RMM 2026 - UK Deputy Leader's report

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The Romanian Master of Mathematics is a competition organised in Romania, birthplace of the IMO, where teams can compete by invitation only. The invited teams tend to be those that have traditionally done well at IMO, giving the organisers licence to set problems which are harder and sometimes require more knowledge than those at IMO. This makes it a contest unlike any other in the world, and we are grateful to the organisers who have honoured us with an invitation to each iteration of the event since its first edition in 2008. The UK team in Romania consists of the six best-performing students from the annual joint winter camp with Hungary over the New Year (although the regulations state that only four of their results will count towards the final team ranking). They are:

Aum Bagla, Simon Langton Grammar School For Boys

Adavya Goyal, St Paul's School

Kelvin Lam, Radley College

Narein Mohan, City of London School

Yuvan Raja, RGS Guildford

Mykhailo Sydorenko, King's Maths School

By special agreement with the organisers, Alex Chui of Tonbridge School is allowed to participate as an online contestant. Our team leader is Anđela Šarković, who is a lecturer at King's College Cambridge and very experienced former maths Olympian. Our observer with contestants is Kian Moshiri, a master's student at Warwick who doubles up as the expert in Euclidean geometry. Both of them reprise their roles from RMM 2025. In what follows I will attempt to diary our experience of this year's competition. [1]

[1] Results can be found on the official website .

23/02. Arrival

Anđela and I arrive at Stansted to find Kian and half the team already waiting in advance of the agreed meeting time of 9am. The other half of the team arrive soon after and we start dealing with the usual faff that comes with trying to board an airplane. When passing through security Adavya's A-Level chemistry textbook falls out of his bag, because obviously he needs to revise for his mocks at RMM. The security personnel make Aum put his foot in some strange box that appears to just measure his feet. I decide to refrain from asking questions.

The team has a couple of questions about the mock we set them. By some coincidence, Adavya had circulated a very similar question to Q2 on the mock, which meant some of the pupils had a lot of time to do Q3, and a couple of them managed it. Not only that, but they found it quite easy, which came as a pleasant surprise to me given that it was actually RMM 2016 Q3 and a very strong UK team made little headway ten years ago.

Narein expresses apprehension about the novel experience of getting on a Ryanair flight given that he has heard bad things. In Ryanair's defence, they are quite likely to land conditional on the event that they do take off, and we arrive in Bucharest unscathed. The organisers have arranged for taxis to take us to the Hotel Irisa, which is where meals are served and conveniently located 5 minutes from the contest venue, Tudor Vianu High School. On the journey from the airport, there is a discussion about optimism. Aum thinks that one should be pessimistic about everything except solving Olympiad problems, which the rest of us found a little odd until we realise that we have different notions of pessimism.

It is soon dinner time after we arrive, and I get to meet the leaders of the Nordic and Baltic teams while Anđela catches up with the Serbians. I learn that the leaders of the Nordic team have the distinction of being the youngest leader-deputy pair. Dinner is concluded with the scrumptious second dessert of the six suggested problems being served to us on a USB stick, at which point Anđela, Kian, and I retire to Anđela's room to try the problems, since her room has a sofa.

Problem Commentary

There will be spoilers for the RMM problems as well as the final results. If you want to avoid this, skip ahead to the discussion on the jury meetings.

> Problem 1: Let n be a positive integer. Alice draws a unit area triangle on the board. Then she draws additional triangles by performing n moves in a row. On each move, she chooses a drawn triangle Δ with no marked points in its interior, marks a point P in its interior, and draws three smaller triangles by joining P to each vertex of Δ with a segment.
> Once these n moves have been performed, Bob chooses three distinct drawn triangles Δ_1, Δ_2, and Δ_3 which contain no marked points in their interiors, such that Δ_2 shares one side with Δ_1 and another with Δ_3. In terms of n, determine the largest possible constant c such that Bob can guarantee that the sum of the areas of Δ_1, Δ_2, and Δ_3 is at least c, regardless of Alice's choices.

