call at five in the morning. At breakfast, Dominic presents us with a suggestion for talismans we are allowed to take into the exam: now ripe kedondongs. The rules state a talisman must "fit in your hand", and all of

the opposing possible definitions[3] of this would mean the fruit was acceptable. I end up being the only person to actually take a kedondong in as a talisman, and none of the officials seem to mind. (Although "food and drink" was a separate category, and it was never clear that I had absolutely no intention of ever actually eating the kedondong, putting it in a different category to what the invigilators would think. As there were no size limits on food, we will never know whether this was actually an acceptable talisman. I doubt anyone will be too distraught at this lack of information). There were some issues concerning jackets, which were not allowed in the exam room, and about half the team had to leave theirs outside. Warren's attempt to use the "I can see about 10 people in there wearing hoodies similar to this one" excuse fails, but Joe's appeal to illness is very successful.

The first question on the paper is a combinatorics question that definitely doesn't seem to be at the easiest end of the easy scale, though in my opinion is fairly nice, but other opinions vary. What everyone agrees on though, is that question 1 is most definitely nice by comparison to question 2, which was a Diophantine equation, for which, unusually, the answer to "are there any strange solutions?" Was "Yes. Lots! But not infinitely many with this nice equation for all of them." I, along with many other people, fell into the trap of finding the solution $(2, 2, 2)$ (and for some people, $(2, 2, 3)$), and then making the normally correct assumption that these would be the only solutions. This question led to very few people attempting the actually approachable question 3, resulting in questions 2 and 3 getting about the same number of complete solutions. Out of the UNKs, only Warren succeeded in wading through the swamp of cases arising from all the possible situations on question 2.

In the afternoon, we head out with our guide, and also Luke (from Ireland) to the old centre of the city, for a bit of tourism. There's a museum about local culture, and then another temple, where bells, pagodas and statues feature again, although in different amounts. We continue our investigations into the world of karma, with Neel posing difficult questions such as whether reincarnation implies the number of alive things, or the sum of all karma are universally conserved quantities. We don't find many answers, but it takes our minds off the exams, both past and future.

11th July

Exam day two. I again manage to sleep well, and nobody seems particularly disappointed with amount of sleep today. The jackets problem has been resolved, and today the rules have changed so that they are allowed. Today's paper, although looking promising at first, ends up following a similar theme to yesterday's: an easy that wasn't the easiest, a medium that was definitely closer

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[3]The favourite definition of this is Warren's, which states the convex hull of your hand must completely contain the convex hull of the talisman. There are problems though: Sam could have an item as a talisman that Joe could not, due to relative hand sizes. And what about long thin objects? A pen couldn't be a talisman, but you're allowed to take them in, even if they are never used... These questions were never answered.

to the harder end of the scale, and a very nice, approachable and not hard by hard standards question 6, that nobody had time to do much on, so looks as though it were nearly impossible: over 90% of contestants scored zero on this question, and there were only 11 complete solutions.

After we leave the exam, and find Dominic, Jill and Gorn, many things are revealed: as a team we have five complete solutions, all to question 4 (I've had a bad day, and get no complete solutions). The other piece of information we receive is that somehow, paper 2 was revealed to some deputy leaders yesterday, and so had to be reset. There are rumours flying around that the original paper contained both G1 and A1, which certainly doesn't sound like a particularly bad thing, given how hard day 1 was found, but we can't know for sure. Of course, this wouldn't have made any real difference to relative marks, as everyone sits the same paper, but it's hard not to speculate about possibilities.

We decide to go for a walk in the afternoon, to a waterfall on a mountain near Chiang Mai. This is along a small path through dense woodland, with insects like woodlice but ten times the size, banana plants with leaves ten times the size of anything in the UK, and a waterfall with a size that was really not particularly impressive.

We are also informed that, as a break from the rice at the hotel, we will be going to a western restaurant to meet Geoff this evening, who we couldn't see immediately after the exam because he was busy helping to agree on the mark scheme. Here, he brings bad news: it looks as though France will be beating us this year, and by some margin.

