OMTC Syllabus and Format

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At a Glance

The *Oxford Mathematics Team Challenge* is a competition between teams composed of four students, which consists of four rounds. There is an *individual round* where each participant scores points for their team. All other rounds are team rounds: the *guts round* and the *maps round* provide a place for paced problem-solving; *lock-in round* offer longer-style questions which develop particular ideas.

The syllabus consists of most of the pure AS Level Mathematics, with the omission of all calculus, and with the addition of various topics from the GCSE and A-Level Mathematics curricula, among others. The few topics outside of the aforementioned syllabi above have been highlighted in blue, and some topics have been explicitly omitted in red.

The following document details the specifics of the syllabus and format of the rounds. For more information and practice problems, please visit

https://www.invariants.org.uk/team-challenge/prepare/

Syllabus

The OMTC will assume *comfort* with the following topics:

Polynomials.

- Solving linear equations in up to two variables.
- Quadratics: completing the square, the discriminant. *Omitted: complex numbers.*
- Polynomial factorisations; use of the Factor Theorem and Remainder Theorem.
- The Binomial Theorem for positive whole exponents, combinations and binomial probabilities – note: we write ${}^nC_r$ for 'n choose r'. The factorial function.
- Polynomial facts: an nth degree polynomial has at most n distinct roots.

Algebra.

- Value and quantity. Distance as the product of constant speed and time. GBP.
- Mean, median and mode.
- Logarithms, exponentiation: their laws, solutions of x in $a^x = b$. Note: we use $\log x = \log_{10} x$.
- Rationalising surds. Decimal expansions, including recurring decimal expansions.
- Sequences and series: arithmetic, geometric, periodic, iterative formulae. Convergence of infinite geometric series.
- Inequalities: sums of squares are non-negative. Bounds (e.g., of sine, cosine).
- Graphical interpretations of formulae and equations; determining equations and inequalities via graphs.
- Graph transformations: in particular, $f(x) \mapsto f(ax), af(x), f(x-a)f(x)+a$ for any number a.
- Functions, including piece-wise, exponential and reciprocal. Curve sketches. Recursively-defined functions.
- *Omitted: Cauchy-Schwarz Inequality, HM-AM-GM-QM inequality.*

Geometry.

- Pythagoras' Theorem.
- 2D geometry: Similarity and congreunce of shapes. Internal angles, angles of polygons. Parallelograms.
- Circumference and area of circles; length of chords and arcs, area of circles, sectors and segments.
- 3D geometry: prisms, tetrahedra, cones, spheres; their surface areas and volumes. Vectors. *Omitted: a more thorough use of vectors – e.g., the dot product.*
- Coordinate geometry: equations of lines and circles in the plane; constructions and loci.
- Circle Theorems: Central Angle Theorem, Same Segment Theorem, Thales' Theorem, cyclic quadrilaterals, Alternate Segment Theorem, chords and tangents.

- Trigonometry: $\tan x = \sin x / \cos x$; $\sin^2 x + \cos^2 x = 1$; $\sin(90° - x) = \cos x$; Periodicity of sine, cosine and tangent; (full) sine and cosine rules.
- Rotations, reflections, enlargements and translations. Tessellation.
- *Omitted: circumcentre, orthocentre, incentre, centroid; Heron's formula. Radians.*

Miscellaneous.

- **Combinatorics:** Choices and permutations. Use of the Binomial Theorem in combinatorics. Probabilities.
- **Number theory:** Linear Diophantine equations, primes, basic rules for divisibility. The Fundamental Theorem of Arithmetic; finding the number of factors of positive integers. Lowest common multiples, highest common factors. *Omitted: a more thorough usage of modular arithmetic. Fermat's Little Theorem.*
- **Sets:** Use of the terms natural numbers, integers, rational numbers and real numbers. The fact that $\mathbb{N} \subset \mathbb{Z} \subset \mathbb{Q} \subset \mathbb{R}$. Unions, intersections, complements. Intervals.
- **Logic:** Implications, statements and their converses; *if and only if* statements. Proofs by deduction, exhaustion and contradiction, and disproof by counterexample.

N.B. This is not a comprehensive list of what may come up in the OMTC – rather, this is a list of what we will expect you to be familiar with!

Format

The OMTC consists of four rounds, which are below in order of occurrence. Calculators, measuring instruments and squared paper are strictly forbidden.

Individual Round

The *individual round* is a multiple choice round consisting of twenty questions, each with five options. All competitors from each team partake in the individual round – there is no provision to balance for teams with less than four people. The round is done (as the name suggests) individually, so there is no team communication.

Competitors start with 10 points. Each correctly-answered question earns 2 points, whilst each incorrectly-answered question deducts half a point *(so don't guess!)*. Thus, each competitor can earn up to fifty points for their team. The team's total score is the sum of their points.

