UK Maths Trust

Mathematical Olympiad for Girls

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Solutions

These are polished solutions and do not illustrate the process of failed ideas and rough work by which candidates may arrive at their own solutions. They are not intended to be the 'best' possible solutions; in some cases we have suggested alternatives, but readers may come up with other equally good ideas.

All of the solutions include comments, which are intended to clarify the reasoning behind the selection of a particular method.

Each question is marked out of 10. It is possible to have a lot of good ideas on a problem, and still score a small number of marks if they are not connected together well. On the other hand, if you've had all the necessary ideas to solve the problem, but made a calculation error or been unclear in your explanation, then you will normally receive nearly all the marks.

Markers' comments have been added following the marking of the paper. They detail the most common approaches and common misconceptions and traps that students should look out for in future.

The end of this document also contains some general comments about Olympiad marking as well as information about the mark distribution and awards thresholds for this paper.

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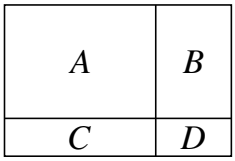
1. *This question requires answers only.*

A rectangular apartment is divided into four rectangular rooms, by two straight interior walls which are parallel to the exterior walls. The rooms have areas A, B, C and D metres squared.



(a) Find the value of D when $A = 8$, $B = 4$ and $C = 12$. [1 mark]

(b) Find the value of C when $A = 7.5$, $B = 6.5$ and $D = 26$. [2 marks]

(c) Find an expression for C in terms of A, B and D. [2 marks]

(d) In this part of the question, A, B, C and D have the values found in part (a). Additionally, the length and the width of each room are whole numbers.

Let P be the perimeter of the apartment. Find all possible values of P. [5 marks]

COMMENTARY

You could write some equations to find the side lengths of each room. However, for the first three parts, it is simpler to consider ratios of areas.

Rooms A and B have the same width, so their areas are in the same ratio as their length. The same is true for rooms C and D. It follows that $A : B = C : D$.

(a) $8 : 4 = 12 : D$, so $D = 6$.

(b) $7.5 : 6.5 = C : 26$ so $C = 30$.

(c) $C = \dfrac{AD}{B}$.

(d) Denote the lengths of A and B by x and y, and the widths of A and C by z and t, respectively. Then the area of B gives $yz = 4$, so there are three options: $(y, z) = (4, 1), (2, 2)$ or $(1, 4)$.

The first case gives $t = 1.5$ which is impossible.

In the second case, $x = 4, t = 3$ so $P = 2(6 + 5) = 22$.

In the third case, $x = 2, t = 6$ so $P = 2(3 + 10) = 26$.

Marker comments:

This question was generally done very well, with more than half of attempts scoring 8 or more.

The most common error in part (d) was including additional answers which do not satisfy the requirements of the question.

Including solutions where the apartment has whole number sides but forgetting that the rooms needs to have whole number sides gives the following common incorrect answers:

- 34, which requires room B to have sides of $\frac{2}{3}$ and 6,
- 62, which requires room B to have sides of $\frac{1}{3}$ and 12

Including solutions where a single room has been checked to have whole number sides, but forgetting that all rooms need to be checked, gives the following common wrong answers:

- 29, where room B has sides 4 and 1 causing room D to have sides 4 and $\frac{3}{2}$

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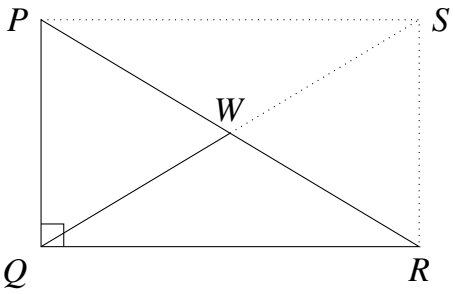
2. (a) Triangle PQR has a right angle at Q and W is the midpoint of the side PR. Use the diagram below to show that $QW = RW$. [2 marks]



(b) Triangle ABC has a right angle at B and $AB < BC$. Let M be the midpoint of AC. Let D be the reflection of C in the line BM (extended beyond M).

Given that angle DAC is $x°$ find, in terms of x, the size of angle BAC. [8 marks]

You must show all your calculations and say what geometrical result(s) you used at each step.

