

Ireland's Participation in the 66th International Mathematical Olympiad

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August 18, 2025

The 66th International Mathematical Olympiad (IMO) took place in Sunshine Coast, Queensland, Australia, from 10–20 July 2025. A total of 630 students (69 of whom were girls) participated from 110 countries of which Qatar participated for the first time.

The Irish delegation consisted of six students (see Table 1) accompanied by Anca Mustata (Deputy Leader, University College Cork), Bernd Kreussler (Team Leader, Mary Immaculate College Limerick) and Stephen Buckley (Observer A, Maynooth University).

1 Team selection and preparation

The team detailed in Table 1 consisted of those six students (in order) who achieved the highest aggregate scores in two Team Selection Tests (TSTs) which were offered on two days in March 2025 to the 13 top scorers of the Final Round of the Irish Mathematical Olympiad (IrMO). Until 2023, the Irish IMO team was selected solely on the basis of their performance at IrMO. It was the second time this year that the team selection process was more rigorous, extensive and in line with best international practice.

Round 1 of the Irish Mathematical Olympiad took place in September 2024 with about 14,000 students sitting a 30-minute paper in their schools. The Final Round of IrMO with 122 participants was held for the 38th time on Saturday, 25th January, 2025. The participants typically attend extra-curricular Mathematics Enrichment classes, which are offered at six Mathematics Enrichment Centres (University College Cork, University College Dublin, University of Galway, University of Limerick, Maynooth University and Atlantic Technological University Sligo) and to which the top performing students from Round 1 were invited by their teachers to attend. More information on the organisation of these classes, as well as links to the individual maths enrichment centres, can be found at the Irish Maths Enrichment/IrMO website <https://www.irmo.ie/>.

Between IMO 2024 and IrMO in January 2025, a number of training opportunities were offered to students who performed well at last year's IrMO. These included a training camp

Name	School	Year
Tianci Yan	The Institute of Education, Dublin	5 th
Ang Yang (Justin) Li	The Institute of Education, Dublin	5 th
Vitalii Halushko	St Vincent's College, Castleknock, Dublin	5 th
Owen Barron	Coláiste an Spioraid Naoimh, Bishopstown, Cork	5 th
Jack McAuliffe	St Flannan's College, Ennis, Co. Clare	4 th
Ben Maguire	St Vincent's College, Castleknock, Dublin	4 th

Table 1: The Irish contestants at the 66th IMO

at the end of August in Cork as well as a new remote problem-solving scheme between September and November 2024. Both training initiatives were run by recent Irish IMO alumni: Fionn Kimber O'Shea and Tianyiwa Xie. Their personal example is encouraging for current Olympiad students and it paved the way for their ambitious goals. Involving enthusiastic IMO alumni allows for a more sustainable extension of training activities in the future.

International collaborations are an essential feature of the Mathematical Olympiad community. Some team members attended, on their own initiative, international Olympiad training classes and/or Maths Camps in China, Croatia, Poland, Ukraine, and WOOT, and the free online classes by Anant Mudgal, facilitated by last year's Irish IMO Deputy Leader and former contestant Tianyiwa Xie.

In addition, students were given the opportunity to participate remotely in the Iranian Geometry Olympiad, the Iranian Combinatorics Olympiad, the European Mathematical Cup, and the British Mathematical Olympiad. Participation in these contests provides very valuable experience for all students involved.

Two training camps, offered to the top 25 performers at IrMO 2025, took place at UCD immediately before the two TSTs. For the majority of the participants, this was the start of the preparation for Maths Olympiads in 2026. After the two TSTs and the IMO team selection, the training initiatives focussed on the six team members. Since none of the team members was tied up by the Leaving Certificate exams this year, the pre-IMO team training could start early. Through April and May, the team sat two practice exams and worked their way through a long problem set. Throughout the month of June, a very intense team training schedule was set up, including problem sets, online sessions and three more practice exams. Many thanks to Anca Mustata who masterminded the team training and conducted most of the training herself.

2 The days in Australia

The Irish IMO team, together with the Leader, Deputy Leader, Observer A and Emily Woolfe (student at UCC and former IMO contestant), arrived in Australia in the evening of Sunday the 6th of July. After moving from Brisbane to Sunshine Coast on the 7th, a pre-IMO training camp was held for the members of the Irish IMO team, from 8–12 July 2025. This was also an opportunity for the students to adjust to the 9-hour time difference from home in advance of the IMO contest. The availability of Emily as additional trainer was very helpful, in particular after Bernd and Stephen moved to the Jury site in Noosa on 10 July.

