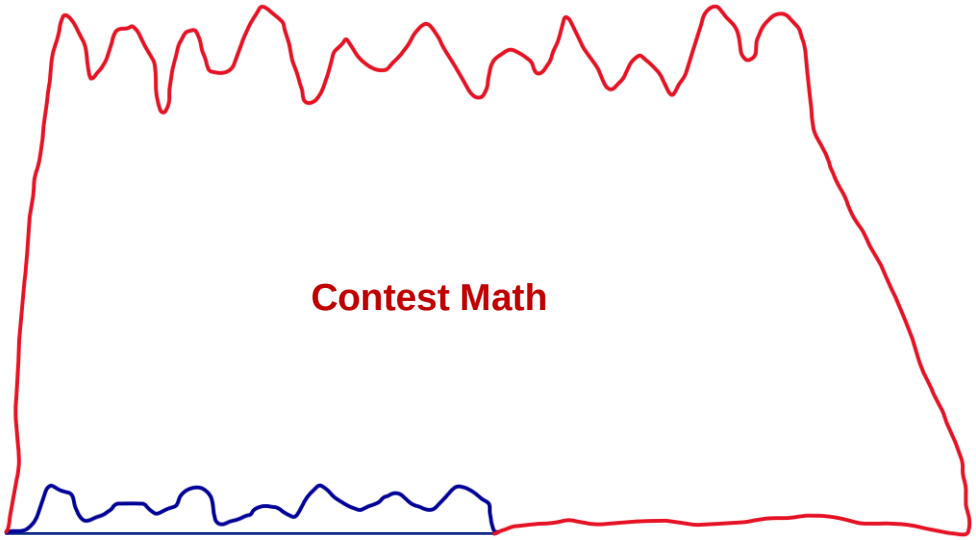
Study Resources

for

Contest Math

School Math vs Contest Math

- I use the term '**School Math**' to describe the body of knowledge covered in school math curriculum before calculus (Pre-Algebra, Algebra 1, Algebra 2, Trigonometry, Geometry, and Pre-Calculus, though some schools will split the topics differently).
- I use the term '**College Math**' to describe the body of knowledge covered in school math curriculum after calculus (Calculus BC, Multivariate Calculus, Linear Algebra, Differential Equations, and so on).
- I use the term '**Contest Math**' to describe the body of knowledge required to compete in math contests through high school (ranging from major middle school contests, such as AMC-8 and MathCounts, to the top high school contests, such as AIME, ARML, and USAMO).
- The School Math is generally trivial. It cuts a narrow path through math body of knowledge and deals almost entirely with very simple topics and problems.



Why Study Contest Math ?

- Contests are the games mathematicians play. They were originally introduced to create an incentive for kids to study math harder. Contests are fun and winning contests is one of the greatest motivators. Anyone who ever made it to MathCounts Nationals will have the memories for the lifetime and will want to continue working hard to stay in the game.

- Participating in high-level contests allows students to find like-minded kids and form a social circle with whom they stay in touch through high school and often beyond. Kids join various forums and servers where they communicate about a variety of interests (not just math). They also occasionally meet at in-person contests.

- Despite the name, Contest Math is not just needed to win math contests. Anyone who plans a career in a math-intense field (such as math, physics, chemistry, economics, computer science, engineering, etc.) needs knowledge and skills far beyond the School Math. This gap is filled by the Contest Math, which is an order of magnitude broader, deeper, and more difficult than the School Math.

- Students who do well in math contests have an advantage when applying to top colleges as it allows to stand out among other talented candidates.

- Solving higher level contest problems requires approaches very similar to those needed in research. Thus, Contest Math prepares students for research. Many top students start doing research while in high school, and most are ready to do it once they arrive to college. This also gives them an advantage later when it comes to going to the graduate school.

School Math is also Important

- While School Math focuses on basic technical skills, those skills are also necessary. Kids must master the mechanics of math and school ensures this. Contest Math doesn't replace School Math!