COMMENTARY

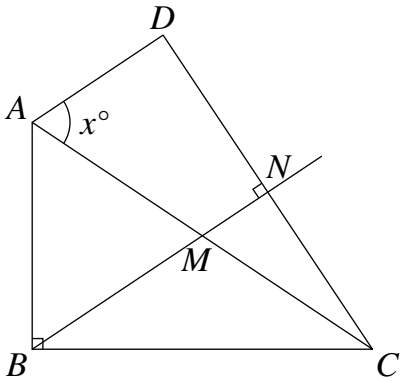
Start by drawing a clear diagram and identify the angle you know and the angle you want to find.

Angle BAC can be found from triangle ABM, and part (a) tells us something important about it. You are given angle DAC; what can you say about the line AD? Think about how you can use properties of reflection.

(a) The diagonals of a rectangle are equal and bisect each other. Hence $QW = \frac{1}{2}QS = \frac{1}{2}PR = RW$.

(b) Let N be the intersection of CD and BM. By the properties of reflection, N is the midpoint of DC and BNC is a right angle.

In triangle ACD, M and N are midpoints of AC and CD, so MN is parallel to AD. It follows that ADC is a right angle and angle $NMC = x°$.



Using the result of part (a), $BM = MC = MA$ so triangle AMB is isosceles with angle angle $x°$ at M. Since angles in a triangle add up to 180°, we find that angle MAB equals $\left(\frac{180 - x}{2}\right)°$.

Alternative

A different way to use properties of reflection is to note that $MD = MC$ and $\angle DMN = \angle NMC$.

The first of these equalities tells us that triangle AMD is isosceles with base angles equal to x and therefore we find that $\angle DMC = 2x$.

The second equality then gives $\angle NMC = x$ and so $\angle AMB = x$. From here, we can finish as before, using the isosceles triangle AMB.

Commentary

Markers' Feedback A large number of students were able to engage with this problem, but a significant number of scripts lacked sufficient justification. Just over 50% scored 2 or higher, around 25% scored 3 or higher (indicating that they were able to apply part (a) to the main problem) and 16% scored 8 or higher over both parts of the question. Part (a) was generally found difficult to write up, seemingly because students were unsure of what they were allowed to state. The intention of this question was to prompt students to construct a rectangle and then use the properties of a rectangle to attain the result. Other successful approaches included using congruency arguments to show $\triangle QWR$ is isosceles, or an argument using vectors to attain two vectors of equal magnitude. Another less used method was to use the converse of angle in a semicircle to show that W is the centre of the circle through P, Q and R, and thus both lengths are radii. Many students are aware of using circle theorems to find angles, but not all are aware they are two way statements. It is a common technique in Olympiad geometry to use the converse of a circle theorem to prove that points lie on a circle.

Some students claimed that dropping a perpendicular from W to QR would bisect the line QR, which implicitly assumes the claim is true leading to a cyclic argument.

In part (b) there were two common successful approaches. The first was to justify that the lines AM, BM, CM, DM were all equal and that the line BM bisects $\angle DMC$ to angle chase over the isosceles triangles. Alternatively, other students used the fact that $\triangle ACD$ is similar to $\triangle MCN$, or equivalently prove $AD \parallel BM$, and therefore found $\angle NMC = x$, finishing with a further isosceles angle chase.

The most common error with this second approach was to assume that the lines AD and BM were parallel. This is not an obvious statement and requires full justification. When students are working on any kind of geometry problem it is important to consider if their statements are making any implicit assumptions. In this question some students claimed that $\angle ADC$ was a right angle, which is only true if the above mentioned lines are parallel. Advice for students is to have a clear diagram that includes the information from the question and to think through why something would be true before adding it to their diagram. If a fact appears true from a diagram, this is a good indicator of what to work towards showing.

3. *This question requires answers only.*

(a) You have three red and four blue cubes. The cubes of the same colour are identical.

This part of the question is about the number of ways to distribute all seven cubes among some boxes, following these rules:

- A box may be empty (so it is possible to put all seven cubes in one box).
- The boxes are considered different (so putting all seven cubes in the first box counts as a different solution from putting all seven cubes in the second box).