12th July

Today is the first of the two day IMO official excursion. We come prepared, taking packs of cards, paper and pens, after stories from previous years where excursions haven't always been the best timed affairs. However, there doesn't seem too much danger of not having enough to do, with the morning spent visiting a temple in Chiang Mai, and then a much larger temple on top of a mountain, and then visiting hot springs and an umbrella making centre in the afternoon.

The temples are about as expected, with the first temple having bells, pagodas and statues, and the second temple having more bells, bigger golden pagodas, more statues and an interesting history. IMO hats are distributed: they have questionable colouring, but definite sun-blocking effectiveness. We talk to some of the other teams, and discover that basically everyone except the Americans are feeling disappointed and annoyed with the medium questions. (The Americans are feeling annoyed with the medium questions, but not disappointed.)

We head to the hot springs for lunch. There is a lot of food, and also some people taking a lot of photos of us all, including photographing everyone individually getting off the bus. The hot spring does what it says on the tin, and is very pleasant after adapting to the temperature. We are also given a geometry

problem from the Americans, involving inverting a circle six consecutive times[4]

Question 3 coordination is also happening around now, but there isn't much tension about this, as we are only expecting 3 single marks here. The results come in to Warren via text about ten minutes after coordination was due to start, and Warren, Harvey and Joe get their expected marks for proving a useful collinearity.

The final stop of the day is the umbrella manufacturing centre. Expectations are low, and this seems set to be a dull museum about how umbrellas are made. We are surprised when it then turns out to be probably the best part of the day. After we get off the bus, we are each presented with a folding fan, which turns out to be a genuinely very useful gift in the hot weather. The rest of the visit is then spent getting any item we wanted painted with a design we picked for a very reasonable price. Hats, fans, wallets and in Neel's case, phones quickly become more colourful. I get my wallet painted with a dragon for about £2, and after assorted items are painted, we head into the shop. Neel buys as much as he can carry, which consists of a scaled-up version of the free fan he got, which is slightly too big for him to fan himself with, but very good for fanning others, and a couple of paintings. I buy nothing and lose my wallet (in that order), which thankfully contains nothing other than a small amount of cash.

Thanks to another good suggestion from Jill, we also go to the night market, where I spend the 50 baht I had in my pocket rather than my wallet on assorted fried things: banana crisps and a packet of fried big crickets, which tasted of fried and crunchy, and could also stare back at you before you ate them. The rest of the team has varying levels of keenness to try one.

13th July

The mood today is tense, with most of the UNKs expecting to be on the border between where the medal boundaries are likely to be. We are getting coordination done of questions 1, 2, 5 and 6, which will, for everyone except me, basically decide exactly what medal they will be getting.

On the bus to today's excursion, we collect guesses on what the medal boundaries will be. The most common guesses for silver are 19 and 20, and for gold, 25 to 27. Joe, Harvey and Sam are expecting 19, and Warren 25, so this year's results could go almost anywhere.

The actual excursion today is to an elephant camp in the morning, and then some orchid gardens and some kind of royal project related to farming in the afternoon. The elephant camp is one of several in Thailand, and has just short of a hundred elephants. After some initial feeding the elephants, there is the main show. Unfortunately, we apparently don't have time to actually ride the elephants, but the show is entertaining. This included the elephants painting,

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[4]Take three circles, Γ_1, Γ_2 and Γ_3. Let Φ_i be the inversion mapping Γ_i to Γ_{i+1}, with centre of inversion at the ex-centre of similitude of these two circles. (Let $\Gamma_4 = \Gamma_1$). Let operation Ω be the composition of the following inversions (in order): $\Phi_1, \Phi_2, \Phi_3, \Phi_1, \Phi_2, \Phi_3$. Show that, for any point A on Γ_1, the application of Ω maps A to itself.

where they produced pictures of trees, flowers and a landscape, apparently of their own accord[5].