- Parents of advanced kids need to work with schools to find proper accelerated placement. If your child spends 45 minutes every day at school (plus homework) doing what they already know, they are at a great disadvantage compared with students in a properly accelerated or gifted class. It is a handicap that is very difficult to overcome, and it also kills kids' interest in math.

- If your school does not offer a properly accelerated program, there are outside programs (e.g., RSM), which cover School Math very well. However, this only works if you can take your child out of your school's math classes (because of the point above) or are homeschooling.

Path through School Math

- Beware of over-acceleration. While young brilliant students can often easily learn new material, it is very dangerous to go too far too fast for several reasons:
  - Early School Math is very easy, but later topics (such as Geometry) are more difficult. College Math is even more difficult. Students who get ahead early often “hit a wall” later. Unless they are homeschooled, there is no re-course and so students struggle.
  - Even the most advanced high school contests are not calculus-based.
  - Contest Math has so much breadth and depth that even the brightest students have hard time learning it all by the time they finish high school. It is better to invest time acquiring more breadth and depth of math knowledge, than run ahead cutting a narrow swath of knowledge.
- The table below shows typical paths through School Math among various groups of talented students. Most students will do well with the path on the left. The other two paths are for those who have the talent and want to succeed in serious math contests and are willing to invest a great deal of time and effort.

Grade	**Talented Students** (sufficient for college plans and career paths)	**Very Talented Students** (required for success in meaningful contests)	**Exceptional Students** (required to compete at the national level)
8th	Geometry	Algebra 2	Pre-Calculus
7th	Algebra 1	Geometry	Algebra 2
6th	Pre-Algebra	Algebra 1	Geometry
5th		Pre-Algebra	Algebra 1

Why Additional Resources ?

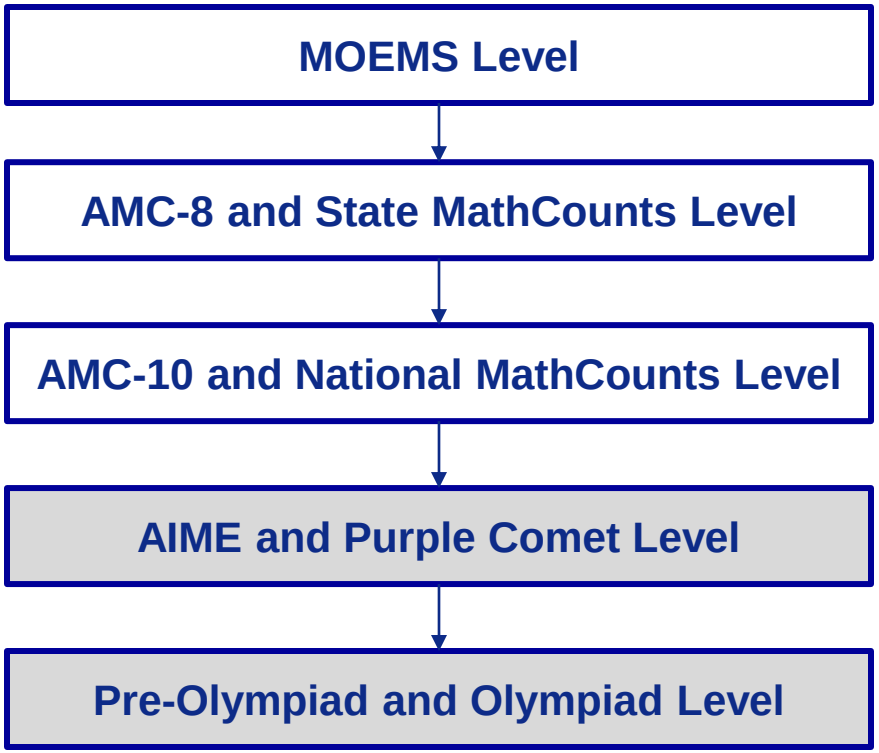
- *Adventures with Mr. Math* 'To Infinity and Beyond' program lays a critical foundation block in Contest Math. However, even with the extra credit work, our program is not sufficient to master Contest Math.
- This document presents a path through Contest Math beyond the foundation laid by our program. The resources presented here will prepare a student for the MathCounts, AMC-8, and AMC-10 contests (the top contests for the best middle school students).
- The advanced resources presented in this document start with Pre-Algebra and so a student must be ready for it to pursue this path. Typically, students are ready between 3rd and 5th grade, though some exceptional students may start earlier.
- Don't try to synchronize School Math and Contest Math curricula. They serve different purposes. You can learn geometry topics in the Contest Math first and then take the Geometry class at school, or you can take the school class before you study contest geometry.