The Jury of the IMO, which is composed of the Team Leaders of the participating countries and a Chairperson who is appointed by the organisers, is the prime decision making body for all IMO matters. This year the IMO Jury was chaired by Norman Do who did an excellent job of making sure that all of the Jury meetings ran smoothly and efficiently. The Jury's most important task is choosing the six contest problems out of a shortlist of 31 problems provided by the IMO Problem Selection Committee, also appointed by the host country. While serving on the Jury, the Team Leaders are forbidden from communicating with the team or Deputy Leader until the end of the second day of examinations.

After the exams are concluded, the final marks for each contestant are agreed in a process known as coordination. This important part of the IMO is well-established and ensures that the scripts of the students from so many different nations are marked fairly and consistently. The decisions in this process are based on detailed and strict marking schemes prepared by the coordination teams. This year, these marking schemes were scrutinised and modified by the Jury through extensive discussions with the problem captains of the coordination team.

The marking of the scripts of each participating country is undertaken by two independent groups. One group consists of the Team Leader, the Deputy Leader and the Official Observers. The second group consists of the coordinators, who are appointed by the local organisers. This is an intensive task for the Leader, Deputy Leader and Observer, as we need to have a full understanding of the solution or attempts of each of our six students so that we can explain the merits of the students' work to the coordinators.

On looking through the students' scripts, it soon became clear that we had a very strong Irish team performance on our hands. Problem 1 was completely solved by five team members. Four students completely solved Problem 2, a geometry problem. In the evening of day 1, after having a closer look at the scripts of the students, it looked like all team members may receive at least an Honourable Mention, which is awarded to any student who did not win a medal, but achieved 7 points out of 7 on at least one problem. It happened only twice in the past (2014 and 2017) that all six members of an Irish IMO team were awarded a Medal or an Honourable Mention. Moreover, three of the Irish students completely solved two of the three problems of the first contest day. Knowing that the problems for the second day were deemed to be slightly more difficult than those for day 1, we were cautiously optimistic that one of the students may receive a Medal this year. As expected, the day-2 scores were lower than those of day 1, but Tianci, Owen and Vitalii scored 14 points on day 2 which put all three in the Medal range. Tianci impressed by scoring on all six problems. He is only the second Irish IMO contestant who was able to do this, after Fiachra Knox in 2004 who then received a Bronze Medal. Owen Barron impressed by solving four problems completely. He is only the third Irish IMO contestant with such an impressive record, after the Silver Medallists Fiachra Knox in 2005 and Lucas Bachmann in 2019.

During the two days of coordination, excursions and other activities were organised for the students. Our students enjoyed trips to Australia Zoo on the 17th of July where they petted Koalas and Kangaroos, and to "Aussie World" (a family theme park) on the 18th.

The final Jury meeting, at which the medal cut-offs were decided, concluded at midnight on Friday 18th July. The closing ceremony was held on Wednesday, 19th July, followed by an Australian BBQ farewell party in the evening. After a more than 30-hour journey, the team returned to Ireland in the morning of the 21st of July, happily welcomed by their families.

3 The problems

The two exams took place on the 15th and 16th of July, starting at 8:30am each morning. On each day, $4\frac{1}{2}$ hours were available to solve three problems.

First Day

Problem 1. A line in the plane is called *sunny* if it is **not** parallel to any of the x -axis, the y -axis, and the line $x + y = 0$. Let $n \geq 3$ be a given integer. Determine all nonnegative integers k such that there exist n distinct lines in the plane satisfying both of the following:

- for all positive integers a and b with $a + b \leq n + 1$, the point (a, b) is on at least one of the lines; and
- exactly k of the n lines are sunny.

(U.S.A.)

Problem 2. Let Ω and Γ be circles with centres M and N , respectively, such that the radius of Ω is less than the radius of Γ . Suppose circles Ω and Γ intersect at two distinct points A and B . Line MN intersects Ω at C and Γ at D , such that points C, M, N and D lie on the line in that order. Let P be the circumcentre of triangle ACD . Line AP intersects Ω again at $E \neq A$. Line AP intersects Γ again at $F \neq A$. Let H be the orthocentre of triangle PMN .

Prove that the line through H parallel to AP is tangent to the circumcircle of triangle BEF . (The *orthocentre* of a triangle is the point of intersection of its altitudes.)

(Vietnam)

Problem 3. Let $\mathbb{N}$ denote the set of positive integers. A function $f : \mathbb{N} \rightarrow \mathbb{N}$ is said to be *bonza* if

$$f(a) \text{ divides } b^a - f(b)^{f(a)}$$

for all positive integers a and b .

Determine the smallest real constant c such that $f(n) \leq cn$ for all bonza functions f and all positive integers n .

(Colombia)

Second Day

Problem 4. A proper divisor of a positive integer N is a positive divisor of N other than N itself. The infinite sequence $a_1, a_2, \dots$ consists of positive integers, each of which has at least three proper divisors. For each $n \geq 1$, the integer a_{n+1} is the sum of the three largest proper divisors of a_n . Determine all possible values of a_1 .