This round lasts **60 minutes**, and is out of **200 points** per team.

Lock-in

Lock-in is the first team round, consisting of four questions, which dip into unfamiliar territory. Each question focusses on a specific concept: part of this round's difficulty comes from comprehending a new concept and, further, working with it.

The questions are split up into multiple parts which require teams to produce mathematical reasoning, mathematical explanation, or mathematical working. The questions are worth 30 points each; how the points are split amongst the parts vary per question.

This round lasts **45 minutes**, and is out of **120 points** per team.

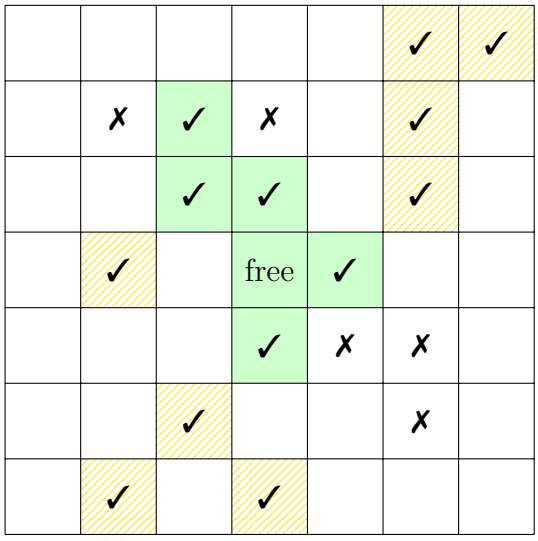
Maps

Maps is a new format in which teams solve problems in a 7×7 grid. Each cell, except for the centermost cell, contains a problem, with cells further away from the centre being generally more difficult and worth more points.

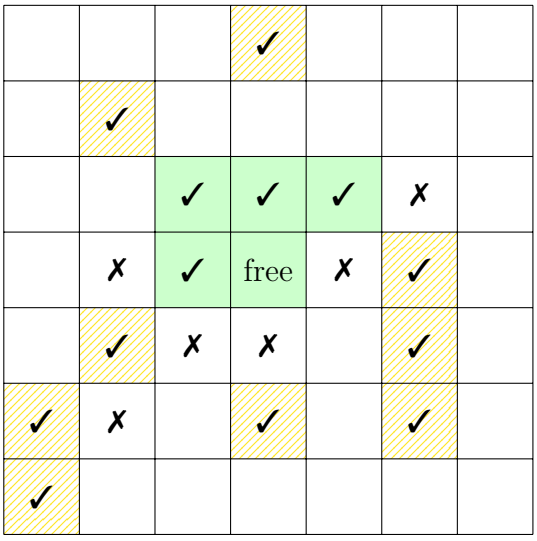
Teams submit integer answers to all questions: they are awarded full points for any correctly-answered questions which are connected to the centre by a series of horizontal and vertical paths of correct answers. Any correctly-answered questions which *aren't* connected are awarded *half* of its full points.

For example, look at the following 7×7 grids. In the examples, teams correctly answered cells with checkmarks (✓), incorrectly answered cells with crosses (✗), and didn't answer anything else. The cells shaded in green scored full points for the teams, whereas the yellow scored half.

diagonal paths don't count;



paths must use (✓) cells.



Moreover, the points distribution is as follows (the free square scores no points). The corners – coloured red, yellow, green and blue – are of a particular mathematical theme, and these questions can sometimes build upon each other.

10	7	4	3	4	7	10
7	4	3	2	3	4	7
4	3	2	1	2	3	4
3	2	1	free	1	2	3
4	3	2	1	2	3	4
7	4	3	2	3	4	7
10	7	4	3	4	7	10

This round lasts **60 minutes**, and is out of **200 points** per team.

Guts

Guts is the last round of the competition, which requires competitors to be economical with their time. It consists of 27 numerical-style questions, grouped in triplets. The triplets progressively increase in difficulty, and their point value increases accordingly. The breakdown of points is as follows:

Round	1	2	3	4	5	6	7	8	9
Score per question	3	4	5	5	6	6	7	8	16

Each team sends one of their members to a problem station to pick up copies of the first set of problems. Teams can only begin the next problem set after having submitted their current one, and are **not** able to resubmit solutions.

The last triplet is an *estimathon* in which contestants offer an estimate to the actual answer – teams whose answer is closer to the actual value score higher. The exact formula is that your score is $16 \times \frac{\min\{A,E\}}{\min\{A,E\}}$ rounded to the nearest integer, where A is the actual solution and E is the team's estimated guess.

Lastly, the scores on this round are displayed live at the front. No pressure!

This round lasts **80 minutes**, and is out of **180 points** per team.