A natural thing to ask is what happens if Alice makes all the triangles have the same area. This leads to $c \leq \frac{3}{2n+1}$, which turns out to be the correct answer. To obtain the other bound, one shows that the triangles can be ordered cyclically, which means that Bob can choose a set of tuples such that every triangle appears in a tuple 3 times, and we conclude by an averaging argument. There are other ways to obtain the lower bound on c but all of the approaches I'm aware of use some sort of Hamiltonian cycle. I think this is a nice problem and suitable for its position. This was a quick solve for us when trying the problems, but it is deceptively simple in the way many combinatorics problems are and many contestants struggled more than expected.

The mark scheme for this problem is extremely detailed and covers a lot of examples of what is considered partial progress. The discussion takes well over an hour and a half and tires out most of the jury members, which means that the subsequent mark scheme discussions were quite brief. Following the new stated philosophy of RMM, the coordinators are very generous with awarding partial marks for the upper bound: a labelled diagram suffices. They are also not picky about miscounting the number of triangles, which I managed to do at some point when trying the problem, but, to the best of my knowledge, this ends up not being an issue with any scripts.

> Problem 2: Let $p \geq 11$ be a prime. Suppose that, if a and b are integers such that $1 \leq a < b \leq p-3$, then $b! - a!$ is not divisible by p. Prove that $p-5$ is divisible by 8.

Initially, I found the question to be very natural and the conclusion mildly surprising. We are given a huge amount of information to play around with, i.e. that many factorials leave distinct residues upon p, and it is clear that Wilson's theorem and some of its consequences will play a big role. The manipulations to show the initial step that $p \equiv 1 \mod 4$ take me more time than it really ought to have, and trying to figure out the missing residues takes up too much time when there were still problems 3-6 to attempt, so I stop trying this problem. Out of curiosity, I check to see whether this very natural question has appeared before, and in fact a very similar one has. Erdos asked whether there exists a prime such that $2!, 3!, \ldots (p-1)!$ leave distinct residues modulo p. There are some more conditions that such a p (called a socialist prime by some researchers) must satisfy, but a computer search has revealed no examples $< 10^{11}$. We sour on this question, both because it is so close to something known and because it seems that the manipulations aren't very pretty. However, the finish from this point is the more interesting part. In my opinion it would have been better to ask that $p \equiv 5 \mod 8$ under the slightly stronger assumption in Erdos' question, since this contains all of the ideas of the solution.

We consider trying to replace this problem because it is known in some sense, but it turns out this is a merit of the problem in the eyes of the RMM PSC. More on this below.

Problem 3: Let $\mathcal{S}$ be a finite subset of $\mathbb{R}^3$. Prove that there exist three polynomials $P(x,y,z)$, $Q(x,y,z)$ and $R(x,y,z)$ with real coefficients, such that a triple of real numbers (a,b,c) is in $\mathcal{S}$ if and only if the system of equations

$$P(x,y,z) = a, \quad Q(x,y,z) = b, \quad R(x,y,z) = c$$

does not have a solution in real numbers x, y, and z.

The tastes of the RMM PSC mean that in recent years there has always been one hard question based on polynomials. As in 2023, the polynomial problem of 2026 is as beautiful as it is difficult, and could only appear on the RMM as it would probably be considered too difficult or not elementary enough at another contest. It is by far my favourite question of this year's contest.

It looks to have a strong algebro-geometric flavour, but resists my attempts to nuke it with results from algebraic geometry so I hunker down to attempt this properly. (I learned later that the result is indeed known in algebraic geometry.) I handwave some sort of argument that we may assume the points lie on the x-axis, but get nowhere until Kian remarks how squares must play a role somehow. This is quite insightful, and after trying the other problems I return to this idea.

It is a famous problem, often given to first year students at Cambridge, whether a polynomial in 2 variables that takes on all positive real numbers must have a root. The answer is no, and the problem proposer Navid confirms that this question was his original motivation. One can adapt the construction to do the simpler version of P3 where the polynomials have 2 variables and just have to miss a single point. From here, some careful bootstrapping lets one do the case of an arbitrary number of points in $\mathbb{R}^2$, and then finally $\mathbb{R}^3$. I think it would be a tall ask of any contestant to find this under exam conditions.

