Geometry

Performance Level Descriptors

Introduction

The federal government requires states to adopt and assess standards and report assessment results using three or more levels. Federal guidance specifies that state's academic performance levels must include descriptions of the content-based competencies associated with each level. The descriptions, referred to as **Performance Level Descriptors (PLDs**), convey the degree of student achievement at each level. The Maryland Comprehensive Assessment Program (MCAP) Policy, Content, and Range PLDs are included in this document.

MCAP Policy Performance Level Descriptors

The MCAP Policy PLDS provide high-level descriptions of a student's ability to apply the knowledge and skills defined by the Maryland Content Standards for English Language Arts (ELA), Mathematics, Science, and Social Studies as demonstrated by their performance on MCAP assessments. Maryland elected to use the four performance levels, described below, when reporting assessment results.

Performance Level	MCAP Policy Performance Level Descriptors
4	**Distinguished Learners** demonstrate advanced proficiency. The students are well prepared for the next grade level or course and are well prepared for college and career readiness.
3	**Proficient Learners** demonstrate proficiency. The students are prepared for the next grade level or course and are on track for college and career readiness.
2	**Developing Learners** demonstrate partial proficiency. The students need additional academic support to ensure success in the next grade level or course and to be on track for college and career readiness.
1	**Beginning Learners** do not yet demonstrate proficiency. The students need substantial academic support to be prepared for the next grade level or course and to be on track for college and career readiness.

MCAP Mathematics Content Performance Level Descriptors

The results from each MCAP Mathematics assessment are reported using four performance levels. Mathematics Content PLDs for Geometry provide broad descriptions of what a student performing at each level means in terms of the mathematics content for the course.

Geometry

Performance Level	MCAP Mathematics Content Performance Level Descriptors for Geometry
4	**Distinguished Learners** demonstrate advanced proficiency in solving complex problems involving congruence, similarity, triangles, trigonometry, circles, geometric measurement, and geometric modeling, and demonstrates an ability to connect multiple grade-level concepts to conceptualize and apply mathematics to model, reason through, and solve problems efficiently, and relate mathematics to the real world.
3	**Proficient Learners** demonstrate proficiency in solving problems involving congruence, similarity, triangles, trigonometry, circles, geometric measurement, and geometric modeling, and demonstrates an ability to conceptualize and apply mathematics to model, reason through, and solve problems efficiently, and relate mathematics to the real world.
2	**Developing Learners** demonstrate partial proficiency in solving problems involving congruence, similarity, triangles, trigonometry, circles, geometric measurement, and geometric modeling, and may need some support in conceptualizing and applying mathematics to model, reason through, and solve problems efficiently, and in relating mathematics to the real world.
1	**Beginning Learners** do not yet demonstrate proficiency in solving problems involving congruence, similarity, triangles, trigonometry, circles, geometric measurement, and geometric modeling where the required mathematics is either directly indicated or uses common grade level procedures, and typically needs support in conceptualizing and applying mathematics to model, reason through, and solve problems efficiently, and in relating mathematics to the real world.

MCAP Mathematics Range Performance Level Descriptors

Range PLDs are grade/course specific descriptors of the cognitive and content level rigor expected at each performance level. The individual grade-level/course PLD documents provide robust descriptions associated with specific content. To show proficiency of the Maryland College and Career Readiness Standards, students must demonstrate their knowledge and skills as described by the Level 3 and Level 4 PLDs.

G.CO Congruence

G.CO.A Experiment with transformations in the plane

G.CO.A.1 Know precise definitions of angle, circle, perpendicular line, parallel line, and line segment, based on the undefined notions of point, line, distance along a line, and distance around a circular arc.

G.CO.A.2 Identify transformations that preserve distance and angle measure to those that do not (e.g., translation versus horizontal stretch).

G.CO.A.3 Given a rectangle, parallelogram, trapezoid, or regular polygon, describe the rotations and reflections that carry it onto itself.

G.CO.A.5 Given a geometric figure and a rotation, reflection, or translation, draw the transformed figure using, e.g., graph paper, tracing paper, or geometry software. Specify a sequence of transformations that will carry a given figure onto another.

