Merrimack School District

Mathematics Curriculum

Geometry

Standards for Mathematical Practices

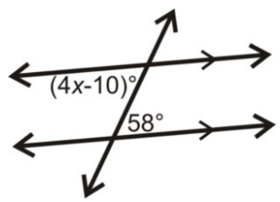
The College and Career Readiness State Standards for Mathematical Practice are expected to be integrated into every mathematics lesson for all students Grades K-12. Below are a few examples of how these Practices may be integrated into tasks that students complete.

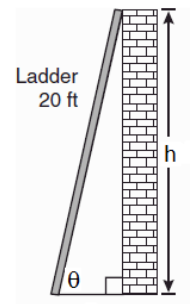
Mathematic Practices	Explanations and Examples
1. Make sense of problems and persevere in solving them.	Mathematically proficient students in Geometry should solve problems by applying their understanding of operations with whole numbers, decimals, and fractions including mixed numbers. They solve problems related to volume and measurement conversions. Students seek the meaning of a problem and look for efficient ways to represent and solve it. They may check their thinking by asking themselves, "What is the most efficient way to solve the problem?", "Does this make sense?", and "Can I solve the problem in a different way?".
2. Reason abstractly and quantitatively.	Mathematically proficient students in Geometry should recognize that a number represents a specific quantity. They connect quantities to written symbols and create a logical representation of the problem at hand, considering both the appropriate units involved and the meaning of quantities. They extend this understanding from whole numbers to their work with fractions and decimals. Students write simple expressions that record calculations with numbers and represent or round numbers using place value concepts.
3. Construct viable arguments and critique the reasoning of others.	In Geometry mathematical proficient students may construct arguments using concrete referents, such as objects, pictures, and drawings. They explain calculations based upon models and properties of operations and rules that generate patterns. They demonstrate and explain the relationship between volume and multiplication. They refine their mathematical communication skills as they participate in mathematical discussions involving questions like "How did you get that?" and "Why is that true?" They explain their thinking to others and respond to others' thinking.
4. Model with mathematics.	Mathematically proficient students in Geometry experiment with representing problem situations in multiple ways including numbers, words (mathematical language), drawing pictures, using objects, making a chart, list, or graph, creating equations, etc. Students need opportunities to connect the different representations and explain the connections. They should be able to use all of these representations as needed. Students should evaluate their results in the context of the situation and whether the results make sense. They also evaluate the utility of models to determine which models are most useful and efficient to solve problems.

Mathematic Practices	Explanations and Examples
5. Use appropriate tools strategically.	Mathematically proficient students consider the available tools (including estimation) when solving a mathematical problem and decide when certain tools might be helpful. For instance, they may use unit cubes to fill a rectangular prism and then use a ruler to measure the dimensions. They use graph paper to accurately create graphs and solve problems or make predictions from real world data.
6. Attend to precision.	Mathematically proficient students in Geometry continue to refine their mathematical communication skills by using clear and precise language in their discussions with others and in their own reasoning. Students use appropriate terminology when referring to expressions, fractions, geometric figures, and coordinate grids. They are careful about specifying units of measure and state the meaning of the symbols they choose. For instance, when figuring out the volume of a rectangular prism they record their answers in cubic units.
7. Look for and make use of structure.	In Geometry mathematically proficient students look closely to discover a pattern or structure. For instance, students use properties of operations as strategies to add, subtract, multiply and divide with whole numbers, fractions, and decimals. They examine numerical patterns and relate them to a rule or a graphical representation.
8. Look for and express regularity in repeated reasoning.	Mathematically proficient students use repeated reasoning to understand algorithms and make generalizations about patterns. Students connect place value and their prior work with operations to understand algorithms to fluently multiply multi-digit numbers and perform all operations with decimals to hundredths. Students explore operations with fractions with visual models and begin to formulate generalizations.

Number and Quantity: Quantities N-Q		
College and Career Readiness Cluster		
Reason Quantitatively and Use Units to Solve Problems.		
Mathematically proficient students can examine the units given in a problem and the expected units in the solution to help them solve problems.		
Enduring Understandings: Examining the units supplied in a problem and the expected units of its answer can help the problem solving process. **Essential Questions:** What can the units given in a problem tell us about how to solve it? Why do we need to consider estimation and exact answers in problem solving?		
College and Career Readiness Standards *Students are expected to:*	**Mathematical Practices**	**Unpacking Explanations and Examples** *What does this standard mean that a student will know and be able to do?*
N.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and	MP.1 Make sense of problems and persevere in solving them. MP.4 Model with mathematics. MP.6 Attend to precision.	**Example**: If finding the area of a rectangle with length 4m and width 12m, what units should my answer have? **Example**: Hannah makes 6 cups of cake batter. She pours and levels all the batter into a rectangular cake pan with a length of 11 inches, a width of 7 inches, and a depth of 2 inches. One cubic inch is approximately equal to 0.069 cup. What is the depth of the batter in the pan when it is completely poured in? Round your answer to the nearest 1/8 of an inch.

interpret the scale and the origin in graphs and data displays.		
N.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.	MP.1 Make sense of problems and persevere in solving them. MP.4 Model with mathematics.	**<u>Examples</u>:** Explain how the units cm, cm^2, and cm^3 are related and how they are different. Describe situations where each would be an appropriate unit of measure.
N.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	MP.1 Make sense of problems and persevere in solving them. MP.6 Attend to precision.	**<u>Example</u>:** If the length of a rectangle is given to the nearest tenth of a centimeter, then calculated measurements should be reported to no more than the nearest tenth.