The Italian leader and one of the USA contestants, Liam Reddy, also produce beautiful solutions to this problem. Reddy's solution is particularly noteworthy because, in the opinion of John Berman, the leader of the USA, it makes the problem seem very easy. I hope that the Italian leader's solution will appear online somewhere in due course so that we can appreciate it. Reddy's solution is now on AoPS.

Problem 4: For any positive integer m, let $\varphi(m)$ be the number of positive integers less than or equal to m and coprime to m. Define $\varphi_0(m) = m$ and, for each positive integer k, $\varphi_k(m) = \varphi(\varphi_{k-1}(m))$. For any integer $n \geq 3$, prove that

$$\varphi_0(2^n - 3) \cdot \varphi_1(2^n - 3) \cdot \varphi_2(2^n - 3) \cdot \ldots \cdot \varphi_n(2^n - 3)$$

has at most n distinct prime divisors.

This is my least favourite of the 6 problems. There is no real number theoretic content and everything just needs to be bounded correctly, so this is a plausible algebra problem. The exact form $2^n - 3$ is irrelevant; all one needs is that it is at most 2^n. It is found very easy by the contestants: a large majority score 6 or 7.

During the jury meeting some of the leaders raise concerns about similarities with USA TSTST 2016 Problem 4. The PSC believed that it was easier to do the problem directly than to derive it from the conclusion of the TSTST problem. Anđela and I agreed and thought it was easy enough that it didn't matter anyway. We learned afterwards that this problem had been submitted to EGMO, and the difficulty means that it would be much more suited to EGMO than RMM. Nonetheless, it was perhaps good that something accessible was given as P4. For many students this would be the only problem where they made significant progress.

Problem 5: Let ABC be a triangle with $AB < AC$, let O be its circumcentre and let $XYZT$ be a parallelogram inside triangle ABC such that

$$\angle AXB = \angle AZC, \ \angle AZB = \angle AXC,$$

$$\angle AYB = \angle ATC, \ \angle ATB = \angle AYC.$$

Prove that the diagonals XZ and YT of the parallelogram intersect on the circumcircle of BOC.

The PSC liked this because they believed that this is a very innovative geometry problem. This is true to a certain extent. The fact that $XYZT$ is a parallelogram is a little bit of a red herring: the angle condition means that one should consider pairs (X, Z) and (Y, T) separately, deduce information about the corresponding configurations, and put this together at the end to obtain the desired conclusion. The intersection point turns out to be the A-Dumpty point.

This slightly unnatural approach is complicated by the difficulty in drawing an accurate diagram. When we were trying the problems, Kian struggled to draw anything before he realised that we only really need to consider a single pair for the most part. However, one can easily draw points X, Z such that the line through them doesn't pass through the A-Dumpty point. It is the presence of a pair which forces the conclusion, which we only realised after drawing some diagrams with Geogebra.

Initially we thought we were just bad at geometry, since none of the other countries had anything to say about the problem. That is probably still true, but it wasn't the only issue. It was only after asking several leaders privately that we realised that no one had managed to do the problem in a reasonable amount of time, if at all. The French leader remarked that he hadn't yet seen an accurate diagram, even in the solutions booklet. This is because the only way the problem conditions can be satisfied is if the parallelogram is very long and thin (at least I think this is true), which is difficult to show on a diagram.

The Serbian delegation had someone who is very good at complex bashing, and he also took a while to come up with something, so we thought there wasn't an easy bash. How wrong we were. After Day 2 the Bulgarian delegation informed us that the problem had been sent to IMO 2023 and 2024, but was rejected both times because there was a quick complex bash. The contestants produced a few of these, and again Liam Reddy's solution, which can be found on AoPS, stands out for its simplicity. This problem was on the whole found extremely challenging, and finding a synthetic solution is probably close to an IMO P3/6 in difficulty.