As we are leaving the elephant park, there is some shocking news! The guide tells us that there someone on the Mongolian team and someone from the Kazakhstan team have been involved in... a romance. This is shocking because Warren's entire presence in the article in the guardian (mentioned earlier) was saying that "there's not much romance [at the IMO]", and as the most experienced team member we would expect him to know this kind of thing.

I forget exactly when, but around this time we receive coordination results from questions 5 and 6. Everything is as expected: Joe gets his mark on question 6 (everyone else gets zero), and on question 5, we get 2 ones, 2 twos and 2 threes, which is also about as expected. Everything seems to hang on what the scores are for question 2.

The orchid farm is not especially thrilling, and the royal project, while I'm sure it is very useful and productive for Thailand, is not the most exciting of destinations. These are livened up by the nervous wait for question 2 results, and at the royal project, they arrive. 212712 is about what we had hoped for: assuming questions 1 and 4 are as expected, Warren has the seven he needs in order to be in with a shot at gold, and Sam, Harvey and Joe have their 19s, and so are on the silver borderline.

We have to wait until 4pm for the results from question 1, which is going to be very important for me, as a bronze is looking quite far-fetched, and so

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[5]Searching the internet afterwards, there are questions as to how genuine these are: in actuality, the elephants paint the same picture every time, but the performance was impressive nevertheless.

I need the 7 to get an honourable mention. The rest of the excursion passes without drama, and after a very long game of liar's poker on the bus on the way back to the hotel, the results from question 1 arrive: Warren gets a text from Dominic reading "P1: 777777, didn't even have to sit down. Coordinators very congratulatory." This very good news for everyone, for obvious reasons. However, Neel has some problems accepting that these scores actually exist[6].

After getting back to the hotel, Warren gets a surprise text, from Dominic, saying they had time to coordinate question 4 as well, and our scores are 717777. This is good news for everyone except me, as I now have a total of 10, which is almost certainly too low for bronze, but is still an honourable mention at least. There is now a tense wait until the medal boundaries are decided tomorrow evening. Our medals could easily be anywhere between G, S, S, S, B, HM and S, B, B, B, B, HM. The latter would be out lowest medal haul since 2001... I try to stay on the positive side of things, pointing out that five of us may have another attempt next year, could well lead to an exceptionally good haul of medals, especially since seeing that many of us feel we could have performed better (I certainly do, but there's no point being annoyed about this now).

We spend the evening playing exchange chess[7] in the recreation room in the hotel. There's the minor problem that we can't find anyone who can't be beaten by Joe fairly quickly (we haven't looked that hard, but he can certainly beat all of us without any problem). We also have another putting-things-on-people's-backs-without-them-realising competition, this time starting a sticker war, using some of the huge number of IMO logo luggage stickers we've brought. This turns out to be

very good advertising, and we manage to hand out a good proportion of the stickers.

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[6] 7 does not exist. This is a well-known result, but will be proved here in the interests of completeness. Lemma: all horses are the same colour. Proof: by induction. Base case: in any set of one horse, all horses in the set are the same colour as all other horses in the set. Inductive step: assume that in every set of k horses, all are the same colour. Consider a set of $k+1$ horses. Consider two overlapping sets of k horses. In each set, all are the same colour, and there is an overlap, so all $k+1$ horses are the same colour. Thus all horses are the same colour. However, we can find two horses that are different colours. This is a contradiction, and so by the explosion principle, all statements are true. Thus 7 does not exist.

[7] An even number of chess games are played in a row. Each side is a team, and play alternating colours. A direction of play down the line of boards is assigned. Whenever a player takes a piece from the opposing player, they pass it to the player on their team in the assigned direction (the game is assumed to be played round the curved face of a cylinder). Placing a piece on the board after receiving it from another player, not into checkmate, and not a pawn on the 1st, 7th or 8th rank, is a valid move. The team with the first checkmate on any board wins.