(i) How many ways are there to distribute all seven cubes among two boxes? [2 marks]

(ii) How many ways are there to distribute all seven cubes among three boxes, so that no colour appears in all three boxes? [3 marks]

(b) The *factorial* of a positive integer n is defined as $n! = 1 \times 2 \times 3 \times \cdots \times n$. For example, $3! = 1 \times 2 \times 3 = 6$.

In how many ways can we write $10! = abc$, where a, b, c are positive integers, such that there is no factor greater than one which is common to all three of them?

Reorderings of a, b, c count as different solutions. For example, $120 \times 54 \times 560$ is not allowed because all three numbers share a common factor of 2, while $640 \times 162 \times 35$ is allowed and counts as a different solution from $162 \times 640 \times 35$. [5 marks]

COMMENTARY

In part (a), the most important thing to realise is that the two colours can be distributed independently. When you have three boxes you need to think carefully how you are going to ensure that only one or two boxes contain each colour.

Before starting part (b), think about how part (a) can help. You are trying to write a number as a product, so you are trying to distribute all the factors you have among the "boxes" a, b and c. You should find that you can count in exactly the same way as in part (a).

(a) We count the number of ways to distribute the cubes of each colour separately. Those numbers then need to be multiplied because for every distribution of red cubes we can have every possible distribution of blue cubes.

(i) The three red cubes can be split as $0 + 3, 1 + 2, 2 + 1$ or $3 + 0$, which is 4 ways. Similarly, the blue cubes can be split in five ways. Hence the total number of ways to distribute the cubes is $4 \times 5 = 20$.

(ii) There are 3 ways for all the red cubes to be in the same box. Otherwise one box contains no red cubes, and there are 2 ways to distribute them between the other two boxes ($1 + 2$ or $2 + 1$). There are three ways to select the box with no red cubes. Hence the number of ways to distribute the red cubes is $3 + (3 \times 2) = 9$.

Similarly, the number of ways to distribute the blue cubes is $3 + (3 \times 3) = 12$.

Hence the total number of ways to distribute the cubes is $9 \times 12 = 108$.

(b) We can factorise $10! = 2^8 \times 3^4 \times 5^2 \times 7$. Each of the numbers a, b and c is a product of some powers of $2, 3, 5$ and 7, where some of the powers must be zero to avoid all three numbers having a common factor greater than one.

The factor of 7 can be in exactly one of the three numbers, giving three options.

Either one of the three numbers is a multiple of 25, or two of them are multiples of 5, giving $3 + 3 = 6$ options.

Distributing the factors of 3 among the three numbers is the same as distributing the four blue cubes in part (a)(ii), which is 12 options.

Finally, we can find the way to distribute the factors of 2 in the same way (imagine there are eight orange cubes), giving $3 + (3 \times 7) = 24$ options.

Therefore the total number of choices for the values of a, b and c is $3 \times 6 \times 12 \times 24 = 5184$.

Marker comments:

This proved to be a challenging question with with fewer than a quarter of attempts scoring 3 or more.

In part (a)(i), a common error was to forget that the cubes of different colour need to be treated separately, and the corresponding counts multiplied together (rather than added). So, for examples, "one red cube in the first box with the rest in the second box" is a different solution from "one blue cube in the first box with the rest in the second box". This error results in the incorrect answer of 8.

In all parts, care is needed to avoid counting some possibilities more than once.

For example, in part (a)(i), once you have fixed the contents of the first box, the contents of the second box is fixed. Considering the options for the second box separately results in counting each possibility twice, and the incorrect answer of 40.

Similarly, in parts (a)(ii) and (b), consider the situation where all cubes are in the second box. This can arise from picking the first two boxes and placing all cubes in the second box, and also from picking the last two boxes and placing all cubes in the second box. Only one of those needs to be included in the count, and failing to exclude the other one results in the incorrect answers of 180 for (a)(i) and 21870 for (b).

It is important, of course, to start by factorising 10! accurately. In long-answer questions, numerical errors are not heavily penalised, but such mistakes are much more costly in answer-only questions.

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4. This question is about finding winning strategies in two-player games. We say that a player has a *winning strategy* if they can win the game no matter what moves the other player makes.

(a) In the first game, Players A and B start with a pile of 100 counters and take turns to remove either 2 or 3 counters from the pile. The winner is the player who removes the final counter. If only one counter remains, the result is a draw.