Problem 6: Let $k > 1$ be an integer, and let S denote the set of all $(k+1)$-tuples of integers $X = (x_1, \dots, x_{k+1})$ such that $1 \leq x_1 < \cdots < x_{k+1} \leq k^2 + 1$. If σ is a permutation of the numbers $1, 2, \dots, k^2 + 1$, say that an element X of S is σ-nice if the sequence $\sigma(x_1), \sigma(x_2), \dots, \sigma(x_{k+1})$ is monotone. Prove that

$$\min_{1 \leq i \leq k} \left\lfloor \frac{x_i}{i} \right\rfloor + \min_{2 \leq i \leq k+1} \left\lfloor \frac{k^2 + 2 - x_i}{k + 2 - i} \right\rfloor \geq k + 1$$

if and only if there exists a permutation σ such that X is the unique σ-nice tuple in S.

Anđela and I have differing views on this problem. She thinks the problem is nice, while I feel that this is a run of the mill hard combinatorics problem, in so much as such a thing exists. We do agree on one thing: the surprise value of the apparently random inequality characterising what seems to me to be the rather strong condition of being the unique σ-nice tuple for some σ. The solution hinges on providing combinatorial interpretations of the algebraic terms, which is an idea that appears in mathematics beyond olympiads. Some amount of insight/intuition can be gained from thinking about Erdos–Szekeres and its proof. I am not really sure how to evaluate the difficulty of this problem. It is certainly tough, but I wouldn't conclude much based on the competition statistics alone since many will have burned unusually large amounts of time on Problem 5.

24/02, Jury meetings

This is the day when leaders have the most to do. Here is a good place to reiterate that the leaders don't choose the problems at RMM. The PSC sets the test and the leaders have a chance to object.

We raise concerns about problems 2 and 4, but it is difficult to actually get anything changed because the extra list is very short so there is a significant lack of credible alternatives. There is the added complication that the coordinators are called only on specific days, so swapping topics between the days is nigh on impossible. We are pleased to see that Sida has two problems on the extra list and Thomas has one, but this is a bittersweet moment as we can't actually propose changes that involve adding lots of UK problems to the test.

The issue is that the problems on the extra list aren't really usable once the extra list is published, but they aren't generally used for much while under embargo (a handful of countries, including the UK, use them for TSTs but not much else). The chair of the PSC, Navid, tells us that he would appreciate it if countries didn't withhold the rights to put problems on the extra list. Anđela counters that there is no incentive to do so if the organisers are so inflexible about changing the problems on the test. She proposes that the extra list not be distributed to the leaders, but that the PSC set the test and have an unseen backup option for each slot, of similar difficulty and topic, in case a problem is found to be known or very objectionable, so that the jury can veto a problem and the backup is used instead (I'm told this is how EGMO is run). This is an eminently sensible suggestion, which John also supports and the Romanians say they will seriously consider. At least some fragment of the special relationship is alive.

There has been another change to the regulations this year: anything written on scratch paper will no longer be considered by the coordinators. I have been warned about this policy by last year's French leader, and I confess I don't understand the rationale at all. This year's French leader and USA delegation are strongly opposed to the policy. Professor Catalin Gherghe, Ph.D., as he is always announced, is the chief organiser and he comes to debate the merits of this policy change. He says that the regulations were sent out and no one protested. I, along with everyone else, didn't realise that we could protest. Future leaders, take note that this is possible. He claims that this is to avoid pointless debates about whether things on the scratch paper are worth partial marks, but this would simply result in contestants not using scratch paper at all. I think most of them are smart enough to realise that there is little benefit in using scratch paper if this is the case. A back and forth where little progress is made ends when the Bulgarian leader proposes a compromise this year that scratch paper is available to the coordinators but not the leaders, so that if something seems like a minor typo is correct in the scratch the students don't get a deduction. This is accepted.

With such trifling matters out of the way, the jury can now get down to business. We approve the extremely detailed mark scheme for problem 1 after extensive discussion, and then the mark schemes for the rest of the problems after some discussion. John, Zach, and I have cleaned up the original problem statements in our capacity as the English language committee, but the jury still felt that something might be ambiguous. A long and somewhat heated debate ensues. In the end, the UK has the honour of casting the tiebreaking vote. This concludes the jury meetings. We give our contestants a brief pep talk over dinner, in full knowledge that our advice about how to write mathematics will have no effect whatsoever. They go to bed early of their own accord, leaving us to agree with other leaders that most of the contestants would probably be very well-behaved without any adult supervision. For the leaders, a welcome change over the past 10 years.