14th July

The main feature of today is waiting for medal boundaries to be announced, and stats to be released, but there's also the IMO lectures to help pass the time. First, a talk about Ramanujan from professor Ken Ono, which starts with the lemma that a selfie with an elephant should be called an 'elphie' (proof by biological induction[8]), and ends with details about the Hausdorff dimension of the partition numbers of specific values modulo a prime.

The second IMO lecture is from professor Ravi Vakil, who starts with an idea of taking a shape, then drawing a slightly bigger shape around it, and uses this to find a novel (and very beautiful) proof of one of Geoff's favourite problems[9].

In the afternoon, Jill has arranged for us to visit Chiang Mai zoo. The most advertised attraction was the pair of giant pandas. The one panda we see does live up to the advertisement, but there is another feature that is very well received: the air conditioning (It's a hot day). Similarly, although the penguins themselves seemed a bit depressed, we thought the building they were in was one of the best places in the zoo. The tortoises, we decided, did not count as part of the IMO (the excursion was not one of the official ones). If they had been, they would have added considerable further weight against some of Warren's views on the IMO.

We decide that attempting to sneak into the final jury meeting is definitely not an achievable goal, and so spend the rest of the evening in the recreation room. The results are published, and medal boundaries announced. I somehow miss the initial shouting about this, and wonder over a couple of minutes later wondering what all the fuss is about. The boundaries are 14, 19, and 26. This is strictly the lowest gold boundary, and non-strictly lowest silver boundary in the modern format of the IMO, and even so, a considerable number less than usual of gold medals have been awarded. Unfortunately, Warren doesn't get one of them. The good news is that the borderline bronze/silvers are on the right side of the border. The other interesting news is that Warren has scored the same as the highest scoring Russian and the lowest scoring American, and that for the first time in a long time, the US have won the team contest.

15th July

The closing ceremony isn't until the afternoon, and so we take the opportunity to not wake up for as long as possible. Meals in the morning are a confused affair, with different team members waking up at different times and some making it to breakfast and some not. I end up having breakfast at around 9am, and then lunch at 11. The closing ceremony is held in yet another room in the hotel big enough to hold everyone at the IMO. The programme seems sensible, and is. There is the mandatory folk dancing, which is only ten minutes long, and very

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[8]Similar to geographical induction. To prove a result, find an example (or two) of it being true, and then the result holds in all cases.

[9]Let the sum of the length, width and height of box A be a, and that of box B be b. If $a > b$, is it ever the case that it is possible to fit A inside B?

professional. Then a slide show of pictures from the week, and then we move on to the awards. The screens scroll through the honourable mentions, and then the time comes for the medals. This has a very impressive level of efficiency, never trying to fit too many people on the stage at once, and everyone being easily visible for photos. Geoff almost ends up giving medals to Joe, Harvey and Warren, but this potential political disaster is avoided after a quick bit of place swapping. There is then the presentation of a special prize (though there were no Special Prizes this year, breaking the pattern started by the previous two being awarded in 1995 and 2005) to Alex Song of Canada, who this year got his fifth gold medal, and his first perfect score, putting him at the top of the hall of fame, as the most successful IMO participant ever.

After the handing over of the IMO flag to Hong Kong, and a few photos, we head off to the exam hall, which has been converted into the venue for the 'farewell banquet'. This is all nice enough, with a market style buffet, and team sized tables. A journalist appears, talks to Geoff for a bit and then leaves again. And then the entertainment starts. This had the potential to be very good, and would have been, if someone hadn't turned the bass on the speakers up to 'seismic'. We're sitting at almost the furthest point from the stage, and if you put a cup of some of the mysterious not-quite-herbal-tea squash from one of the stalls on the table, you can see the ripples from the sound system. We stay for the first few folk dancing performances, but then decide to leave in favour of the lobby of the hotel, where the music is quiet enough to have a conversation over.

