Syllabus For Indian Mathematics Olympiads

Bash.X

October 2024

§1 Disclaimer

This document is not official guidance, but an approximation based upon one person's experience. There is no promise that the Indian Mathematics Olympiads, will follow this syllabus. Manier times there may appear problems which may demand more knowledge. In addition, the content of these exams changes over time as well albeit gradually and in ways such that it is easily predictable. This list is *not* intended to be an exhaustive enumeration; it highlights guidelines for the "most common cases" and is deliberately ambiguous about certain topics.

§2 Introduction

Each topic is classified into one of the following categories.

✔ **Required** Topics in this category are prerequisite knowledge for solutions, and all contestants are expected to know them.

O **Useful for solution** Topics in this category are often useful in solutions and contestants are encouraged to be familiar with this topic. However, when a solution is related to this topic, often there is a different solution using only "required" knowledge, or else the solution would be reasonable even to non-experts. Terms from these topics will typically not appear in problem statements without definition. Therefore, these topics are less important than topics marked as "required".

!! **Advanced topic** Topics in this area may be helpful (or occasionally even necessary) in more difficult problems on the INMO. However, beginners should prioritize learning other topics before these ones. Concepts from this area will typically not appear in problem statements without definition.

§3 General

In general, not much knowledge is demanded of contestants. Problem statements are largely meant to be understandable even to those without much formal training. Topics usually covered in advanced undergraduate studies are often excluded. Rather, the problems are somewhat meant to test ingenuity and intuition rather than mere knowledge, and often demand simple tools to be used in unexpected ways.

All students are expected to be fluent with mathematical proofs especially for INMO.

§4 Topics For IOQM

§4.1 Basics OF Mathematics

Category	Topic
✔	Mathematical Aptitude and Maturity (familarity with methods of solving puzzles like one in p20 of IOQM 2024)
✔	Number Systems
✔	Elementary manipulation (e.g. factoring or expanding) of algebraic equations, expressions, identitie and inequalities
✔	Ratio & Propartion
✔	Polynomials in one variable and basic properties like Vieta's relations or the fundamental theorem of algebra
✔	Sets & Relations
✔	Linear And Quadratic Equations
✔	Progresions & Series
✔	Basics Of Inequalities
✔	Functions (Log, Modulus, GIF, FPF etc.)
✔	Basic Counting
✔	Binomial Theorem (Basic)
✔	Basic Geometry (Results on Triangles, Quadrilaterals and Circles)
✔	Coordinate Geometry (Basic Concepts)
✔	Diophantine Equations(basic)
✔	Trigonometry(basic - class 10 level)
✔	Practical Mathematics
O	Complex Numbers
O	Probability & Statistics
O	Surface Area & Volume
!!	Vectors & Three-Dimensional Geometry
!!	Matrices, determinants, and other concepts from linear algebra
!!	Calculus in one variable

§4.2 Algebra

Category	Topic
✔	Polynomials
✔	Inequalities
✔	Mathematical Induction
✔	Recurrence Relation
✔	Functional Equations
!!	Linear Algebra(Basic)

§4.3 Number Theory

Category	Topic
✔	Divisiblity
✔	Euclid's Division Lemma
✔	Primes & Composite
✔	Fundamental Theorem Of Arithmetic
✔	GCD & LCM
✔	Base Systems
✔	Basic Results like Four Number Lemma
✔	Modular Arithmetic
✔	Remainders & Residue System
✔	Important Theorems like Euler's Thm, Fermat's Little Thm, Wilson Thm, carmicheal Thm etc.
✔	Arithmetic Functions and their properties ($d(n)$, $\sigma(n)$, $\phi(n)$)
✔	Diophantine Equations
!!	Results like Wolstenholme's Thm and Luca's Thm

§4.4 Combinatorics

Category	Topic
✔	Permutations And Combinations
✔	Distribution Of Objects and Beggar's Theorem
✔	Diophantine Equations of mixed concepts (like ones of the form xy = integer)
✔	Binomial and Multinomial Thm
O	Application Of Recurrence Relations(Very Important)
O	Dirichlet's Or Pigeon Hole Principle
O	Geometric Counting
O	Probability
!!	Generating Functions And its Applications (basic)
!!	Methods of solving grid based questions And bijection Principle and its applications

§4.5 Geometry

Category	Topic
✔	Angle Chasing
✔	Results On Triangles(like Stewart's and Appolonius's Thm and Area Lemma, centre's of triangle, incircles and ex-circles, euler line, nine-point circle)
✔	Results On Quadrilaterals(like methods of finding areas and application of Trigonometry based on properties)
✔	Results On Circles(Power Of Point, Tangent-Secant Thm, Bramhagupta's Thm)
✔	Trigonometry(reults like MN-Cot Thm, sine, cosine, tangent rule, projection, mollweide's rule)
✔	Coordinate Geometry(results on straight lines, circles, ellipse, parabola, hyperbola)
O	Results On Cylclic and Tangential Quadrilaterals(like ptolemy's thm, pitot's thm)
O	Concurrency & Collinearity(results like ceva, melanus, carnot's Thm)
!!	Similitude & Homothecy
!!	Application Of Complex Numbers

§5 Topics For RMO

All of IOQM topics are required.