25/02, Day 1

Aum doesn't feel well today but it doesn't seem like any medications would help. Otherwise, there is relatively little to do until the contestants' scripts arrive. We meet them after the exam and they generally seem ok. Aum is not pleased with his performance, but given that he likely had a bout of food poisoning it can hardly be considered a reflection of his ability. Most importantly, he is feeling better. Yuvan looks rather worried, but his description of what he had attempted sounds very promising. Narein says that he has given us a lot of material to work with, which is certainly better than giving us nothing to work with.

The guides attempt to bring Kian and the pupils on a tour of the palace. Unfortunately they arrive too late and are denied entry. We don't manage to book another slot later in the week, which is a shame. Note to the leaders next year: a tour of the palace needs to be booked at least 24 hours in advance, so this requires a little planning.

We receive the scripts, do some marking, and get the contestants to explain some parts of their solutions to us in more detail after dinner. This goes quite well and we are convinced that there are lots of marks to be earned.

With considerable effort (more than it took to mark most of the scripts), Kian finds and books an escape room that can accommodate 7 people and is in English for the team to do on Day 2. One of Anđela's local friends recommends a restaurant for dinner tomorrow, Zexe, where Kian also manages to make a reservation. We are left to muse about the coming storm. Some of the contestants wished for a(nother) geometry problem on Day 2. A classic example of be careful what you wish for.

26/02, Day 2

Question time is more eventful for us today, as Mykhailo has predictably gone straight for the geometry question and found it to be a rather odd configuration. As with some other jury members, he goes through the five stages of grief attempting to understand what is going on. Thankfully question time ends around the bargaining stage.

Coordination for problem 3 is over in under a minute. Problem 2 also passes largely without incident. We point to the relevant items in Yuvan's script and the coordinators graciously agree that is enough for the marks we asked for. We have to try a bit harder to explain Narein's partial progress. The coordinators come round soon enough and remark that no one else has gotten those marks with such a line of argument.

Coordination for problem 1 is more interesting. We again manage to persuade the coordinators that Yuvan has made more progress than they thought, and they manage to persuade us that Mykhailo's and Aum's scripts are worth more marks than we initially asked for. Kian and I were initially skeptical of the mark Anđela proposed for Mykhailo, which is probably a lesson in optimism if nothing else.

We are done in time to see our pupils as they leave the exam hall. Most of them are wondering what on earth is going on in problem 5, which is fair enough, but Aum claims a complex bash. They compare notes with a few other contestants and are somewhat reassured by everyone else finding problems 5 and 6 quite hard.

It is Adavya's birthday today, and Anđela has arranged for a delicious Egyptian cake to be delivered to the hotel. We sing Adavya happy birthday, and he likes the cake enough to somewhat distract him from talking about how his birthday present is to come against what he believes to be the hardest day of RMM in its history. They then go to do the escape room, where Kelvin shortens the process considerably by managing to guess the code for one of the padlocks.

Dinner at Zexe is very nice. The team seizes the chance to ask the newly of age Adavya about his plans to go clubbing when he matriculates at Cambridge. Kian, Anđela, and I try some Romanian specialties, but the young ones choose to avoid having any culinary adventures. More bone marrow for me I suppose. The USA team are also dining at Zexe on our recommendation, but we didn't coordinate very well and find ourselves on different floors of the restaurant, which is a shame.

We go back to the Irisa so that the contestants can play cards for a while, with the exception of Mykhailo who goes to his room to try and complete his attempt at Problem 5. I am told he has been doing this all day. The USA team are quite social and chatty by the standards of contestant teams at international maths competitions. Kian and I are puzzled by some of them apparently having sat Putnam. After they leave, some other contestants arrive and Narein explains the rules of Irish snap to them, adding that this is a variant of Snap seldom played outside the UK. Apparently this has replaced Mao as the card game of choice nowadays. I am once again reminded of how many years I have behind me.