(Lithuania)

Problem 5. Alice and Bazza are playing the inekoalaty game, a two-player game whose rules depend on a positive real number λ which is known to both players. On the n^{th} turn of the game (starting with $n = 1$) the following happens:

- If n is odd, Alice chooses a nonnegative real number x_n such that

$$x_1 + x_2 + \dots + x_n \leq \lambda n.$$

- If n is even, Bazza chooses a nonnegative real number x_n such that

$$x_1^2 + x_2^2 + \dots + x_n^2 \leq n.$$

If a player cannot choose a suitable number x_n , the game ends and the other player wins. If the game goes on forever, neither player wins. All chosen numbers are known to both players. Determine all values of λ for which Alice has a winning strategy and all those for which Bazza has a winning strategy.

(Italy)

Problem 6. Consider a 2025×2025 grid of unit squares. Matilda wishes to place on the grid some rectangular tiles, possibly of different sizes, such that each side of every tile lies on a grid line and every unit square is covered by at most one tile.

Determine the minimum number of tiles Matilda needs to place so that each row and each column of the grid has exactly one unit square that is not covered by any tile.

(Singapore)

4 The results

The Jury tries to choose the contest problems such that Problems 1 and 4 are the most accessible, while Problems 2 and 5 are more challenging. Problems 3 and 6 are usually the most difficult problems, whose existence on the paper is justified in posing a sizeable challenge even to the top students in the IMO competition. Table 2, which shows the scores achieved by all contestants on the 6 problems, illustrates that this gradient of difficulty was generally maintained this year also. The scores for Problem 3 were much higher than normal, whereas Problem 6 was solved by only six contestants – five of them achieved the perfect score of 42 points.

	P1	P2	P3	P4	P5	P6
0	60	198	418	70	266	569
1	26	126	36	28	52	45
2	58	19	25	52	19	6
3	31	13	16	28	38	1
4	14	5	12	25	23	1
5	19	7	14	23	12	2
6	54	9	7	62	5	0
7	368	253	102	342	215	6
average	5.216	3.306	1.600	5.075	3.002	0.184

Table 2: The number of contestants achieving each possible number of points on Problems 1–6

The medal cut-offs were as follows: 35 points needed for a Gold medal (72 students), 28 for Silver (104 students) and 19 for Bronze (145 students). A further 132 students were awarded an Honourable Mention.

Name	P1	P2	P3	P4	P5	P6	total	ranking	award
Tianci Yan	7	7	3	6	7	1	31	91	Silver Medal
Owen Barron	7	7	0	7	7	0	28	148	Silver Medal
Vitalii Halushko	4	7	0	7	7	0	25	203	Bronze Medal
Angyang Li	7	7	0	3	1	0	18	322	Honourable Mention
Jack McAuliffe	7	1	0	7	0	0	15	366	Honourable Mention
Ben Maguire	7	1	0	1	1	0	10	448	Honourable Mention

Table 3: The results of the Irish contestants

Table 3 shows the results of the Irish contestants. The performance of the Irish team this year was record breaking, with two Silver Medals and one Bronze Medal and three Honourable Mentions. The team scored a total of 127 points, the highest score of an Irish team at the IMO, a more than 50% improvement of the previous best of 84 points in 2022. So far, only five students from Ireland have obtained a score of at least 25 points at an IMO, three of them this year. Also, Ang Yang (Justin) Li, Jack McAuliffe and Ben Maguire were awarded Honourable Mentions for their complete solutions to one or two problems. Never before, an Irish team came home from the IMO with three medals. During 37 years, since Ireland’s first participation at the IMO in Australia in 1988, a total of two Silver Medals were earned by students on the Irish team (in 2005 and 2019). This underlines the significance of the performance of this year’s Irish team. All its members are eligible to participate in IMO 2026.

From the available statistical information it can be noted that the scores at IMO 2025 were in general higher than at other recent IMO contests. In total, 43.8% of all possible points were scored at this year's IMO. This is the second highest total score in the past 30 years, only in 2022 a higher score was achieved by all IMO contestants. This may partially explain the huge increase in this year's record team total, but not the record number of medals. The rules for the IMO stipulate that at most half of the contestants should be awarded a medal and that the ratio between the number of students earning Gold, Silver and Bronze medals should be as close as possible to 1 : 2 : 3. A Silver Medallist usually has a higher score than three quarters of the participants, and a Bronze Medallist scores in the top half of the contestants.

The IMO is a contest of individuals. In the inofficial ranking of countries by the aggregate score of their team members, Ireland took 42nd place, this corresponds to a relative ranking of 62.39%. This is the first time ever that an Irish team is ranked in the top half of participating countries.