§5.1 Algebra

Category	Topic
✔	Polynomials & Theory Of Equations
✔	Inequalities
✔	Functional Equations
✔	Sequence & Series(Advanced)
O	Calculus(Basic)
!!	Linear Algebra(Basic)
!!	Abstract Algebra(Basic)

§5.2 Number Theory

Category	Topic
✔	Fundamentals Of Number Theory
✔	Modular Arithmetic(basic topics like Remainders, Residue Classes, Inverses, FLT, Carmicheal Thm, Wilson Thm, Euler Thm)
✔	Arithmetic Functions(like $d(n)$, $\sigma(n)$, $\phi(n)$, Floor Functions and Its Properties Like Hermite's Identity)
✔	Diophantine Equations(Some Advanced Methods like Inequalities, Modular Contradictions, Pythagorean Triplets, Infinite Descent, Veita Jumping, Pell's Equations etc.)
O	Quadratic Residues, Orders, Primitive Roots and Lagrange's Thm etc.
O	Lifting The Exponent, Zsigmondy's Thm and results related to Largest Exponent
!!	Advanced Arithmetic Functions And Their Applications(like Dirichlet Convolution, Mobius Inversion)

§5.3 Combinatorics

Category	Topic
✔	Pegionhole principle & Ramsey Numbers and basic results like Dirichlet thm, Erdos-Szekeres thm
✔	Resuts like sum, product and division rules
✔	Binomial and Multinomial Thm and Bijective Counting
✔	Counting Lattice Paths, integer compositions, Set Partitions and Stirling Numbers (results like Hemachandra Recurrsion)
O	Principle Of Inclusion And Exclusion
O	Generating Functions
O	Recurrence Relations
O	Algorithms, Processes, Existence etc.
!!	Game Theory, Extremal Combinatorics
!!	Graph Theory And Probabilistic Method

§5.4 Geometry

Category	Topic
✔	Assorted Configurations(Simson line, Incircles, Excircles, Isogonal & Isotomic Conjugates, Symmedians, Mixtilinear Incircles etc.)
✔	Similitude And Homothecy
✔	Properties Of Triangle
✔	Properties Of Quadrilaterals
✔	Transversals and Harmonic Divisions
✔	Circles
O	Inversion
O	Concurrency & Collinearity(results like ceva, melanus, carnot's Thm)
!!	Advanced Results on Triangles (like poles and polars, lemione geometry, Apollonian circles, Isogonal Circles, Bocard Geometry, Tucker Circles, Orthopole)

§6 Topics For INMO

§6.1 Algebra

Category	Topic
✔	Polynomials & Theory Of Equations
✔	Inequalities
✔	Functional Equations
✔	Sequence & Series(Advanced)
O	Calculus(Basic)
O	Linear Algebra(Basic)
!!	Abstract Algebra(Basic)

§6.2 Number Theory

Category	Topic
✔	Basics Of Number Theory
✔	Modular Arithmetic(Advanced)
✔	Largest Exponent
✔	Integer Polynomials
O	Quadratic Residues
!!	Construction

§6.3 Combinatorics

Category	Topic
✔	Principle Of Inclusion & Exclusion: Linear Algebra view
✔	Twelvefold Way & Partial Orders
✔	Mobius Inversion And Its Applications
✔	Generating Functions And Its Applications
✔	Composition Of EGF, Euler Pentagonal Number Theorem
✔	Graphs, Graph Colouring
O	Results Like Menger's Thm, Planar Graphs, Euler's Thm
!!	Map Colouring Problems, Discharge Method, Group Actions, Colouring & Symmetry, Poyla's Thm
!!	Hamiltonian Graphs, Line graphs, Edge Colouring

§6.4 Geometry

Category	Topic
✔	Computational Geometry
✔	Complex Numbers
✔	Barycentric Coordinates
✔	Inversion
O	Projective Geometry
!!	Complete Quadrilaterals(like spiral similarity, Miquel's Thm, Gauss-Bodenmiller's Thm)