Algebra: Creating Equations		A-CED
College and Career Readiness Cluster		
Create Equations That Describe Numbers or Relationships		
Mathematically proficient students can create expressions and equations to model mathematical relationships.		
Enduring Understandings: Equations and inequalities can be used to model geometric relationships. **Essential Questions:** How can we use equations or inequalities to represent geometric relationships?		
College and Career Readiness Standards *Students are expected to:*	**Mathematical Practices**	**Unpacking Explanations and Examples** *What does this standard mean that a student will know and be able to do?*
A.CED.A.1 Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions*.	MP.1 Make sense of problems and persevere in solving them. MP.6 Attend to precision.	**Example:** Students should be able to decontextualize mathematical information from geometric diagrams and create appropriate equations using that information.  Write and solve an equation to find *x*. Justify your solution.

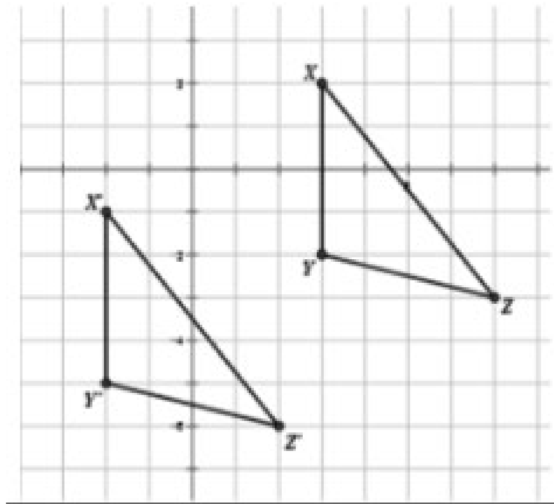
A.CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.	MP.1 Make sense of problems and persevere in solving them. MP.6 Attend to precision.	**Example:** The area of a rectangle is 40 in^2. Write an equation for the length of the rectangle related to the width. Graph the length as it relates to the width of the rectangle. Interpret the meaning of the graph. **Example:** The formula for the surface area of a cylinder is given by $A = \pi r^2 h$, where r represents the radius of the circular cross-section of the cylinder and h represents the height. Select a fixed value for h and graph the area as it relates to the radius. Select a fixed value for r and graph the area as it relates to the height. Compare the graphs. What is the appropriate domain for r and h? Be sure to label your graphs and use an appropriate scale. **Example:** John has a 20-foot ladder leaning against a wall. Create an equation that represents the relationship between the angle the ladder makes with the ground and the maximum height of ladder can reach against the wall. 

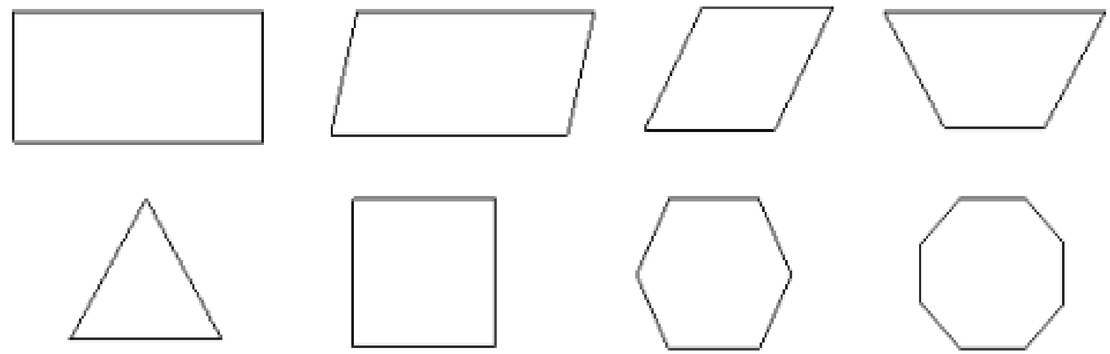
A.CED.A.3 Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or non-viable options in a modeling context.	MP.1 Make sense of problems and persevere in solving them. MP.2 Reason abstractly and quantitatively. MP.6 Attend to precision.	**<u>Example</u>:** Students will understand when solutions are not appropriate. When a side length is *x* - 6, students must know that *x* must be greater than 6.
A.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R.	MP.1 Make sense of problems and persevere in solving them.	**<u>Example</u>:** The Pythagorean Theorem expresses the relation between the legs *a* and *b* of a right triangle and its hypotenuse *c* with the equation $a^2 + b^2 = c^2$. • Why might the theorem need to be solved for *c*? • Solve the equation for *c* and write a problem situation where this form of the equation might be useful. • Solve the equation for *b* and write a problem situation where this form of the equation might be useful. **<u>Example</u>**: Solve the volume of a sphere formula for the radius, *r*.

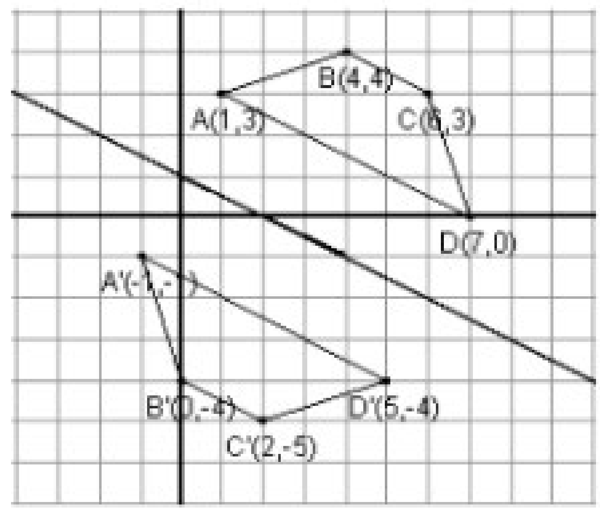
Algebra: Reasoning With Equations and Inequalities A-REI		
College and Career Readiness Cluster		
Understanding Solving Equations as a Process of Reasoning and Explain the Reasoning		
Mathematically proficient students understand that inverse operations can be used to solve equations. The terms students should learn to use with increasing precision with this cluster are: **inverse operations**		
Enduring Understandings: Basic properties and principles of algebra can be applied to the understanding of geometric concepts? **Essential Questions:** How can we write an algebraic proof to support our solution? How can we use our understanding of geometric concepts to construct algebraic models?		
College and Career Readiness Standards *Students are expected to:*	**Mathematical Practices**	**Unpacking Explanations and Examples** *What does this standard mean that a student will know and be able to do?*
A.REI.A.1 Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.	MP.1 Make sense of problems and persevere in solving them. MP.3 Construct viable arguments and critique the reasoning of others.	**Example:** Write a formal, two column algebraic proof for the following statement. If $2x + 7 = 15$ then $x = 4$.