The figures in Table 4 have the following meaning. The first figure after the topic indicates the percentage of points out of the maximum possible, scored in total by all participants. The second number is the same for the Irish team and the final column indicates the Irish average score as a percentage of the overall average. The strong performance of the Irish team is evident from the table. Problems 1, 2, 4 and 5 cover all four areas appearing in Olympiad mathematics, and the Irish team scored in all of them above the average of all contestants. The strongest results were achieved in geometry, a very welcome flip of a long-standing issue. This is the result of the constant and systematic efforts of Anca Mustata to improve geometry training in Ireland. The weakest of the areas now seems to be number theory.

The detailed results can be found on the official IMO website, which is located at <https://www.imo-official.org>.

Problem	topic	all countries	Ireland	relative
1	combinatorics	74.5	92.9	124.6
2	geometry	47.2	71.4	151.2
3	number theory	22.9	7.1	31.3
4	number theory	72.5	73.8	101.8
5	algebra	42.9	54.8	127.7
6	combinatorics	2.6	2.4	90.5
all		43.8	50.4	115.1

Table 4: Relative results of the Irish team for each problem

5 Outlook

The next countries to host the IMO will be

- 2026 China
- 2027 Hungary
- 2028 Saudi Arabia
- 2029 Mongolia

6 Conclusions

It is notable (e.g. from the graphic for IRL on imo-official) that Ireland's performance in Mathematical Olympiads has become generally stronger and more consistent in the past decade. This increased performance is underpinned by training activities which have grown in scope and impact. Of particular importance is the successful roll-out of the Junior Maths Enrichment (JME) programme, consisting of mathematical problem-solving activities for Junior Cycle students, within four universities across Ireland: University College Cork, University College Dublin, University of Galway, and Maynooth University. The JME programme is very important in that it engages Irish students in mathematical problem-solving activities at an earlier age; it is well-known that such students have a greatly enhanced probability to succeed at a high level. Feedback from students and parents on the JME programme continues to be overwhelmingly positive. Four of the six IMO team members this year participated for the first time in the Final Round of IrMO when they were in Junior Cycle (second or third year Post Primary School).

Of course, the delivery of the new Maths Enrichment activities described above, as well as the running of training camps and the sending of a full team of six students, together with Leader, Deputy Leader and Observer, to the IMO contest requires sustained funding. It is of primary importance that sufficient funding becomes available for these activities. An increased level of funding would also allow the scope of these initiatives to be widened further, so that more students nationally can benefit from Mathematical Enrichment programmes, leading to improved Irish performance in international mathematics contests.

The work done during the IMO by the Leader, Deputy Leader and Observer, in particular when marking the scripts of the students is intense and requires a lot of time. With now all six students attacking at least four of the six context problems in a meaningful way, this workload has increased in recent years. The availability of an Observer in this process was very beneficial and helped to ensure that the best possible results for the Irish students could be secured. Even in the problem selection stage, the helping hand of an Observer is very useful for the Leader to get a better picture of the difficulties involved in the shortlisted problems. The consolidation of the practice of sending an Irish Observer to the IMO, will be important for future years.

7 Acknowledgements

Ireland could not participate in the International Mathematical Olympiad without the continued financial support of the Department of Education and Youth, which is gratefully acknowledged. We are grateful to the Minister for Education and Youth, Helen McEntee TD, and the entire team at the department, especially Orla Dowling, Emma Salmon and Sinéad Hoey, for their continuing help and support.

The principal foundation for the success of the contestants is the work done with the students in the Mathematics Enrichment Programmes at six third level institutions. Senior Enrichment programmes and the running of Junior Enrichment programmes are carried out for free by volunteers in their spare time. Thanks go to more than 80 trainers at the six Irish enrichment centres. The team success is also theirs! Thanks also to the above-named universities for permitting the use of their facilities in the delivery of the national Maths Enrichment Programme.

The 2024-2025 camps were organised by Mark Flanagan, Myrto Manolaki, Fionn Kimber O'Shea and Anca Mustata. Many thanks to all who contributed training sessions at the camps and those who helped with the marking of the exams of the Irish Maths Olympiad and the TSTs.

We gratefully acknowledge sponsorship from Susquehanna, which made the Irish squad and TST camps in UCD possible. The training camps in Cork and on the Sunshine Coast were possible due to the generous donation of the Irish National Mathematical Competition fund. We owe this to Tom Laffey, Gary Maguire, Finbarr Holland, Donal Hurley and all the founding members. In 1988 in Australia, Tom Laffey and Deputy Finbarr Holland lead the first Irish team participating in the IMO. It felt very special for the team in 2025 to have achieved such outstanding results in the country where the Irish IMO-journey began 37 years ago.

Finally, thanks to the hosts for organising this year's IMO in Australia and especially to Jack, the team guide.