Mathematics | High School—Geometry

Students' prior knowledge includes:

- Students understand congruence and similarity using physical models, transparencies, or geometry software (grade 8).
- Students understand and apply the Pythagorean Theorem (grade 8).
- Student solve real world and mathematical problems involving volume of cylinders, cones and spheres (grade 8).
- Students draw, construct and describe geometrical figures and describe the relationships between them (grade 7).
- Students solve real-life and mathematical problems involving angle measures, area, surface area, and volume (grade 7).

Students in high school will extend prior knowledge to include:

Congruence

- Experiment with transformations in the plane.
- Understand congruence in terms of rigid motions.
- Prove and apply geometric theorems.
- Make geometric constructions.

Similarity, Right Triangles, and Trigonometry

- Understand similarity.
- Prove theorems involving similarity.
- Define trigonometric ratios and solve problems involving right triangles.
- Apply trigonometry to general triangles.

Circles

- Understand and apply theorems involving circles.
- Find arc lengths and areas of sectors of circles.

Expressing Geometric Properties with Equations

- Understand and use conic sections.
- Use coordinates to verify simple geometric theorems algebraically.

Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

Geometric Measurement and Dimension

- Explain surface area and volume formulas and use them to solve problems.
- Visualize relationships between two-dimensional and three-dimensional objects.

Modeling with Geometry

- Apply geometric concepts in modeling situations.

Domain: Congruence HS.G-CO

Cluster: Experiment with transformations in the plane

Code	Standards	Annotation
HS.G-CO.1	Know precise definitions of angle, circle, perpendicular line, parallel line, and line segment, based on the undefined notions of point, line, and plane.	
HS.G-CO.2	Represent transformations in the plane. Describe transformations as functions that take points in the plane as inputs and give other points as outputs. Compare transformations that preserve distance and angle to those that do not (e.g., translation versus horizontal stretch).	
HS.G-CO.3	Given a rectangle, parallelogram, trapezoid, or regular polygon, describe the rotations and reflections that carry it onto itself.	
HS.G-CO.4	Develop or verify experimentally the characteristics of rotations, reflections, and translations in terms of angles, circles, perpendicular lines, parallel lines, and line segments.	Example: Using patty paper or geometry software, develop/verify that the reflection line is the perpendicular bisector of the segment that connects the pre-image to its image.
HS.G-CO.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.	

Cluster: Understand congruence in terms of rigid motions

Code	Standards	Annotation
HS.G-CO.6	Use geometric descriptions of rigid motions to predict the effect of a given rigid motion on a given figure. Use the definition of congruence in terms of rigid motions to decide if two figures are congruent.	**Congruent:** Two plane or solid figures are congruent if one can be obtained from the other by rigid motion (a sequence of rotations, reflections, and translations). **Rigid motion:** A transformation of points in space consisting of a sequence of one or more translations, reflections, and/or rotations. Rigid motions are here assumed to preserve distances and angle measures.
HS.G-CO.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.	
HS.G-CO.8	Prove two triangles are congruent using the congruence theorems such as ASA, SAS, and SSS.	

Cluster: Prove and apply geometric theorems		
Code	**Standards**	**Annotation**
HS.G-CO.9	Prove and apply theorems about lines and angles.	"Proof" may take on a variety of forms (flow, paragraph, 2-column, informal). Theorems include but are not limited to: 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 equidistant from the segment's endpoints.
HS.G-CO.10	Prove and apply theorems about triangle properties.	"Proof" may take on a variety of forms (flow, paragraph, 2-column, informal). Theorems include but are not limited to: 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.
HS.G-CO.11	Prove and apply theorems about parallelograms.	"Proof" may take on a variety of forms (flow, paragraph, 2-column, informal). Theorems include but are not limited to: Opposite sides are congruent, opposite angles are congruent, the diagonals of a parallelogram bisect each other, and rectangles are parallelograms with congruent diagonals.

Cluster: Make geometric constructions		
Code	**Standards**	**Annotation**
HS.G-CO.12	Make basic geometric constructions with a variety of tools and methods.	Basic constructions include: 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. Tools may include compass and straightedge, string, reflective devices, paper folding or dynamic geometric software.
(+)HS.G-CO.13	Apply basic constructions to create polygons such as equilateral triangles, squares, and regular hexagons inscribed in circles.	