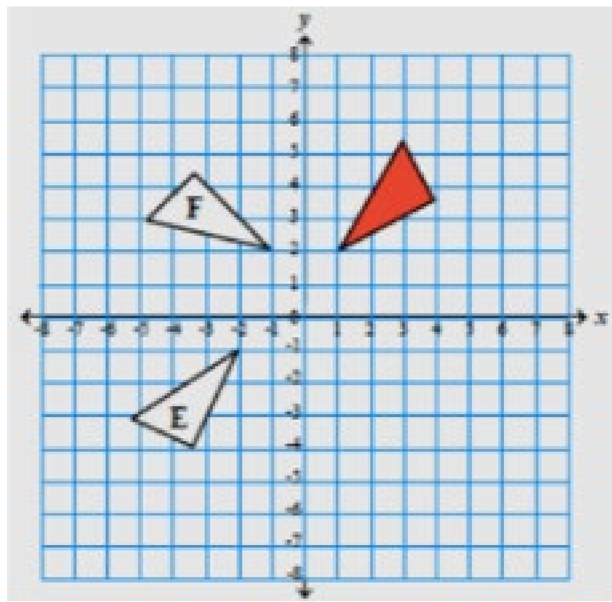
Geometry: Congruence		G-CO
College and Career Readiness Cluster		
Experiment with transformations in the plane.		
Mathematically proficient students transform geometric figures. The terms students should learn to use with increasing precision with this cluster are: **translation, reflection, rotation, transformation, image, pre-image**		
Enduring Understandings: Shapes can undergo transformations and yet may maintain some or all of their properties. **Essential Questions:** Why do some transformations result in congruent figures? Why do some transformations result in similar figures? What are some examples of transformations that do not result in congruent or similar figures?		
College and Career Readiness Standards *Students are expected to:*	**Mathematical Practices**	**Unpacking Explanations and Examples** *What does this standard mean that a student will know and be able to do?*
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.	MP.1 Make sense of problems and persevere in solving them.	**Example:** Students will be able to understand the required geometric vocabulary and notation, and be able to differentiate the vocabulary. ie. A line versus a line segment.

G.CO.A.2 Represent transformations in the plane using, e.g., transparencies and geometry software; 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).	MP.1 Make sense of problems and persevere in solving them. MP.6 Attend to precision.	**Example**: Students describe and compare function transformations on a set of points as inputs to produce another set of points as outputs. They distinguish between transformations that are rigid (preserve distance and angle measure: reflections, rotations, translations, or combinations of these) and those that are not (dilations or rigid motions followed by dilations).Transformations produce congruent figures while dilations produce similar figures. **Example**: A plane figure is translated 3 units right and 2 units down. The translated figure is then dilated with a scale factor of 4, centered at the origin. a. Draw a plane figure and represent the described transformation of the figure in the plane. b. Explain how the transformation is a function with inputs and outputs. c. Determine the relationship between the pre-image and the image after a series of transformations. Provide evidence to support your answer. **Example**: Transform ΔABC with vertices A (1, 1), B (6, 3) and C (2, 13) using the function rule $(x, y) \rightarrow (-y, x)$ and describe the transformation as completely as possible. (This is not intended for students to memorize transformation rules and thus be able to identify the transformation from the rule. Students should understand the structure of the rule and how to use it as a function to generate outputs from the provided inputs.)

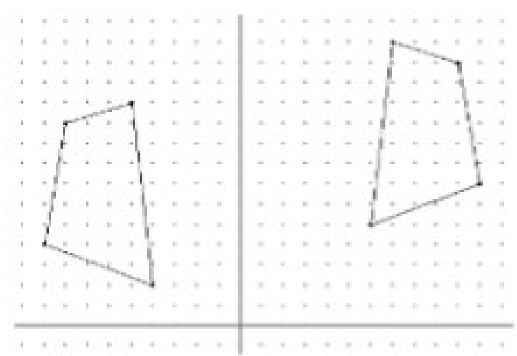
		Example: Complete the rule for the transformation at the below: $(x,y) \rightarrow$ (____,____) and determine if the transformations preserve distance and angle. Provide justification for your answer. 
G.CO.A.3 Given a rectangle, parallelogram, trapezoid, or regular polygon, describe the rotations and reflections that carry it onto itself.	MP.1 Make sense of problems and persevere in solving them. MP.6 Attend to precision.	**Example:** Students describe and illustrate how a rectangle, parallelogram, isosceles trapezoid or regular polygon are mapped onto themselves using transformations. Students determine the number of lines of reflection symmetry and the degree of rotational symmetry of any regular polygon.