Evidence Statement Code	Level 4 – Distinguished *A student performing at this level should be able to:*	Level 3 – Proficient *A student performing at this level should be able to:*	Level 2 – Developing *A student performing at this level should be able to:*	Level 1 – Beginning *A student performing at this level should be able to:*
G.CO.A.1		use precise definitions of geometric terms.	identify a geometric term given a precise definition.	identify the precise definition of a given geometric term.
G.CO.A.2 G.CO.A.3	apply knowledge of rigid transformations to solve problems.	draw or identify a transformed figure given a mapping statement or determine the sequence of rigid transformations needed to carry a figure onto itself or another figure.	draw or identify a transformed figure given a single rigid transformation or determine a single rigid transformation needed to carry a figure onto itself or another figure.	identify a rigid transformation that was applied to a figure to map it onto another figure.
G.CO.A.5	identify when a sequence of transformations preserves congruence.	identify when a single transformation preserves congruence.		

G.CO Congruence

G.CO.B Understand congruence in terms of rigid motions.

G.CO.B.6 Use geometric descriptions of rigid motions to transform figures and to predict the effect of a given rigid motion on a given figure; given two figures, use the definition of congruence in terms of rigid motions to decide if they are congruent.

G.CO.B.7 Use the definition of congruence in terms of rigid motions to show that two triangles are congruent if and only if corresponding pairs of sides and corresponding pairs of angles are congruent.

G.CO.B.8 Explain how the criteria for triangle congruence (ASA, SAS, SSS, AAS and HL) follow from the definition of congruence in terms of rigid motions.

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G.CO.B.6 G.CO.B.7	use the definition of congruence to explain or prove relationships among geometric figures.	describe the effect of a sequence of rigid transformations on a given figure or use the definition of congruence to determine relationships among geometric figures.	describe the effect of a rigid transformation on a given figure.	identify transformations that preserve lengths and angle measures.
G.CO.B.7 G.CO.B.8		describe how the criteria for triangle congruence follows from the definition of congruence in terms of rigid motion.	identify the corresponding parts of congruent triangles under a transformation.	identify the criteria for triangle congruence that proves two given triangles are congruent.

G.CO Congruence

G.CO.C Prove geometric theorems.

G.CO.C.9 Prove and/or apply theorems about lines and angles. Theorems include vertical angles are congruent; when a transversal crosses parallel lines, alternate interior angles are congruent and corresponding angles are congruent; points on a perpendicular bisector of a line segment are exactly those equidistant from the segment's endpoints.

G.CO.C.10 Prove and/or apply theorems about triangles. Theorems include measures of interior angles of a triangle sum to 180°; base angles of isosceles triangles are congruent; the segment joining midpoints of two sides of a triangle is parallel to the third side and half the length; the medians of a triangle meet at a point.

G.CO.C.11 Prove and/or apply theorems about parallelograms. Theorems include opposite sides are congruent, opposite angles are congruent, the diagonals of a parallelogram bisect each other, and conversely, rectangles are parallelograms with congruent diagonals.

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G.CO.C.9 G.CO.C.10 G.CO.C.11	prove and/or apply line, angle, triangle and parallelogram theorems.	prove line, angle, triangle and parallelogram theorems with supports or apply these theorems to solve a problem.	identify a missing statement or reason to complete a proof involving lines, angles, triangles or parallelograms.	solve a one-step problem involving theorems about lines, angles, triangles, or parallelograms with all pertinent information explicitly given.

G.CO Congruence

G.CO.D Make geometric constructions.

G.CO.D.12 Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.). Copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.

G.CO.D.13 Construct an equilateral triangle, a square, and a regular hexagon inscribed in a circle.

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G.CO.D.12 G.CO.D.13	represent or produce a geometric construction to solve a problem.	Produce or complete a geometric construction that requires three or more steps or describe a geometric construction given a set of steps or a marked up image.	Complete a geometric construction that requires one or two steps or identify a geometric construction given a set of steps or a marked up image.	identify the correct tools needed for a geometric construction.
G.CO.D.12	justify the steps or results of a geometric construction.			