Player A goes first. Describe the winning strategy for Player B, and explain why this strategy guarantees a win. [2 marks]

(b) Players A and B are now playing a different game. They start with a pile of 700 counters, and take turns to remove 1, 3 or 4 counters from the pile. The winner is the player who removes the final counter. (If there are only two counters left, the current player must remove one counter.)

Player A goes first.

(i) Show that Player B can ensure that, at the end of their first turn, there are either 693 or 695 counters remaining. [1 mark]

(ii) Show that Player B can win if, at the end of one of their turns, there are 7 or 9 counters remaining. [1 mark]

(iii) Determine which player has a winning strategy.

You should

- Describe how the winning player should select their moves, which may depend on the other player's moves.
- Explain why this strategy guarantees that this player will take the final counter.

[6 marks]

COMMENTARY

The best way to tackle problems like this is to try playing the game. It is useful to think "from the end": which numbers of counters would the winning player reach on their penultimate move?

These "winning positions" should not be too difficult to find for the first game. In the second game, parts (i) and (ii) suggest that there are two types of winning positions.

When answering the final part, you need to make sure that you

- Describe how the winning player should choose their moves;
- Explain why they are always able to make those moves;
- Explain why those moves mean that the other player cannot reach zero counters.
- Conclude that the winning player must eventually reach zero counters.

(a) Player B should do make the opposite move from Player A: whenever Player A removes two counters, Player B should remove three, and vice versa.

This means that the number of counters decreases by 5 every two turns. Since it starts as a multiple of 5, it will be a multiple of 5 at the end of each of Player B's turns, and will never be a a multiple of 5 at the end of Player A's turn.

Since the number of counters decreases every turn, it will eventually reach zero, which is a multiple of 5, so this must happen at the end of Player B's turn.

(b) (i) Player B can achieve this as follows. If Player A removes one counter, Player B should remove 4 to reach 695. If Player A removes three or four counters, Player B should remove four or three, respectively, to reach 693.

(ii) Note that if Player B ends their turn with 2 counters remaining, they are guaranteed to win (because Player A must remove 1 and then Player B takes the final counter.).

Starting with 7 counters, if Player A removes four or three, Player B can reach zero. And if Player A removes one, Player B can remove four to reach 2.

Starting with 9 counters, if Player A removes three or four, Player B can remove four or three to reach 2. If Player A removes one, Player B can also remove one to reach 7 which we already know is a winning positions.

(iii) Player B has a winning strategy, which is to ensure that, at the end of each of their turns, the number of counters is either a multiple of 7 or two more than a multiple of 7.

They can carry out this strategy as follows. Whenever Player A starts on a multiple of 7, Player B can ensure that the number of counters decreases by 5 or 7 (by taking $4, 4$ and 3 counters after Player A takes $1, 3$ and 4, respectively). Whenever Player A starts on a number which is 2 more than a multiple of 7, Player B can ensure that the number of counters decreases by 2 or 7 (by taking $1, 4$ and 3 counters after Player A takes $1, 3$ and 4, respectively).

Furthermore, Player A can never end numbers which are multiples of 7 or two more than a multiple of 7 (if they start on one of those numbers). This is because going between those numbers requires decreasing the number of counters by 2, 5 or 7, which cannot be done in one move.

In this game, Player A starts with 700 counters, which is a multiple of 7. Since the number of counters decreases every turn, it will reach 0 or 2 at the end of one of Player B's turns, and we know those are both winning positions.

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COMMENTARY

Markers' Feedback Candidates performed quite well on parts (a), b(i) and b(ii). However, part b(iii) was found very challenging, with only 10% scoring 5 or more marks.

Students often omitted to mention why the game must finish, but markers showed leniency on this point. Those solutions which were not quite correct often showed an essentially correct strategy for B, but did not demonstrate that A could not sneak in and steal victory before B could take the last counter.

There were two effective strategies. The most common was to identify winning positions as counter pile sizes which are $1, 3, 4, 5$ or $6 \pmod 7$, from which the player moving next can force a win, and losing positions as counter pile sizes which are 0 or $2 \pmod 7$, from which either the player whose turn it is has lost (and there are 0 counters) or no matter what that player does, the other player can force a win.