		Example: For each of the following shapes, describe the rotations and reflections that carry it onto itself. 
G.CO.A.4 Develop definitions of rotations, reflections, and translations in terms of angles, circles, perpendicular lines, parallel lines, and line segments.	MP.1 Make sense of problems and persevere in solving them. MP.6 Attend to precision.	**<u>Example</u>:** Students develop the definition of each transformation in regards to the characteristics between pre-image and image points. • For a translation: connecting any point on the pre-image to its corresponding point on the translated image, and connecting a second point on the pre-image to its corresponding point on the translated image, the two segments are equal in length, translate in the same direction, and are parallel. • For a reflection: connecting any point on the pre-image to its corresponding point on the reflected image, the line of reflection is a perpendicular bisector of the line segment. • For a rotation: connecting the center of rotation to any point on the pre-image and to its corresponding point on the rotated image, the line segments are equal in length and the measure of the angle formed is the angle of rotation.

		Example: Is quadrilateral A'B'C'D' a reflection of quadrilateral ABCD across the given line? Justify your reasoning. 
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	MP.1 Make sense of problems and persevere in solving them. MP.6 Attend to precision.	**Example**: Students transform a geometric figure given a rotation, reflection, or translation. They create sequences of transformations that map a geometric figure onto itself and another geometric figure. Students predict and verify the sequence of transformations (a composition) that will map a figure onto another.

a sequence of transformations that will carry a given figure onto another.		**<u>Example</u>:** Part 1 Draw the shaded triangle after: a. It has been translated −7 units horizontally and +1 units vertically. Label your answer A. b. It has been reflected over the x-axis. Label your answer B. c. It has been rotated 90° clockwise about the origin. Label your answer C. d. It has been reflected over the line $y = x$. Label your answer D. Part 2 Describe fully the single transformation that: a. Takes the shaded triangle onto the triangle labeled E. b. Takes the shaded triangle onto the triangle labeled F. 

Geometry: Congruence		G-CO
College and Career Readiness Cluster		
Understanding Congruence in terms of rigid motions.		
Mathematically proficient students understand which transformations produce congruent images.		
Enduring Understandings: Location and orientation do not impact congruence. **Essential Questions:** How can the properties of transformations illustrate congruence? How do we know a pre-image and an image are congruent?		
College and Career Readiness Standards *Students are expected to:*	**Mathematical Practices**	**Unpacking Explanations and Examples** *What does this standard mean that a student will know and be able to do?*
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.	MP.4 Model with mathematics. MP.5 Use appropriate tools strategically. MP.7 Look for and make use of structure.	**Example:** Students use descriptions of rigid motion and transformed geometric figures to predict the effects rigid motion has on figures in the coordinate plane. Students recognize rigid transformations preserve size and shape or distance and angle and develop the definition of congruent. Students determine if two figures are congruent by determining if rigid motions will turn one figure into the other.

		Example: Consider parallelogram ABCD with coordinates A(2, -2), B(4, 4), C(12, 4) and D(10, -2). Make predictions about how the lengths, perimeter, area and angle measures will change under each transformation. a. A reflection over the x-axis. b. A rotation of 270° counter clockwise about the origin. c. A dilation of scale factor 3 about the origin. d. A translation to the right 5 and down 3. Perform each of the transformations to assess your predictions. Compare and contrast which transformations preserved the size and/or shape with those that did not preserve size and/or shape. Generalize, how could you determine if a transformation would maintain congruency from the pre-image to the image? **Example:** Determine if the figures below are congruent. Justify. 

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.	MP.7 Look for and make use of structure. MP.6 Attend to precision.	**<u>Example</u>:** A rigid motion is a transformation of points in space consisting of a sequence of one or more translations, reflections, and/or rotations. Rigid motions are assumed to preserve distances and angle measures. Two triangles are said to be congruent if one can be exactly superimposed on the other by a rigid motion, and the congruence theorems specify the conditions under which this can occur. Students identify corresponding sides and corresponding angles of congruent triangles. Explain that in a pair of congruent triangles, corresponding sides are congruent (distance is preserved) and corresponding angles are congruent (angles measure is preserved). They demonstrate that when distance is preserved (corresponding sides are congruent) and angle measure is preserved (corresponding angles are congruent) the triangles must also be congruent.
G.CO.B.8 Explain how the criteria for triangle congruence (ASA, SAS, and SSS) follow from the definition of congruence in terms of rigid motions.	MP.7 Look for and make use of structure.	**<u>Example</u>:** List the sufficient conditions to prove triangles are congruent: ASA, SAS, and SSS. Map a triangle with one of the sufficient conditions (e.g., SSS) onto the original triangle and show that corresponding sides and corresponding angles are congruent. Why do each of SAS, ASA, SSS work? **<u>Example</u>:** Josh is told that ΔABC and ΔDEF share two sets of congruent sides and one set of congruent angles: $\overline{AB}$ is congruent to $\overline{DE}$, $\overline{BC}$ is congruent to $\overline{EF}$, and $\angle B$ is congruent to $\angle E$. He is asked if these two triangles must be congruent. Josh draws two triangles and says, "They are definitely congruent because two pairs of sides are congruent and the angle between them is congruent!" a. Explain Josh's reasoning using one of the triangle congruence criteria: ASA, SSS, SAS. b. Given two triangles ΔABC and ΔDEF, what is an example of three given congruent parts that will not guarentee the two triangles are congruent.