G.SRT Similarity, Right Triangles and Trigonometry

G.SRT.A Understand similarity in terms of similarity transformations.

G.SRT.A.1 Verify experimentally the properties of dilations given by a center and a scale factor:

a. A dilation takes a line not passing through the center of the dilation to a parallel line and leaves a line passing through the center unchanged.

b. The dilation of a line segment is longer or shorter in the ratio given by the scale factor.

G.SRT.A.2 Given two figures, determine if they are similar and provide support for the determination.

G.SRT.A.3 Use the properties of similarity transformations to establish the AA criterion for two triangles to be similar.

G.SRT.A Prove theorems involving similarity

G.SRT.B.4 Prove and/or apply theorems about triangles. Theorems include: a line parallel to one side of a triangle divides the other two proportionally, and conversely; the Pythagorean Theorem proved using triangle similarity

G.SRT.B.5 Use given information to determine if two triangles are similar or congruent and then find either a missing side or a missing angle.

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G.SRT.A.1 G.SRT.A.1a G.SRT.A.1b	apply properties of dilations to justify conclusions.	apply properties of dilations to solve problems.	describe the effect of a dilation on a given figure and/or calculate relevant measures.	recognize that dilation does not preserve congruence.
G.SRT.A.2 G.SRT.A.3 G.SRT.B.4 G.SRT.B.5	use congruence and similarity criteria for triangles to prove statements or generalize about triangles.	use congruence and similarity criteria for triangles to solve problems or prove statements with supports.	identify the corresponding parts of similar triangles or determine the missing measure of a side or angle of given similar triangles.	identify if two triangles are similar or congruent based only on appearances.

G.SRT Similarity, Right Triangles and Trigonometry

G.SRT.C Define trigonometric ratios and solve problems involving right triangles.

G.SRT.C.6 Use trigonometric ratios to find missing sides and angles of right triangles given other sides and angles.
G.SRT.C.7 Use the relationship between the sine and cosine of complementary angles to solve problems.
G.SRT.C.8 Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.

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G.SRT.C.6 G.SRT.C.8	justify right triangle relationships or the relationship between the sine and cosine of complimentary angles to solve problems.	apply right triangle relationships to determine unknown angle measures and side lengths of a right triangle.	apply right triangle relationships to determine unknown angle measures of a right triangle.	apply right triangle relationships to determine unknown side lengths of a right triangle.
G.SRT.C.7		apply the relationship between the sine and cosine of complimentary angles to solve problems.		

G.C Circles

G.C.A Understand and apply theorems about circles.

G.C.A.2 Identify and describe relationships among inscribed angles, radii, and chords. Include the relationship between central, inscribed, and circumscribed angles; inscribed angles on a diameter are right angles; the radius of a circle is perpendicular to the tangent where the radius intersects the circle.

G.C.A.3 Construct the inscribed and circumscribed circles of a triangle and prove properties of angles for a quadrilateral inscribed in a circle.

G.C.B Find arc lengths and areas of sectors of circles.

G.C.B.5 Find arc length and areas of sectors

G.GPE Expressing Geometric Properties

G.GPE.A Translate between the geometric description and the equation for a conic section.

G.GPE.A.1 Given the center-radius form of the equation of a circle, identify the coordinates of the center of the circle and the radius. Items could ask students to use the distance formula to find the radius of a circle.

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G.C.A.2 G.C.A.3 G.C.B.5 G.GPE.A.1	solve problems or prove statements by combining multiple attributes and relationships of circles.	solve problems by applying attributes and relationships of circles.	solve problems by applying attributes and relationships of circles, with all pertinent information explicitly given.	identify attributes and relationships of circles.

G.GPE Expressing Geometric Properties

G.GPE.B Use coordinates to prove simple geometric theorems algebraically.

