

Mathematics Guidelines for Physics Events

In addition to the various science and engineering topics that are identified in the rules, Science Olympiad participants will also need to have knowledge and skills in mathematics to successfully participate in many events. The following guidelines have been prepared to help Event Supervisors who may not regularly work with middle school (Division B) and high school (Division C) students target their expectations with regard to mathematical ability students may bring to events. This information may be useful for teams as they assign team members to Physics Events as well as prepare for those events. Team members in need of additional mathematics help may want to consider using online resources such as Khan Academy in their preparation.

Event Supervisors should keep in mind that most students in the United States do not take Algebra in 8th grade. According to the US Department of Education only 24% of middle school students will take this class and less than two-thirds of middle schools (59%) even offer this course¹. This does not mean that Algebra concepts, topics, and skills should not be part of Science Olympiad events, even in middle school (Division B). Science Olympiad participants are often an atypical student population with their interest in STEM pushing them into advanced mathematics earlier than most. What this does mean is that Event Supervisors should check with their Tournament Directors to get a sense of the students and schools that will be competing at a given tournament and *whenever any test question can be written to require less mathematics it should be*.

Guidelines for Division B Mathematics

The mathematics knowledge of Division B participants is generally limited to what students learn in middle or junior high school. Therefore, Event Supervisors should create tests that assume students know no more than the following, which comprises a typical Algebra I curriculum together with basic geometry and a few other concepts. These limitations are particularly relevant for physics tests because that subject is especially mathematical.

Expressions:

- Evaluation of general algebraic expressions
- Interpretation of parentheses
- Order of operations

Equations: Simplifying and solving equations

Inequalities: Solving inequalities, absolute value expressions

Linear equations and functions in one and two variables:

- Definition of a function, both as a formula and as a graph
- Plot one- and two-variable equations on the coordinate plane
- Graph regions of numbers that are covered by linear inequalities
- Calculate where an equation intercepts the x- and y- axes on a coordinate plane
- Calculate the domain and range of an equation
- Derive the equation of a line, given its slope and y-intercept (slope-intercept form), as well as its slope and another point on the line (point-slope form)
- Solve and graph systems of multiple equations

Polynomials and quadratic functions:

- Quadratic formula basics, such as solving, graphing and analysis
- Methods for factoring quadratic equations and “completing the square”

¹ U.S Department of Education, *A Leak in the STEM Pipeline: Taking Algebra Early*, November 2018, <https://www2.ed.gov/datastory/stem/algebra/index.html>

Basic geometry:

- Points, lines, line segments, rays, and planes
- Angles and angular measure
- Parallel and perpendicular lines and planes, coordinates
- Polygons: Kinds, area, perimeter, and circumference
- Triangles: Kinds, sum of angles theorem, Pythagorean theorem
- Similarity and congruence
- Circles and arcs
- Common geometric solids, area and volume

Other Topics

- Scientific notation and significant figures
- Step and piecewise functions
- Definitions of trigonometric functions with emphasis on using a calculator to convert between dimensions of a right triangle and angles. Trigonometric identities and related topics are specifically excluded.

Guidelines for Division C Mathematics

The mathematics knowledge of Division C participants is generally limited to what students learn in high school. Therefore, test writers should create tests that assume students know no more than the following, which comprises a typical Algebra I, Algebra II, Geometry, and Trigonometry curriculum. These limitations are particularly relevant for physics tests because that subject is especially mathematical.

Algebra I: See topics listed in “Guidelines for Division B Mathematics” above

Algebra II:

- Systems of equations and inequalities
- Matrices
- Polynomials and polynomial functions
- Quadratic functions and inequalities
- Conic sections
- Rational expressions and equations
- Exponential and logarithmic functions
- Sequences and series

Geometry:

- Basic geometry topics listed in “Guidelines for Division B Mathematics” above
- Analytic geometry and computations with coordinates
- Geometric reasoning

Trigonometry:

- Trigonometric functions defined in terms of right triangles and circles
- Inverse Trigonometric Functions
- Graphs of trigonometric and inverse trigonometric functions
- Trigonometric identities: To keep tests focused on appropriate subject matter, test writers should avoid all but the most basic manipulations using trigonometric identities. However, to properly learn trigonometry, students should learn to use these identities, including Sum and Difference of Angles, Double-Angle, Half-Angle, Laws of cosines and sines, etc.
- Vectors, dot product, polar coordinates
- Parametric equations