Geometry: Congruence		G-CO
College and Career Readiness Cluster		
Prove Geometric Theorems		
Mathematically proficient students communicate precisely by engaging in discussion about their reasoning using appropriate mathematical language. The terms students should learn to use with increasing precision with this cluster are: **postulate, theorem, vertical angles, transversal, parallel lines, alternate interior angles, congruent, corresponding angles, perpendicular bisector, line segment, equidistant**		
Enduring Understandings: Deductive reasoning can be used to prove geometric theorems. **Essential Questions:** Why is geometric proof necessary?		
College and Career Readiness Standards *Students are expected to:*	**Mathematical Practices**	**Unpacking Explanations and Examples** *What does this standard mean that a student will know and be able to do?*

G.CO.C.9 Prove 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.	MP.1 Make sense of problems and persevere in solving them. MP.2 Reason abstractly and quantitatively. MP.3 Construct viable arguments and critique the reasoning of others. MP.5 Use appropriate tools strategically.	**Example:** Use formal 2-column proofs to prove theorems. Informal and flow proofs are also acceptable.
G.CO.C.10 Prove 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	MP.1 Make sense of problems and persevere in solving them. MP.2 Reason abstractly and quantitatively. MP.3 Construct viable arguments and critique the reasoning of others.	**Example:** Given an isosceles triangle with a vertex angle of 40 degrees, prove that the measure of each base angle is 70 degrees. **Example:** Given an equilateral triangle with side length *n* units find the area of the triangle.

meet at a point.	MP.5 Use appropriate tools strategically.	

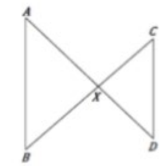
G.CO.C.11 Prove theorems about parallelograms. Theorems include: opposite sides are congruent, opposite angles are congruent, diagonals of a paralellogram bisect each other, and conversely, rectangles are parallelograms with congruent diagonals.	MP.1 Make sense of problems and persevere in solving them. MP.2 Reason abstractly and quantitatively. MP.3 Construct viable arguments and critique the reasoning of others. MP.5 Use appropriate tools strategically.	**Example:** Given parallelogram *ABCD* with $\angle A$ measuring 28 degrees, prove that $\angle D$ has the measure 152 degrees.

Geometry: Crongruence		
College and Career Readiness Cluster		
Make Geometric Constructions		
Mathematically proficient students communicate precisely by engaging in discussion about their reasoning using appropriate mathematical language. The terms students should learn to use with increasing precision with this cluster are: **construction, bisector, perpendicular, parallel, midpoint**		
Enduring Understandings: Constructing a shape is more reliable than using measuring tools to draw it. **Essential Questions:** How can I guarantee that I am making an accurate figure? Why are measurement tools unreliable for making geometric constructions?		
College and Career Readiness Standards *Students are expected to:*	**Mathematical Practices**	**Unpacking Explanations and Examples** *What does this standard mean that a student will know and be able to do?*
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	MP.5 Use appropriate tools strategically. MP.6 Attend to precision.	Students use various tools to perform the geometric constructions. Students formalize and explain how these constructions result in the desired objects. The standard includes the following: • Copying a segment • Copying an angle • Bisecting a segment • Bisecting an angle • Constructing perpendicular lines, including the perpendicular bisector of a line segment • Constructing a line parallel to a given line through a point not on the line.

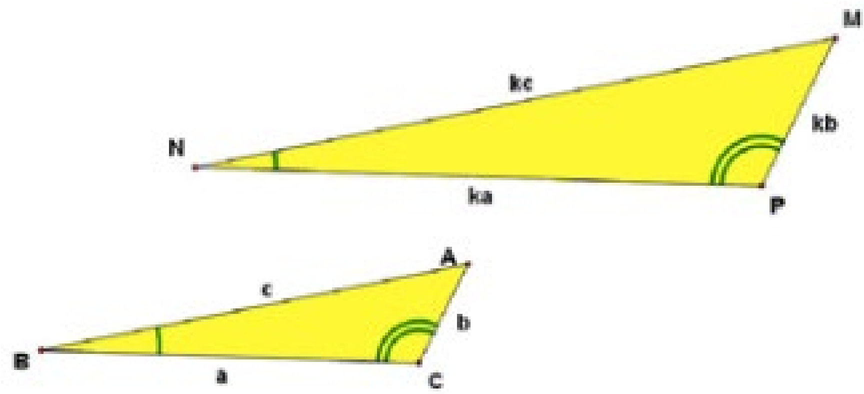
segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a Line segment; and constructing a line parallel to a given line through a point not on the line.		<u>**Example**</u>**:** You have been asked to place a warehouse so that it is an equal distance from the three roads indicated on a map. Find this location and show your work. a. How would you use construction to determine the location of the warehouse?
G.CO.D.13 Construct an equilateral triangle, a square, and a regular hexagon inscribed in a circle.	MP.5 Use appropriate tools strategically. MP.6 Attend to precision.	<u>**Example**</u>: As an extension to constructing perpendicular bisectors, have students construct equilateral triangles, squares, and regular hexagons inscribed in a circle.

Geometry: Similarity, Right Triangles, and Trigonometry		
College and Career Readiness Cluster		
Understanding Similarity in Terms of Similarity Transformations		
Mathematically proficient students communicate precisely by engaging in discussion about their reasoning using appropriate mathematical language. The terms students should learn to use with increasing precision with this cluster are: **dilation, scale factor, similarity, proportion, mapping**		
Enduring Understandings: Shapes can undergo transformations and yet maintain some of their properties. **Essential Questions:** Which transformations result in similar figures?		
College and Career Readiness Standards *Students are expected to:*	**Mathematical Practices**	**Unpacking Explanations and Examples** *What does this standard mean that a student will know and be able to do?*
G.SRT.A.1 Verify experimentally the properties of dilations given by a center and a scale factor. A dilation takes a line not passing through the center	MP.6 Attend to precision	**Example:** Given triangle ABC dilate with a scale factor of 2 centered at the origin. Use distance formula or Pythagorean Theorem to verify that corresponding sides of triangle A'B'C' are twice the length of triangle ABC. a. Perform $(x, y) \rightarrow (x, 2y)$ check for similarity using distance formula b. Perform $(x, y) \rightarrow (2x, 2y)$ check for similarity using distance formula