G.GPE.B.4 Use coordinates to prove simple geometric theorems algebraically.
G.GPE.B.5 Use the relationships between the slopes for parallel and perpendicular lines to solve problems.
G.GPE.B.6 Find the point on a directed line segment between two given points that partitions the segment in a given ratio.
G.GPE.B.7 Use coordinates to compute perimeters of polygons and areas of triangles and rectangles, e.g., using the distance formula.

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G.GPE.B.4 G.GPE.B.5 G.GPE.B.6 G.GPE.B.7	prove theorems or solve problems using unknown coordinates or by combining multiple relationships.	prove theorems or solve problems using coordinates.	solve problems involving parallel or perpendicular lines or the perimeter of polygons on a coordinate plane.	determine the slope of a line that is parallel or perpendicular to a given line, the distance between two points in the coordinate plane, or the coordinates of the midpoint of a line segment.

G.GMD Geometric Measurement and Dimension

G.GMD.A Explain volume formulas and use them to solve problems.

G.GMD.A.1 Give an informal argument for the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid, and cone. Use dissection arguments, Cavalieri's principle, and informal limit arguments.

G.GMD.A.3 Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.

G.GMD.B Visualize relationships between two-dimensional and three-dimensional objects.

G.GMD.B.4-1 Identify the shape of a two-dimensional cross-sections of three-dimensional objects.

G.GMD.B.4-2 Identify the three-dimensional object generated by a rotation of a two-dimensional object.

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G.GMD.A.1	compose an informal argument for circumference, area or volume formulas.	complete an informal argument for circumference, area, or volume formulas with supports.		
G.GMD.A.3		solve real-world problems involving volume.	solve real-world problems involving volumes with all pertinent information explicitly provided.	solve real-world problems involving a single volume formula with all pertinent information explicitly provided.
G.GMD.B.4-1 G.GMD.B.4-2		identify the two-dimensional cross-section of a three dimensional object or identify the three dimensional object generated by a rotation of a two-dimensional object.		

G.MG Modeling with Geometry

G.MG.A Apply geometric concepts in modeling situations.

G.MG.A.1 Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).

G.MG.A.2 Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).

G.MG.A.3 Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).

Note: *'Modeling with Geometry' is a domain of the content standards but is not the same as the Modeling Subclaim, which can include every content standard in geometry.*

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G.MG.A.1 G.MG.A.3	apply geometric concepts in modeling situations to solve problems with multiple constraints and/or that require connecting multiple grade level concepts.	apply geometric concepts in modeling situations to solve problems.	deconstruct a composite geometric figure and describe the measurements of the components of the figure in a modeling situation.	identify a single geometric shape in a modeling situation and describe it's measurements.
G.MG.A.2	calculate a missing measure in modeling situations involving density.	calculate density in modeling situations involving area and volume.	calculate density in modeling situations given an area or volume.	identify the correct units in modeling situations involving density.

Reasoning Performance Level Descriptors

All reasoning assessment items connect to both the Geometry reasoning evidence statements and the content evidence statements.

Students must provide evidence of their ability to reason mathematically by responding to:

- one-point machine scored items. For one-point reasoning items, refer to the associated content PLDs.
- four-point constructed response items. For four-point reasoning items, refer to both the reasoning PLDs below and the associated content PLDs.

Reasoning Evidence Statements

G.R.1 Identify a counterexample to refute a conjecture/claim.
G.R.2 Identify a correct method and justification given two or more chains of reasoning.
G.R.3 Determine cases where a given proposition is true or false.
G.R.4 Identify an unstated assumption that makes a problem well-posed or makes a particular method viable.
G.R.5 Construct, autonomously, chains of reasoning that will justify or refute geometric propositions or conjectures.
G.R.6 Apply geometric reasoning in a coordinate setting, and/or use coordinates to draw geometric conclusions.
G.R.7 Present solutions to multi-step problems in the form of valid chains of reasoning or describe errors in solutions to multi-step problems and present corrected solutions.
G.R.8 Use a combination of algebraic and geometric reasoning to justify or refute propositions or conjectures about geometric figures.