Domain: Similarity, Right Triangles, and Trigonometry — HS.G-SRT

Cluster: Understand similarity

Code	Standards	Annotation
HS.G-SRT.1	Verify experimentally the properties of dilations given by a center and a scale factor.	
HS.G-SRT.2	Given two figures, use transformations to decide if they are similar. Apply the meaning of similarity for triangles as the equality of all corresponding pairs of angles and the proportionality of all corresponding pairs of sides.	
HS.G-SRT.3	Use the properties of similarity transformations to establish the AA criterion for two triangles to be similar.	"Establish" may mean justify or prove the AA Similarity Theorem.

Cluster: Prove theorems involving similarity

Code	Standards	Annotation
HS.G-SRT.4	Prove similarity theorems about triangles.	Theorems include: a line parallel to one side of a triangle divides the other two proportionally, and conversely.
HS.G-SRT.5	Use congruence and similarity criteria for triangles to solve problems and to prove relationships in geometric figures.	

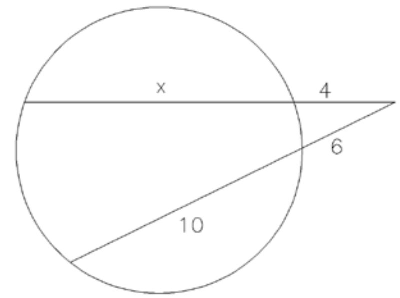
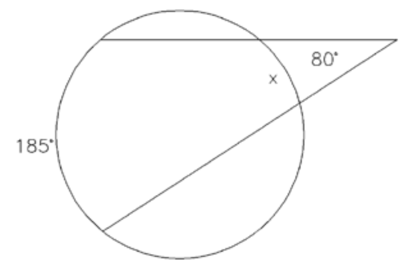
Cluster: Define trigonometric ratios and solve problems involving right triangles

Code	Standards	Annotation
HS.G-SRT.6	Understand how the properties of similar right triangles allow the trigonometric ratios to be defined, and determine the sine, cosine, and tangent of an acute angle in a right triangle.	Example: Verify experimentally that the side ratios in similar right triangles are dependent upon the measure of an acute angle in the triangle, due to the preservation of angle measure in similarity. Use this discovery to develop definitions of the trigonometric ratios for acute angles.
HS.G-SRT.7	Explain and use the relationship between the sine and cosine of complementary angles.	
HS.G-SRT.8*	Use special right triangles (30°-60°-90° and 45°-45°-90°), trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.	

Cluster: Apply trigonometry to general triangles		
Code	**Standards**	**Annotation**
(+)HS.G-SRT.9	Derive the formula $A = 1/2\ ab\ sin(C)$ for the area of a triangle by drawing an auxiliary line from a vertex perpendicular to the opposite side.	
(+)HS.G-SRT.10*	Solve unknown sides and angles of non-right triangles using the Laws of Sines and Cosines.	
(+)HS.G-SRT.11*	Understand and apply the Law of Sines and the Law of Cosines to find unknown measurements in context.	Examples: Surveying problems, resultant forces

Domain: Circles — HS.G-C

Cluster: Understand and apply theorems about circles

Code	Standards	Annotation
HS.G-C.1	Understand and apply theorems about relationships with line segments and circles including radii, diameter, secants, tangents, and chords.	Example: Solve for x.  Solution: x = 20
HS.G-C.2	Understand and apply theorems about relationships with angles formed by radii, diameter, secants, tangents, and chords. Understand and apply properties of angles for a quadrilateral inscribed in a circle.	Example: Solve for x.  Solution: $x = 25^{\circ}$
HS.G-C.3	Construct the incenter and circumcenter of a triangle. Relate the incenter and circumcenter to the inscribed and circumscribed circles.	
(+)HS.G-C.4	Construct a tangent line from a point outside a given circle to the circle.	