of the dilation to a parallel line, and leaves a line passing through the center unchanged. 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, use the definition of similarity in terms of similarity transformations to decide if they are similar; explain using similarity transformations the meaning of similarity for triangles as the equality of all corresponding pairs of angles	MP.3 Construct viable arguments and critique the reasoning of others. MP.5 Use appropriate tools strategically. MP.7 Look for and make use of structure.	Students use the idea of dilation transformations to develop the definition of similarity. They understand that a similarity transformation is a rigid motion followed by a dilation. Students demonstrate that in a pair of similar triangles, corresponding angles are congruent (angle measure is preserved) and corresponding sides are proportional. They determine that two figures are similar by verifying that angle measure is preserved and corresponding sides are proportional. **Example:** In the picture below, line segments AD and BC intersect at X. Line segments AB and CD are drawn, forming two triangles ΔAXB and ΔCXD. In each part a-d below, some additional assumptions about the picture are given. For each assumption: I. Determine whether the given assumptions are enough to prove that the two triangles are similar. If so, what is the correct correspondence of vertices. If not, explain why not.

and the proportionality of all corresponding pairs of sides.		II. If the two triangles must be similar, prove this result by describing a sequence of similarity transformations that maps one variable to the other. a. AX and AD satisfy the equation $2AX = 3XD$. b. AX, BX, CX, and DX satisfy the equation $\frac{AX}{BX} = \frac{CX}{DX}$ c. Lines AB and CD are parallel d. ∠XAB is congruent to angle ∠XCD. 

G.SRT.A.3 Use the properties of similarity transformations to establish the AA criterion for two triangles to be similar.	MP.7 Look for and make use of structure. MP.8 Look for and express regularity in repeated reasoning.	Students can use the theorem that the angle sum of a triangle is 180° and verify that the AA criterion is equivalent to the AAA criterion. Given two triangles for which AA holds, students use rigid motions to map a vertex of one triangle onto the corresponding vertex of the other in such a way that their corresponding sides are in line. Then show that dilation will complete the mapping of one triangle onto the other. **Example:** Given that ΔMNP is a dilation of ΔABC with scale factor k, use properties of dilations to show that the AA criterion is sufficient to prove similarity.

		M kc kb N ka P A c b B a C

Geometry: Similarity, Right Triangles, and Trigonometry

College and Career Readiness Cluster

Prove Theorems involving Similarity

Mathematically proficient students communicate precisely by engaging in discussion about their reasoning using appropriate mathematical language. The terms students should learn to use with increasing precision with this cluster are: **proof, theorem, postulate, similarity, proportionality, ratios, scale factor**

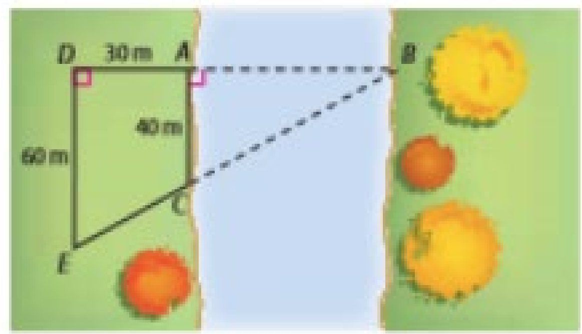
Enduring Understandings:

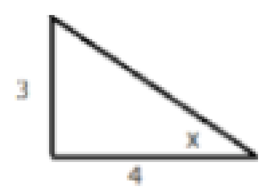
Deductive reasoning can be used to prove geometric theorems about similarity.

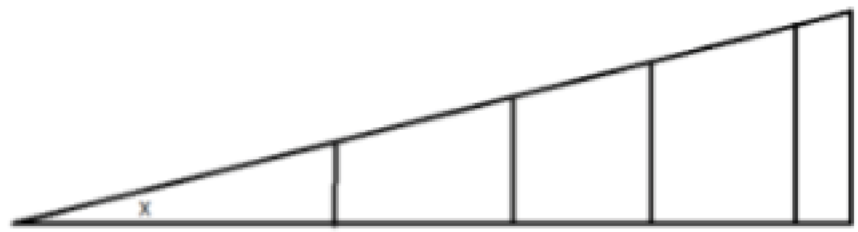
Essential Questions:

How can similarity be used to prove relationships in geometric figures?
How is similarity used in real world models?

College and Career Readiness Standards *Students are expected to:*	**Mathematical Practices**	**Unpacking Explanations and Examples** *What does this standard mean that a student will know and be able to do?*
G.SRT.B.4 Prove 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.	MP.2 Reason abstractly and quantitatively. MP.3 Construct viable arguments and critique the reasoning of others.	**<u>Example</u>**: Use AA, SAS, and SSS similarity theorems to prove triangles are similar. Use triangle similarity to prove other theorems about triangles: Prove a line which intercepts a triangle and is parallel to one side divides the other two sides proportionally and its converse.

G.SRT.B.5 Use congruence and similarity criteria for triangles to solve problems and to prove relationships in geometric figures.	MP.2 Reason abstractly and quantitatively. MP.3 Construct viable arguments and critique the reasoning of others.	The similarity postulates include SSS, SAS, and AA. The congruence postulates include SSS, SAS, ASA, AAS, and H-L. Students apply triangle congruence and triangle similarity to solve problem situations (e.g., indirect measurement, missing side(s)/angle measure(s), side splitting). **Example**: Calculate the distance across the river. 