Who and How Much Time ?

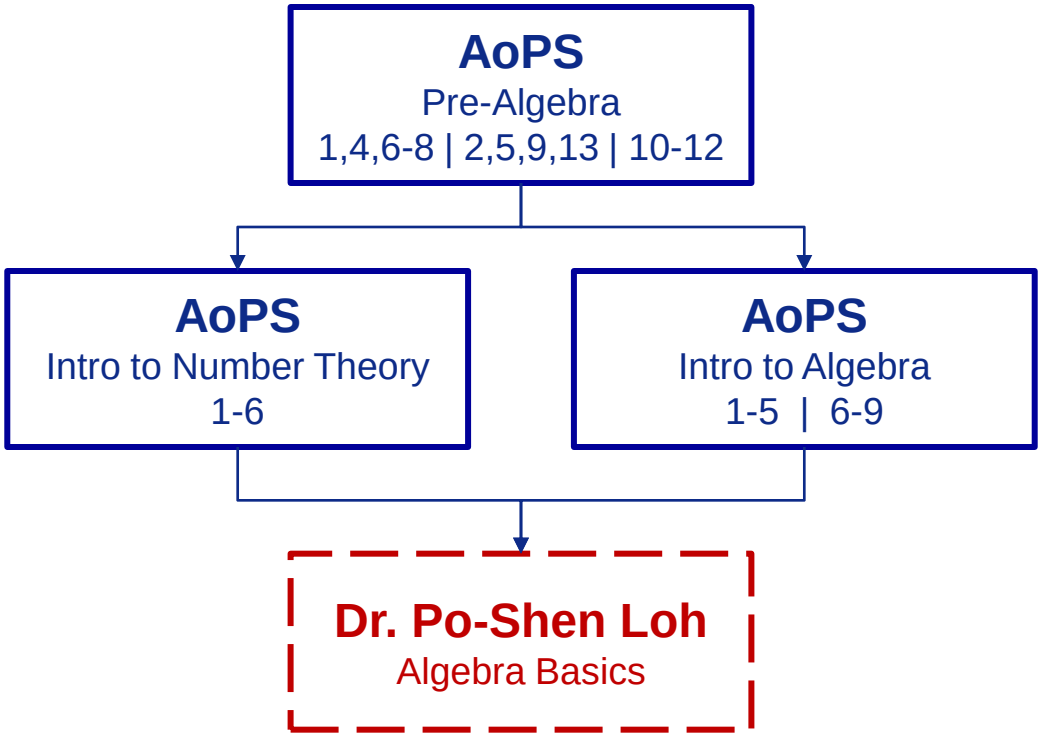
- **Who Can Do It**?
  - ✓ Anyone ready to learn Pre-Algebra and beyond.
  - ✓ Typically, ready to start between 3rd and 5th grade (depending on the student).
- **Who Should Do It?**
  - ✓ Any student who enjoys math and wants to spend time beyond 1-3 hours per week offered by the Mr. Math program.
  - ✓ Any student who wants to improve their results in math contests at a faster pace.
- **Who Must Do It?**
  - ✓ Any student who wants to achieve success in meaningful middle school math contests (such as AMC-8 and MathCounts) and beyond (AMC-10, AIME, etc) must start on this path as early as possible.
- **How Much Time to Invest?**
  - ✓ Depends on individual objectives.
  - ✓ Top students in State and Nationally invest significant amount of time year-round and even more in the summer.