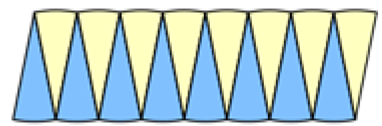
Cluster: Find arc lengths and areas of sectors of circles

Code	Standards	Annotation
HS.G-C.5	Explain and use the formulas for arc length and area of sectors of circles.	

Domain: Expressing Geometric Properties with Equations		HS.G-GPE
Cluster: Understand and use conic sections		
Code	**Standards**	**Annotation**
HS.G-GPE.1	Derive the equation of a circle of given center and radius. Derive the equation of a parabola given a focus and directrix. (+) Derive the equations of ellipses and hyperbolas given foci, using the fact that the sum or difference of distances from the foci is constant.	
HS.G-GPE.2	Convert between the standard and general form equations of conic sections.	Conic sections include the circle, ellipse, parabola and hyperbola.
HS.G-GPE.3	Identify key features of conic sections given their equations. Apply properties of conic sections in real world situations. *	Key features include: Circle – center, radius Parabola – vertex, focus, directrix Ellipse – center, foci, vertices, length of major and minor axis Hyperbola – center, foci, asymptotes
Cluster: Use coordinates to verify simple geometric theorems algebraically		
Code	**Standards**	**Annotation**
HS.G-GPE.4	Use coordinates to verify simple geometric theorems algebraically. Use coordinates to verify algebraically that a given set of points produces a particular type of triangle or quadrilateral.	Example: Given a rhombus with vertices at (2,0), (-2,0), (0,3) and (0,-3), verify that the diagonals are perpendicular. This standard allows for a coordinate proof. Example: Verify algebraically whether a figure defined by four given points in the coordinate plane is a rectangle. Refer to table 8a and 8b for exclusive and inclusive classifications of quadrilaterals
HS.G-GPE.5	Develop and verify the slope criteria for parallel and perpendicular lines. Apply the slope criteria for parallel and perpendicular lines to solve geometric problems using algebra.	Example: Find the equation of a line parallel or perpendicular to a given line that passes through a given point.
HS.G-GPE.6	Use coordinates to find the midpoint or endpoint of a line segment. (+) Find the point on a directed line segment between two given points that partitions the segment in a given ratio.	(+) Example: Find the coordinates of the point that is 2/3 the distance from the point (1,5) to (-4,7).
HS.G-GPE.7*	Use coordinates to compute perimeters of polygons and areas of triangles, parallelograms, trapezoids and kites.	

Domain: Geometric Measurement and Dimension

Cluster: Explain surface area and volume formulas and use them to solve problems

Code	Standards	Annotation
HS.G-GMD.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.	May use dissection arguments. Cavalieri's Principle or informal limit arguments. **<u>Cavalieri's Principle</u>:** 2D: Suppose two regions in a plane are included between two parallel lines in that plane. If every line parallel to these two lines intersects both regions in line segments of equal length, then the two regions have equal areas. 3D: Suppose two regions in three-space (solids) are included between two parallel planes. If every plane parallel to these two planes intersects both regions in <u>cross-sections</u> of equal area, then the two regions have equal volumes. <u>Example</u>: The area of a circle can be deduced by rearranging sectors of two semi-circles to form a rough rectangle. Area: $= r \cdot \frac{1}{2} \cdot \text{Circumference}$ $= r \cdot \frac{1}{2} \cdot 2\pi r$ $= \pi r^2$ 
HS.G-GMD.2	Calculate the surface area for prisms, cylinders, pyramids, cones, and spheres to solve problems.	
HS.G-GMD.3*	Know and apply volume formulas for prisms, cylinders, pyramids, cones, and spheres to solve problems.	

Cluster: Visualize relationships between two-dimensional and three-dimensional objects

Code	Standards	Annotation
HS.G-GMD.4	Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects.	

Domain: Modeling with Geometry*		HS.G-MG
Cluster: Apply geometric concepts in modeling situations		
Code	**Standards**	**Annotation**
HS.G-MG.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).	
HS.G-MG.2*	Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).	
HS.G-MG.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).	Example: Students design a soft drink package that minimizes surface area and cost. Example: Design an art sculpture composed of at least four solids. Calculate the amount of material used to build it.