Geometry: Similarity, Right Triangles, and Trigonometry		
College and Career Readiness Cluster		
Define trigonometric ratios and solve problems involving right triangles.		
Mathematically proficient students communicate precisely by engaging in discussion about their reasoning using appropriate mathematical language. The terms students should learn to use with increasing precision with this cluster are: **similarity, trigonometry, proportionality, sine, cosine, tangent, ratio, Pythagorean Theorem, inverse, complementary**		
Enduring Understandings: Trigonometry can be used to solve right triangles. **Essential Questions:** When is it appropriate to use trigonometry to solve a triangle? What is the usefulness of trigonometry in solving real world problems?		
College and Career Readiness Standards *Students are expected to:*	**Mathematical Practices**	**Unpacking Explanations and Examples** *What does this standard mean that a student will know and be able to do?*
G.SRT.C.6 Understand that by similarity, side ratios in right triangles are properties of the angles in the triangle, leading to definitions of trigonometric ratios for acute angles	MP.7 Look for and make use of structure.	Students establish that the side ratios of a right triangle are equivalent to the corresponding side ratios of similar right triangles and are a function of the acute angles.  **Example**: Find the sine, cosine, and tangent of x.

		Example: Explain why the sine of x is the same regardless of which triangle is used to find it in the figure below. 
G.SRT.C.7 Explain and use the relationship between the sine and cosine of complementary angles.	MP.7 Look for and make use of structure. MP.2 Reason abstractly and quantitatively.	Students can explain why the sine of an acute angle in a right triangle is the cosine of complementary angle in the same right triangle. **Example**: Using the diagram above, provide an argument justifying why $sin\ A = cos\ B$. Students use the relationship between the sine and cosine of complementary angles. **Example**: Complete the following statement: If sin 30° = ½, then cos ______= ½ **Example**: Angles F and G are complementary. As the measure of angle F increases, $sin\ F$ increases by 0.2. How does $cos\ G$ change?
G.SRT.C.8 Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.	MP.7 Look for and make use of structure. MP.2 Reason abstractly and quantitatively.	**Example**: Find the height of a flagpole to the nearest tenth if the angle of elevation of the sun is 28° and the shadow of the flagpole is 50 feet. **Example**: A new house is 32 feet wide. The rafters will rise at a 36° angle and meet at the centerline of the house. Each rafter also needs to overhang the side of the house by 2 feet. How long should the carpenter make each rafter?

Geometry: Circles

College and Career Readiness Cluster

Understand and Apply Theorems About Circles

Mathematically proficient students communicate precisely by engaging in discussion about their reasoning using appropriate mathematical language. The terms students should learn to use with increasing precision with this cluster are: **center, inscribed angles, radius, diameter, chords, central angle, circumscribed angles, tangent, secant, inscribed polygons, locus, circumference, arc, sector, semi-circle, minor arc, major arc, arc length, area, point of tangency, pi**

Enduring Understandings:

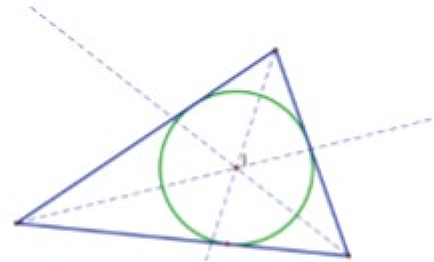
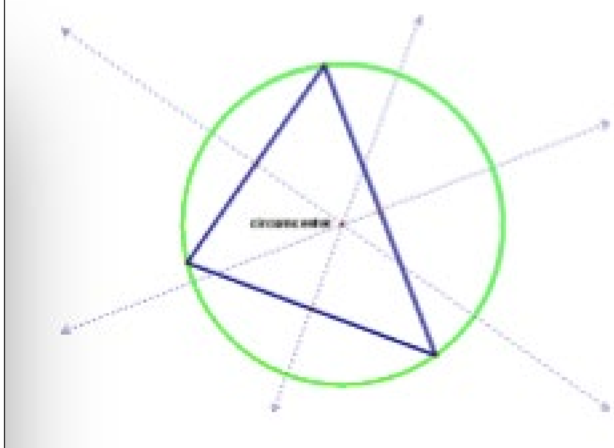
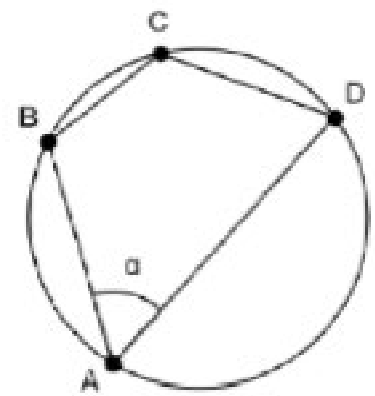
All circles are similar; their parts, segments, and angles have predictable properties.

Essential Questions:

How can I use the properties of circles to solve real world problems?
What is the difference between an inscribed angle and a central angle?

College and Career Readiness Standards *Students are expected to:*	**Mathematical Practices**	**Unpacking Explanations and Examples** *What does this standard mean that a student will know and be able to do?*
G.C.A.1 Prove that all circles are similar.	MP.2 Reason abstractly and quantitatively.	**Example:** Prove that any two circles are similar.
G.C.A.2 Identify and describe relationships	MP.7 Look for and make use of structure.	Students can: • Identify central angles, inscribed angles, circumscribed angles, diameters, radii, chords, and tangents. • Describe the relationship between a central angle and the arc it intercepts.

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.	MP.8 Look for and express regularity in repeated reasoning.	• Describe the relationship between an inscribed angle and the arc it intercepts. • Describe the relationship between a circumscribed angle and the arcs it intercepts. • Recognize that an inscribed angle whose sides intersect the endpoints of the diameter of a circle is a right angle. • Recognize that the radius of a circle is perpendicular to the tangent where the radius intersects the circle. **Example**: Given a circle with radius of 10 and chord length of 12, find the distance from the chord to the center of 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.	MP.5 Use appropriate tools strategically. MP.6 Attend to precision.	Students construct the inscribed circle whose center is the point of intersection of the angle bisectors (the incenter). Students construct the circumscribed circle whose center is the point of intersection of the perpendicular bisectors of each side of the triangle (the circumcenter). Students prove properties of angles for a quadrilateral inscribed in a circle. **Example**: Given the inscribed quadrilateral below prove that angle B is supplementary to angle D.   

