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, and all other rounds are team rounds which vary in style. All other rounds are team rounds: the *guts round* provides a place for paced problem-solving; lastly, the *maps round* and *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 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, but it is recommended to look at practice problems via

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

where we have collated problems from other olympiads which will simulate the OMTC fairly well.

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. 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.
- Logarithms, exponentiation: their laws, solutions of x in $a^x = b$.
- Rationalising surds.
- 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: $\tan x = \sin x / \cos x$; $\sin^2 x + \cos^2 x = 1$; $\sin(90^\circ - x) = \cos x$; 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.*

Miscellaneous.

- **Combinatorics:** Choices and permutations. Use of the Binomial Theorem in combinatorics. Probabilities.
- **Number theory:** Diophantine equations, primes, basic rules for divisibility. The Fundamental Theorem of Arithmetic. *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.
- The Gregorian Calendar.

Format

The OMTC consists of four rounds. Calculators are strictly not allowed. **Geometric instruments?**

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. Competitors have 60 minutes to answer as many questions as they can.

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!)*.

This round is out of **200** marks per team.

Guts

Guts is a fast-paced team round which requires competitors to be economical with their time. It consists of 27 short-answer questions, grouped in triplets. The triplets gradually increase in difficulty, but also in the number of points you can get from them.

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 various things – teams whose answer is closer to the actual value score higher!

This round is out of **???** marks per team.

Maps

Maps is a new format in which teams solve problems in a 7×7 grid[1]. 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 may submit answers to questions, and are only rewarded points for any correctly-answered questions which are **connected** to the center by a series of horizontal and vertical paths of correct answers.

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 shaded cells scored points for the teams.

diagonal paths don't count;

					✓	✓
	✗	✓	✗		✓	
		✓	✓		✓	
	✓		free	✓		
			✓	✗	✗	
		✓			✗	
	✓		✓			

paths must use (✓) cells.

			✓			
	✓					
		✓	✓	✓	✗	
	✗	✓	free	✗	✓	
	✓	✗	✗		✓	
✓	✗		✓		✓	
✓						

This round is out of **???** marks per team.

Lock-in

Lock-in is the last round which consists of four long-style 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.

This round is out of **???** marks per team.

[1] Very subject to change, but some reasonably-sized odd × odd grid.