Contest Math Path

- We break Contest Math into five levels shown below. This document covers the first three levels. For resources at the last two levels, contact Mr. Math.
- Students should complete a lower level before proceeding to a higher level. Students are expected to show mastery (Gold Pin for MOEMS, DHR for AMC 8) before moving on to the next level.
- The next three slides show the resources for each level. The slides at the end provide details about various resources and their availability.



MOEMS Level



Practice

MathCounts
Warm-Ups & Workouts
Problem Level 1-4

MOEMS
Divisions E & J

MathCounts
Past Contests
School and Chapter

AMC-8 and State MathCounts Level

AoPS
Intro to Counting & Prob
1-5 | 7-9,12

AoPS
Intro to Algebra
10-14 | 15-18 | 19-22

AoPS
Intro to Geometry
1-6 | 7-10 | 11-13

AoPS
Intro to Number Theory
7-11

Dr. Po-Shen Loh
Combinatorics Tools

Dr. Po-Shen Loh
Algebra Tools

Dr. Po-Shen Loh
Geometry Tools

Dr. Po-Shen Loh
Number Theory Tools

Practice

MathCounts
Warm-Ups & Workouts
Problem Level 4+

MathCounts
Past Contests
Chapter and State

AMC-8
Past Contests

MyMathCounts
AMC-8 Prep Books
Volumes 1-5

AMC-10 and National MathCounts Level

AoPS
Intro to Counting & Prob
6,10,11,13,14

AoPS
Intermediate Algebra
1-3 | 4,5 | 6-9 | 10,11

AoPS
Intro to Geometry
14-19

AoPS
Intro to Number Theory
12-15

Practice

AMC-10
Past Contests

MyMathCounts
AMC-10 Prep Books
Volumes 1-5

MathCounts
Past Contests
National

Lexington MT
Past Contests

Study Materials

- All Study Materials for the first three levels fall into two categories – *Art of Problem Solving* books or classes and *Dr Po-Shen Loh* classes.
- At the AIME, Pre-Olympiad and Olympiad levels, you would need a lot more resources.

AoPS Books and Classes

- Pre-Algebra
- Intro to Algebra
- Intro to Number Theory
- Intro to Geometry
- Intro to Combinatorics
- Intermediate Algebra

Dr. Po-Shen Loh Programs

- Algebra Basics
- Algebra Tools
- Geometry Tools
- Number Theory Tools
- Combinatorics Tools

AoPS Books

- *Art of Problem Solving* (AoPS) offers the most comprehensive set of materials to learn what students need up through AMC-10 and National MathCounts level.
- Students can work independently using AoPS books or take classes (see the next slide).
- All AoPS books (with solutions) and classes are found at https://artofproblemsolving.com/.
- If using books, work through each chapter systemically. Solve all problems (except a few harder problems at the end of the Challenge Problems section – you can return to those later while moving on to the next level).
- If you get a problem wrong or cannot solve it, try again using the hints. At the end, read solutions.
- I grouped chapters in "units" (separated by '|') so that students can study several books – finish a "unit" from one book and then a "unit" from another book – for more variety.
- Students will likely need regular (weekly) help from a "coach" (could be a parent, if decent at Contest Math) to explain open questions.

AoPS Classes

- Self-paced AoPS classes. These are helpful for students who want a slightly more “fun” learning environment than working from books, though these classes do not add much educational value beyond that offered by the AoPS books.
- Instructor-led AoPS classes. These are good for students who need structured environment with regular class time and homework. However, this is also a “limitation” as students are forced to work at a particular pace on each chapter, which may sometimes be too fast and sometimes too slow for a particular student. Also, teachers/TA’s will help with some open questions. However, this is still basically the same value as the books offer.
- Classes outside AoPS using AoPS books. Some coaches run these classes. Their value depends largely on the coach and the personality of the student.