27/02, Closing Ceremony

As is traditional, we go to Brutal Pancakes for breakfast on the last full day in Romania. I have never been, but Anđela and Kian are big fans. I have difficulty making a choice from the cornucopia of options on offer, but when the food arrives it lives up to the hype. Narein says that his pancakes alone are enough motivation for him to make the team next year, which is understandable. Mykhailo is still trying to fix his geometry solution. Kian demonstrates how to drink water from a glass and then tries to induct Adavya and Yuvan into the cult of rowing. They wisely decline.

Anđela and I go to coordinate Problem 4, which lasts for all of a minute. Kian joins us for Problem 5, where the coordinators tell us it took them 2 hours to read Aum's one page complex bash. A sense of dread washes over me as Kian and I can't decipher a couple of sentences in Aum's work when asked by the coordinators to elaborate. After all, an incomplete bash would (rightly) be awarded 0. We agree the marks for everyone else. Alex has found a moving points solution that the coordinators didn't quite believe, but this is significantly easier to explain. We ask to reschedule to discuss Aum's solution.

Anđela and I go to deal with Problem 6, and we get most of the marks that we could possibly have gotten after we convince the coordinators that Adavya's scribbles in fact correspond to words in the English language. Kian has managed to understand what Aum meant, and comes up with five different ways to explain it to the coordinators, who eventually convince themselves that what is written is correct by doing some trig bash. We finally get the marks. Overall, the coordination is a good experience and the coordinators have kept to their promise of rewarding ideas where this is possible.

Delays in coordination of Problem 6 morph into delays in the final jury meeting to decide cutoffs, leaving us plenty of time to wonder about medal boundaries. We note that the marks we have received are quite tightly bunched together which probably means lots of people on various medal boundaries. The organisers come in and tell us the possible medal distributions. After some careful introspection the jury votes to award lots of medals. The final medal boundaries are 16, 20, 24 – almost exactly what Anđela predicted. Never doubt Anđela. When the scores and boundaries are announced, Adavya immediately gets to work and computes that we have come fourth, one mark off Romania A in third place. This is a great result, but some of them choose to rue what could have been. I suppose that is in some sense the mark of a great competitor, but Kian rightly encourages them to look on the bright side.

The closing ceremony opens with Catalin giving a speech written by Nicușor Dan about how you can do anything as a mathematician. The buildup to the speech convinces Kian that he would actually make an appearance, and when it transpires that he won't Kian resolves to never forgive Catalin. Our contestants go up to receive their medals, Narein gets a chance to show off his gym gains, and we manage to take some nice group photos at the end.

After dinner, the crowd of leaders and organisers slowly thins out. Navid starts to shake hands with literally everyone. It is unclear how many hours this took him. We say goodbye to the delegations we managed to see somewhat regularly during the week, with promises to keep in touch and the hope of seeing them again soon. Kian collects a lot of phone numbers.

28/02, Departure

I wake up at 5:45 feeling like a zombie. Our contestants appear to be in the same boat, but we manage to board the plane, and when I open my eyes again the plane is nearly back in London. Anđela warmly congratulates all the contestants on their well-deserved achievements and bids us farewell until Trinity camp.

Conclusion

Overall this was a successful RMM year for the UK and for our pupils. They did well to solve the problems they should have solved and have every reason to be satisfied. We came fourth in the team rankings, which is the highest rank we have achieved since 2017, when the UK came second. Alex has received his third gold medal at RMM, a feat which has been equalled by few others. We aren't sure if any other participant has achieved this apart from previous UK contestant Joe Benton, who won gold in 2015, 2016 and 2017. All of this bodes very well for the future, and we hope to see this year's contestants demonstrate their skills at the upcoming Trinity camp and beyond. I'd also like to reiterate that, following the discussions this year, future leaders should carefully consider what happens with the extra list and scratch paper and voice suggestions or concerns. Thanks from me are due to

- the PSC, the organisers, and the coordinators for their hard work and what was a very smooth time in Romania.
- Hayley and others from the UKMT for supporting us on this trip.
- Anđela and Kian for their good humour and tireless effort before and during the contest, on both the mathematical and administrative sides. They were excellent company that made the trip much more enjoyable.
- our team of Aum, Adavya, Kelvin, Narein, Yuvan, Mykhailo, and Alex. They worked hard on the training and contest problems, and we look forward to seeing what they achieve next.