The other strategy is to have rules about how player B should respond to player A's moves. If A takes 3, then B should take 4; if A takes 4, B should take 3; every time that A takes 1, B should respond alternately by taking 4 and then 1, starting with 4 on the first occasion that A takes 1. In terms of winning and losing positions, 700 is $0 \pmod 7$ and so is a losing position. Now $3 + 4 = 4 + 3 = 7$ so that combination of moves keeps A in a losing position. When the combination is 1 then 4, this leaves a counter pile of size which is $2 \mod 7$ and so a losing position. A subsequent combination of $1 + 1 = 2$ changes the counter pile to $0 \pmod 7$, so A is still in a losing position. At this point, a scrupulous proof will point out why A cannot sneak in and steal victory by reducing the counter pile to size 0 before B has the chance to do so. The game cannot finish when it is B's turn to move and the game must end (the counter pile is getting strictly smaller). Therefore B wins.

Some candidates classified moves as winning or losing, rather than positions, but if done correctly, this works just as well.

5. A cuboid has side lengths $a-x$, a and $a+x$, where a, x are positive integers with $a > x$. The main body diagonal of the cuboid (connecting one vertex to the opposite vertex, passing through the centre of the cuboid) has length d.

This question asks you to prove that it is impossible for d to be an integer.

(a) Write down and simplify an equation relating a, x and d. [1 mark]

(b) Find all possible remainders that a square number can give when divided by 8. Hence prove that it is not possible for d to be an odd integer. [3 marks]

(c) Now suppose that d is an even integer.

(i) Prove that a and x must also be even. [1 mark]

(ii) Let $a = 2a_1$, $x = 2x_1$ and $d = 2d_1$. Find and simplify an equation relating a_1, x_1 and d_1. [1 mark]

(d) Complete the proof that it is impossible for d to be an integer. [4 marks]

COMMENTARY

This is a challenging problem, but the question structure should give you some hints for how to approach it. You will show that d can be neither even nor odd, but the two proofs are very different.

To prove that d cannot be odd, you need to look at the remainders when various square numbers are divided by 8. It turns out that there is only a small number of possible remainders, and none of them fit the equation found in part (a).

The proof that d cannot be even uses the technique called "infinite descent". This basically involves showing that, if there were an even integer d that satisfies the equation, we would able to keep dividing it by 2 indefinitely to get a new solution.

(a) Using Pythagoras gives

$$(a-x)^2 + a^2 + (a+x)^2 = d^2$$

which simplifies to

$$3a^2 + 2x^2 = d^2.$$

(b) Every number can be written as $8k + r$ where $r = 0, 1, \ldots, 7$. Squaring those shows that the remainders when they are dividing by 8 are $0, 1, 4, 1, 0, 1, 4, 1$. So the only possible remainders are 0, 1 and 4.

If d is odd, then d^2 gives remainder 1 when divided by 8. Since $2x^2$ is even, a must be odd and therefore $3a^2$ gives reminder 3 when divided by 8. The options for the remainder of $2x^2$ are $0, 2$ and 8 (which is same as 0).

Hence the possible remainders of $3a^2 + 2x^2$ are 3 and 5, so this can never equal d^2 and hence d can't be an odd integer.

(c) Now suppose that d is even.

(i) $3a^2 = d^2 - 2x^2$ and both terms on the right are even, so a must be even.

But then a^2 and d^2 are both multiples of 4 (as squares of even numbers), which means that $2x^2$ must also be a multiple of 4. This is only possible if x is also even.

(ii) Since all three numbers are even, we can write $a = 2a_1, x = 2x_1$ and $d = 2d_1$. Substituting into the equation gives

$$12a_1^2 + 8x_1^2 = 4d_1^2$$

which simplifies to

$$3a_1^2 + 2x_1^2 = d_1^2.$$

(d) The final equation obtained in (c) is the same as the original equation for a, x and d. This means that we could apply the same reasoning to conclude that a_1, x_1 and d_1 must all be even.

But then we can repeat the same reasoning indefinitely, dividing by 2 to get a new set of three integers every time. This is not possible because the numbers are getting smaller and so can't remain positive integers. The conclusion is that d cannot be even.

We already know that d cannot be odd. So it is not possible for d to be a positive integer.

COMMENTARY

Markers' Feedback

This question was in general found difficult, with around 2/3 of attempts scoring 2 or less marks, but it also attracted a number of very good solutions, with 80 scoring 8 and above and 45 scoring full marks. Some attempts clearly had stopped when candidates ran out of time, indicating this question's position on the paper added to its difficulty.

