



## Harvard Undergraduate Science Olympiad India 2024 Open Round Mathematics Syllabus: 7th-8th Grade

### Potential Topics Covered on the Exam:

This syllabus contains topics which will be covered both in the open and the in person round. Please note that not necessarily every topic on this list will be on the exam, don't get overwhelmed! The syllabus is meant to be exhaustive of all *potential* topics that could be on the exam. A great place to start is with making sure you're comfortable with the ICSE curriculum for 7th-8th grade. It will be a difficult exam, but remember you don't need, nor do we expect you, to get a 100%! Just do your best and show us all that you've learned!

### Advanced Topics:

For those looking to further challenge themselves, below in **red** are more advanced topics that may also be tested. Students are encouraged to first learn the topics not in red before tackling these. Good luck and happy studying!

### Algebra:

- Polynomials:
  - Divisibility and Factorization of Polynomials;
  - Vieta's Theorem;
  - **Binomial Theorem;**
  - **Rational Root Theorem;**
- Sequences and Series:
  - Arithmetic, Geometric, and Other Telescoping Series;
- Inequalities:
  - AM-GM Inequalities;
  - **QM-HM Inequalities;**
  - Triangle Inequality;

- Functions:
  - Odd and Even Functions;
  - Concave and Convex Functions;
  - Floor and Ceiling Functions with their properties;

### Number Theory:

- Modular Arithmetic:
  - Prime factorization;
  - Congruences;
  - Fermat's Little Theorem;
- Miscellaneous:
  - Pythagorean Triples;
  - Bases;

### Geometry:

- Triangles:
  - Law of Sines;
  - Law of Cosines;
  - Centers of Triangles:
    - Centroid (medians);
    - Circumcenter (perpendicular bisectors);
    - Orthocenter (altitudes);
    - Incenter (angle bisectors);
  - Area Formulas:
    - Heron's formula;
    - Inradius formula;
    - Circumradius formula;
    - Sine formula;
  - Ratio of side lengths:
    - Similar Triangles;
    - Congruent Triangles;
    - Angle Bisector Theorem;
  - Special Triangles:
    - 3-4-5 (side lengths);
    - 13-14-15 (side lengths);
    - 30-60-90 (angles);
    - 45-45-90 (angles);
- Circles:
  - Tangent Circles;
  - Power of a Point;
  - Cyclic Quadrilaterals;
  - Ptolemy's Theorem;

- Inscribed Angles;
- Miscellaneous:
  - 3D Geometry;
    - Volumes of prisms, pyramids, cones, cylinders, cones, and spheres;
    - Surface Areas of prisms, pyramids, cones, cylinders, cones, and spheres;

### **Combinatorics:**

- Counting Principles:
  - Stars and Bars;
  - Pigeonhole Principle;
  - Invariance Principle;
  - Principle of Inclusion-Exclusion;
- Enumerative Combinatorics:
  - Permutations, Combinations, and Partitions;
  - Pascal's Triangle;
- Strategies:
  - Casework;
  - Constructive Counting;
  - Complementary Counting;
  - Symmetry;

**Preparation for Exam:** The AOPS community website provides examples of textbooks as well as problems with their solutions which can be used to study for mathematics olympiads.

Also, the following books cover good fundamentals. Most of these books can be found online.

- Problem-Solving Strategies by Arthur Engel;
- The Arts of Crafts of Problem Solving by Paul Zeitz.

Note that these books and websites are not required to prepare for the exam, nor are they the only way possible to prepare. We expect the difficulty and style of the questions in this exam to resemble those of the questions in competitions like AMC10, AMC12, AIME, HMMT, etc. Therefore, check out the questions and their solutions from these exams on the AOPS community website: <https://artofproblemsolving.com/community>.