Level 4 – Distinguished *A student performing at this level should be able to provide evidence of mathematical reasoning by communicating:*	**Level 3 – Proficient** *A student performing at this level should be able to provide evidence of mathematical reasoning by communicating:*	**Level 2 – Developing** *A student performing at this level should be able to provide evidence of mathematical reasoning by communicating:*	**Level 1 – Beginning** *A student performing at this level should be able to provide evidence of mathematical reasoning by communicating:*
a sophisticated chain of reasoning.	a well-developed chain of reasoning.	a partially developed, valid chain of reasoning.	the beginning of a chain of reasoning.
a precise, logical solution pathway.	a logical solution pathway that may contain minor flaws.	a solution pathway that contains some correct processes yielding an incorrect solution.	an attempted solution pathway.
an extensive command of mathematical representations and vocabulary.	a proficient command of mathematical representations and vocabulary.	an understanding of some mathematical representations and vocabulary.	a developing understanding of some mathematical representations and vocabulary.

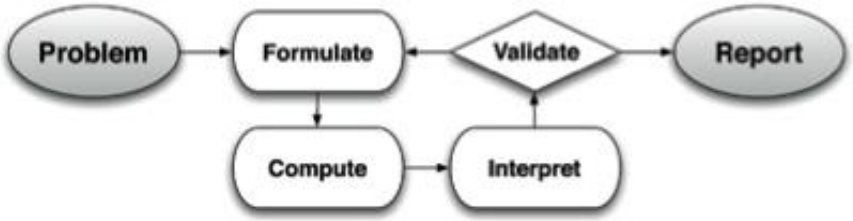
Modeling Performance Level Descriptors

All modeling assessment items connect to both the Geometry modeling evidence statements and the content evidence statements.

Students must provide responding to:

- one-point machine scored items. For one-point modeling items, refer to the associated content PLDs.
- four-point constructed response items. For four-point modeling items, refer to both the modeling PLDs below and the associated content PLDs.

Modeling Cycle



Modeling Evidence Statements

G.M.1	Choose an appropriate mathematical model to solve a real-world problem.
G.M.2	Construct a mathematical model to solve a real-world problem.
G.M.3	Validate a given model and/ or make improvements to a given model.
G.M.4	Interpret the solution to a real-world problem in terms of context.
G.M.5	Use and/or provide a reasonable estimate of a quantity needed to solve a problem.
G.M.6	Solve multi-step contextual word problems with degree of difficulty appropriate to the course, requiring application of course-level knowledge and skills articulated in the standards.
G.M.7	Solve multi-step contextual word problems with degree of difficulty appropriate to the course, involving perimeter, area, or volume that require the use 8th grade algebra skills.
G.M.8	Solve multi-step contextual word problems with degree of difficulty appropriate to the course, requiring application of course-level knowledge and skills involving right triangles in an applied setting.
G.M.9	Identify information or assumptions needed to solve a problem.

Level 4 – Distinguished *A student performing at this level should be able to provide evidence of the ability to use the modeling cycle by:*	**Level 3 - Proficient** *A student performing at this level should be able to provide evidence of the ability to use the modeling cycle by:*	**Level 2 - Developing** *A student performing at this level should be able to provide evidence of the ability to use the modeling cycle by:*	**Level 1 - Beginning** *A student performing at this level should be able to provide evidence of the ability to use the modeling cycle by:*
determining the information or mathematics needed to solve a problem that requires connecting multiple grade-level concepts.	determining needed information or mathematics.	identifying needed information or mathematics.	identifying some needed information or mathematics.
communicating an accurate, organized solution path aligned to the problem using appropriate, effective, and precise representations.	communicating an accurate, organized solution path aligned to the problem using appropriate, effective, and precise representations that may contain minor flaws.	communicating a partial solution path that may contain mathematical errors.	communicating the beginning of a solution path, containing mathematical errors.
evaluating or validating a solution path or showing how to improve a model or correct a given solution.	evaluating or validating a solution path or showing how to improve a model, but work may include minor flaws.	partially validating a solution path or incorrectly improving the model.	attempting to validate a solution path.