Lots of people in part (a) either thought the diagonal d was the diagonal of a face of the cuboid (leading to an incorrect answer of $d = \sqrt{2a^2 + 2x^2}$ in most cases), misread the side lengths (common to be written down as $a - x, a - x, a + x$ instead of $a - x, a, a + x$) or got the correct answer $d^2 = 3a^2 + 2x^2$ and incorrectly took the square root to be $d = \sqrt{3}a + \sqrt{2}x$, which lost the mark.

It was common to only do the first part of (b) and skip the other part here – indeed, candidates who did not solve part (a) could still pick up this mark. Common incorrect answers for the first part of b included listing 8 as a remainder, or missing out 4. We were generous and allowed answers of 1/2, 1/8 and 0 or similar. Many people's solutions to (b) lost a mark because there was not sufficient justification given for why $3a^2 + 2x^2$ could not leave a remainder of 1 when divided by 8.

Part (c)(i) was found very difficult, and a substantial number of attempts only showed a was even. Many attempted to use odd/even arguments to say that both a and x are even – which doesn't work, as in the equation $d^2 = 3a^2 + 2x^2$, having a be even and x be odd makes both sides even. Using the possible remainders of squares in the same way as part (b) provides a natural method for doing this question. Many people

also successfully used an argument about multiples of 4, or by writing $a = 2k$ and then cancelling common factors to show x had to be even.

Part (c)(ii) was often answered by those who couldn't score any other marks on the question, but it was often left unsimplified and therefore couldn't score the mark.

When candidates made a serious attempt on part (d) it was mostly answered well, and we were generous with wording choices recognising such an idea could be tough to phrase. If no solution was found we awarded a mark for the idea that d_2, a_2 and x_2 could be found in a similar way, or some indication that the sequence can continue.

As a further step, we would recommend candidates look at modular arithmetic notation (for example, a number is equal to $1 \pmod 8$ if it leaves a remainder of 1 when divided by 8) to formalise some of the ideas introduced in this question.

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General comments

For many students, and possibly some teachers, this is the first experience of attempting a Maths Olympiad paper. It may therefore be useful to understand how these papers are marked, as students may be disappointed to receive a small number of marks for a problem they thought they had almost solved.

Long-answer questions in Olympiad papers are marked using what we call the '0+/10−' principle. This means that the markers first read the whole write-up and decide whether the student has a viable strategy to solve the problem. It may be that there are some mistakes or small gaps in their reasoning, but if those could be relatively easily filled in then this response is marked in the '10−' regime, with usually up to three marks being taken away for gaps and mistakes. Common examples of small gaps are algebraic or arithmetical errors (provided they don't change the nature of the argument), missing one of several cases in a counting question, or lack of geometrical reasons when calculating angles.

If, on the other hand, the student has only started to explore the problem and has only made some useful observations, but does not have a strategy to generalise or prove them, then the script is marked in the '0+' regime. Up to three marks may be available for spotting a pattern or trying an idea which, if progressed further, could lead to a solution. Examples of this in the present paper would be: in Question 2, applying the result from part (a) to identify isosceles triangles AMB and BMC or, in Question 4, identifying that Player B has a winning strategy involving multiples of 7. Notice that these all involve a substantial engagement with the problem, rather than just looking at some examples or special cases. Teachers should therefore reiterate to students that scoring even one or two marks on any of these questions is a real achievement.

The Mathematical Olympiad for Girls is slightly different from other Maths Olympiads in that questions are broken down into several parts. Most of the time, the final part is the "main question" and the first part (or parts) are intended to suggest some useful results or good approaches to the problem. The reason for structuring the paper in this way is that the setters know that many of the candidates are not experienced in olympiad mathematics, and the hope is that by giving these pointers, we enable them to engage with the questions even if they are not familiar with standard olympiad techniques or "tricks". A useful hint is to read the whole question first and try to understand how the early parts may be helpful in solving the main problem.

The present paper also contains some answer-only questions, which nevertheless require a similar way of thinking to the usual olympiad questions. These questions are designed so that partial marks can be awarded to incorrect answers which show good progress towards the correct solution.