Dr. Po-Shen Loh Programs

- Dr. Po-Shen Loh's classes are fun, and his explanations are very interesting.
- Students can work independently using self-paced online interactive recordings or take instructor-led classes run by high school students
- Dr. Loh's programs can be found at https://daily.poshenloh.com/.
- While Dr. Loh is exceptional at explaining concepts, the programs do not provide sufficient material for comprehensive education. I recommend using these resource after learning via AoPS books or classes. Ideally, it is done with a bit of a delay, so it can serve as a review after students likely forgot some things.
- Dr. Loh's programs are optional for students who mastered the material (achieved Honor Roll in AMC 8 and have no particular areas of weakness).

Learning vs Practicing

- The resources I recommend in this document are split into Study Materials and Practice Materials. Students should work on those in parallel.
- A typical time split is 2:1 for using Study Materials vs Practice Materials. Since studying involves a lot of problem solving, the real split between studying and practicing is 1:3.
- From time to time (usually before the contests) revert to 100% practicing for at least a few weeks to let the new knowledge settle.
- Make sure your child is not overwhelmed by the new material. The sign of getting overwhelmed is when kids (a) start forgetting what they learned 3-6 months ago and (b) struggle with practice problems and don't have great contest results. Go back and try some problems from the past material from time to time to see that they still remember.

Practice Materials

- Practice materials for each level are organized from left to right in the order of importance.
- Practice materials boxed with dotted lines are optional.
- Keep track of all solved problems. First, this allows to see the progress (note that the progress in Contest Math is not linear).
- Most importantly, keep track of all problems solved incorrectly or not solved at all (ignore silly mistakes). After a year or so, students should return to those and try them again.
- Make sure your child is not overwhelmed by the new material. The sign of getting overwhelmed is when kids (a) start forgetting what they learned 3-6 months ago and (b) struggle with practice problems and don’t have great contest results.

Practice Material Details

- MyMathCounts contest preparation books (http://mymathcounts.com/new/) have key formulas at the beginning of each chapter, examples in the middle (which can be skipped), and problem sets at the end. While I usually do not recommend them at the AMC 8 level, they are very good for review at the AMC 10 level. The books are available for purchase as PDF's, which are much easier to print/copy. While the material (in particular, AMC 10 preparation books) is good, there are many mistakes and typos.
- MathCounts Warm-Ups and Workouts (https://mathcountsstore.com/) offer collections of problems with varying difficulty that are great for practicing. They are available for many years. Note that Warm-Up and Workout books (which are cheaper) do not include solutions – to get them with solutions you should buy School Handbooks. The problems are assigned a difficulty level (in the answer section) and I point out recommended level of problems to practice.
- Past MathCounts and AMC tests can be downloaded from http://mathteamnyc.weebly.com/. Many solutions are also available there.
- You can also find solutions for AMC tests on AoPS website at https://artofproblemsolving.com/wiki/index.php/AMC_Problems_and_Solutions.
- MOEMS books are available at http://store.moems.org/mm5/merchant.mvc?Screen=PLST.
- Past Lexington Math Contests can be found at https://www.lhsmath.org/LMT/Problems_and_Solutions.

Do I Need a Coach ?

- Most students who aspire and are capable of competing at the State or National level in meaningful contests (such as MathCounts, AMC-10, AIME, and beyond) have a coach.
- Aside from these top students, coaches are optional.
- Coach's job is not teaching the material. That is done via resources I provided. A good coach focuses on these things:
  - Identifying student's weaknesses and help correct them or work around them.
  - Teach approaches to solving difficult problems (not techniques).
  - Help students understand difficult concepts which they may not understand from the study resources.

Advanced Mr. Math Programs

- Deep Divers
  - For hard working students who have studied the material of AoPS books (or similar)
  - Main objective: to identify “holes” in students’ knowledge and understanding
  - Teaches students how to use what they have learned to solve difficult problems
  - Meets weekly, work in pairs led by a teacher/TA

- Rising Stars
  - Mentoring program for exceptional students who have shown dedication and great success in math contests
  - Mentors are among the best high schoolers in the country
  - Teaches students how to find paths to solve hard problems
  - Exposes talented young students to the techniques of their successful predecessors
  - Meets weekly with two mentees for each mentor

- Mr. Math Coaching
  - Limited to a few exceptional students
  - Usually takes new students when they have just made AIME or are getting close to