After the leaders have gone back to their hotel to pack, the Australians, Kiwis and us decide it would be fun to try and organise a rave in the recreation room. This starts as a joke, but then we decide to actually try and get it to happen. There are speakers along the side of the room, and a microphone that can be connected to them, so we know they work. Seyoon and Warren go to ask reception if we can "borrow their sound system". Surprisingly, the answer is "yes, we'll send someone down in fifteen minutes." About twenty five minutes later, someone does indeed turn up, and after swapping a couple of wires round,

we have control of the speakers, and the rave actually happens! The Kiwis are put in charge of the music, and soon enough we actually have a reasonable crowd of people not caring that they have almost no idea how to dance (apart from one person from the Kazakhstan team, who actually seems to be able to). This goes on until 11:30pm, when the hotel staff decide that they now have enough non-IMO guests who would want to sleep to outweigh us wanting to use the speakers.

We stay around in the recreation room until about two in the morning, when most things have calmed down sufficiently that we decide to head up to our rooms.

16th July

A not particularly long amount of time later, we wake up, quickly pack everything, then head down to breakfast before the rush of people trying to use the lifts. We get down, and soon enough are on a minibus to the airport. Dominic leaves us with a case of things that he doesn't want on his trip round Burma, and then heads off to a different flight. One Air Asia flight later, and we're in Kuala Lumpur again, where we'll be spending the day with Geoff's friend Dave, and his wife Maria, who have organised a buffet lunch in a hotel right next to a train station with direct connections to the airport, until our flight back to the UK, in the evening

There is a very good buffet lunch, as promised, and after this we (except Joe, who isn't feeling well), go with Maria on what has to be the shortest IMO excursion in history to see the Petronas twin towers. There is a very efficient train journey, and then about five minutes at the towers (just enough time for a team photo), before we have to catch the train back to the hotel, to pick up our luggage, and catch the train to the airport.

Jill describes Kuala Lumpur airport as the worst she's ever been to. It's easy to see why. Even ignoring the difficulties with Dominic's extra luggage and then losing Geoff, there are no or very few seats where you would want them, and about three times more queues than all other airports manage to get people on international flights with. After we go through security, there are a large number of shops, selling things you might want on a long, international flight: travel pillows and bottles of water, for example. I get one of each of these. It then turns out that to get to the gate, you have to go through security. Again. This, of course, means binning the water. We then go through a third, and then fourth passport check, and then finally make it onto the plane.

We pass Geoff, who has somehow been upgraded to one of the best seats on the plane, to our seats in economy, and settle down for the thirteen hours of international flight, which lives up to and does not surpass expectations. Neel does maths, and everyone else sleeps. We arrive back in Britain, and after some congratulations and goodbyes, we all head off back to our respective parts of the country. UKMT events are frequent enough that it probably won't be long before we see each other again.

Acknowledgements

There are a huge number of people who do a huge amount of work to make events like the IMO and the UKMT activities throughout the year, and leading up to the IMO happen. I do not know all their names to thank, as many of their roles have only the effects visible, with little trace of the people responsible. This year especially, nearly everything at the IMO was very efficient, and when things did go wrong, they were almost always put right very quickly. The total number of names needed to thank everyone is too many to reasonably put here, and it seems unfair to only thank the visible faces, but I will do so anyway. Thanks go to Geoff for everything he does within UKMT and the IMO, Dominic for all of the marking and coordination he did, on top of being a good friend as well as deputy leader. Also to Jill, for never failing to have good suggestions for things to do to fill time, and our guide, Gorn, who always did everything he could to fulfil our requests, and the requests of the organisers, even when these didn't quite line up. To Joseph Myers, who makes it possible for this report to be read, to the Glow Cloud (all hail), and of course to the organisers of the IMO itself. To Bev, who sorts out many things that I know about, and probably even more that I don't. Finally, thanks go to the ancient Greeks, for starting modern mathematics.