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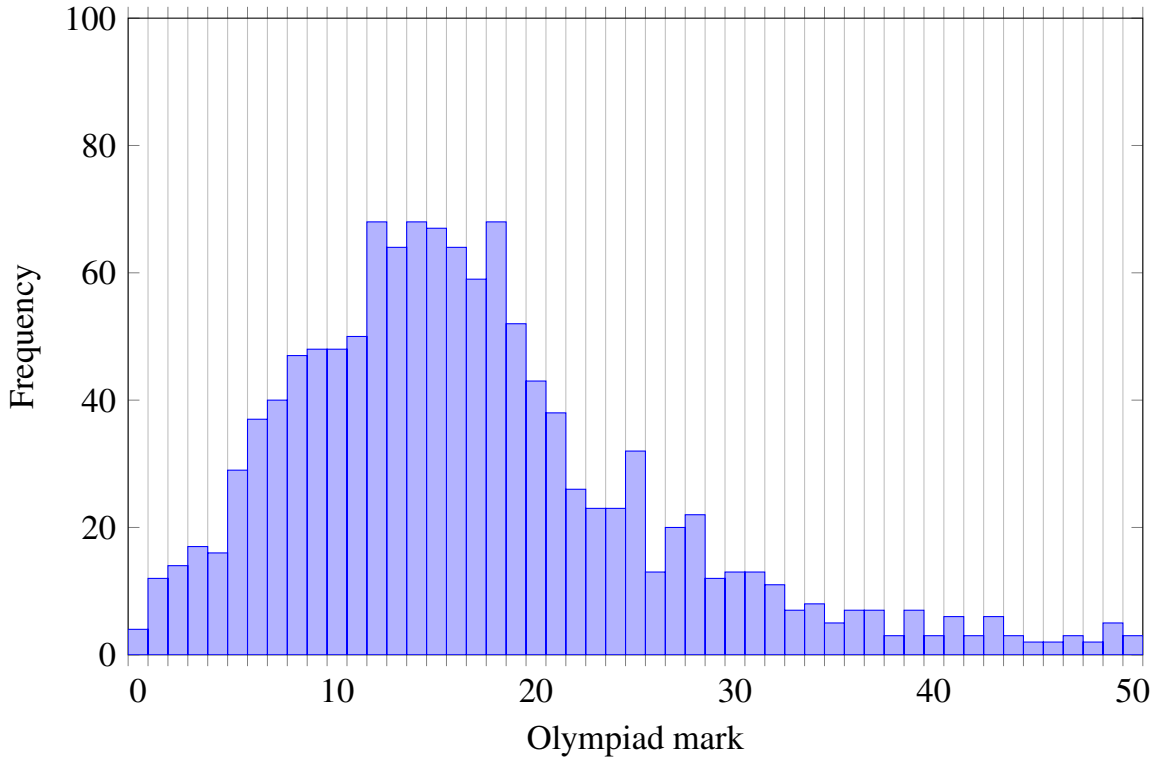
Mark distribution

The MOG 2026 paper was marked by a team of Hugh Ainsley, Connie Bambridge-Sutton, Ruth Barber, Rebecca Bazlov, Robin Bhattacharyya, Malcolm Blake, Raka Chattophadyay, Donald Chui, James Cranch, Laura Daniels, Carl Dolby, Chris Eagle, Ben Fairfax, Chris Garton, Anthony Goncharov, Amit Goyal, Aleksander Goodier, Aditya Gupta, Jon Hart, William Harwood, Ahmed Ittihad Hasib, Alexander Hurst, Michael Illing, Vesan Kadelburg, Adem Kesaev, Audrey Kueh, Larry Lau, Rhys Lewis, Sida Li, Thomas Lowe, Luke Lorimer, Michael Lucas, Arya Mosahab, Oliver Murray, Joseph Myers, Calvin Newn, Satish Raghavan, Heerpal Sahota, Amit Shah, Harcharan Sidhu, Geoff Smith, Stephen Tate, Aurelia Walker, Tommy Walker Mackay, Emma Wheeler, Gilly Wilson, Lingde Yang and Yifu Zhang.

We received responses from 1243 candidates. The mean mark was 16.8 and the median was 15.



The award thresholds were: 13 for Merit, 21 for Distinction and 36 for a Medal (36 for Bronze, 41 for Silver and 48 for Gold).