G.C.A.4 Construct a tangent line to a circle from a point outside a given circle to the circle.	MP.5 Use appropriate tools strategically. MP.6 Attend to precision.	**<u>Example</u>:** Given a circle and a point outside of the circle, construct a tangent line to a circle from the given point.
G.C.B.5 Find arc lengths and areas of sectors and circles.	MP.5 Use appropriate tools strategically. MP.6 Attend to precision.	**<u>Example</u>:** Given circle C and points A and B on the circle a. Find the arc length AB. b. Find area of the shaded sector. **Example:** Derive the formula for arc length using the formula for circumference. **Example:** Derive the formula for the area of a sector using the formula for the area of a circle.

Geometry: Expressing Geometric Properties with Equations		
College and Career Readiness Cluster		
Translate Between the Geometry Description and the Equation for a Conic Section.		
Mathematically proficient students communicate precisely by engaging in discussion about their reasoning using appropriate mathematical language. The terms students should learn to use with increasing precision with this cluster are: **center, radius, circle, standard form of the equation of a circle**		
Enduring Understandings: Algebraic equations can be used to model circles. **Essential Questions:** How can we use algebra to model the geometric concept of a circle? How can we recognize that a given equation represents a circle?		
College and Career Readiness Standards *Students are expected to:*	**Mathematical Practices**	**Unpacking Explanations and Examples** *What does this standard mean that a student will know and be able to do?*
G.GPE.A.1 Derive the equation of a circle of given center and radius using the Pythagorean Theorem.	MP.1 Make sense of problems and persevere in solving them. MP.4 Model with mathematics.	With the exception of completing the square, students should be able to write equations in standard form given a center and radius or a graph. They should also be able to graph a standard form equation of a circle. **<u>Example</u>:** Write the equation of the circle with center (5, -3) and radius 4.

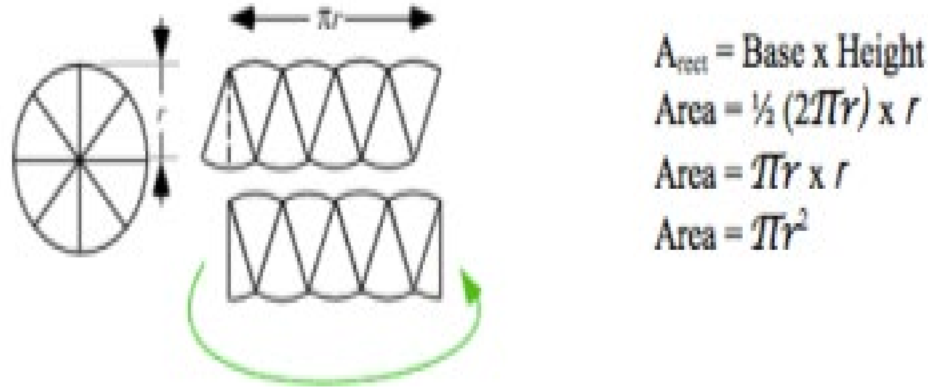
Geometry: Expressing Geometric Properties with Equations		
College and Career Readiness Cluster		
Use coordinates to prove simple geometric theorems algebraically		
Mathematically proficient students communicate precisely by engaging in discussion about their reasoning using appropriate mathematical language. The terms students should learn to use with increasing precision with this cluster are: **coordinates, slope, parallel, perpendicular, perimeter, prove, disprove, distance formula**		
Enduring Understandings: Geometric theorems or relationships can be proven using Cartesian Coordinates. **Essential Questions:** How do we use coordinates to prove simple geometric theorems algebraically?		
College and Career Readiness Standards *Students are expected to:*	**Mathematical Practices**	**Unpacking Explanations and Examples** *What does this standard mean that a student will know and be able to do?*
G.GPE.B.4 Use coordinates to prove simple geometric theorems algebraically. For example, prove or disprove that a figure defined by four given points in the coordinate plane is a rectangle; prove or disprove that	MP.3 Construct viable arguments and critique the reasoning of others.	**Example**: The coordinates for the vertices of quadrilateral MNPQ are $M(3,0)$, $N(1,3)$, $P(-2,1)$, and $Q(0,-2)$. a. Classify quadrilateral MNPQ. b. Identify the properties used to determine your classification c. Use slope and length to provide supporting evidence of the properties **Example**: If quadrilateral $ABCD$ is a rectangle, where $A(1, 2)$, $B(6, 0)$, $C(10, 10)$ and D is unknown. a. Find the coordinates of the D. b. Verify that $ABCD$ is a rectangle providing evidence related to the sides and angles.

the point $(1,\sqrt{3})$ lies on the circle centered at the origin and containing the point (0,2).		
G.GPE.B.5 Prove the slope criteria for parallel and perpendicular lines and use them to solve geometric problems (e.g., find the equation of a line parallel or perpendicular to a given line that passes through a given point).	MP.3 Construct viable arguments and critique the reasoning of others.	**<u>Example</u>**: Suppose a line k in a coordinate plane has slope $\frac{c}{d}$. a. What is the slope of a line parallel to k? Why must this be the case? b. What is the slope of a line perpendicular to k? Why does this seem reasonable? **<u>Example</u>**: Two points $A(0,-4)$, $B(2,-1)$ determines a line, AB. a. What is the equation of the line AB? b. What is the equation of the line perpendicular to line AB. passing through the point $(2,-1)$?

G.GPE.B.6 Find the point on a ray between two given points that partitions the segment in a given ratio.	MP.5 Use appropriate tools strategically.	**Example:** Construct point C on segment AB such that AC is one seventh of AB.

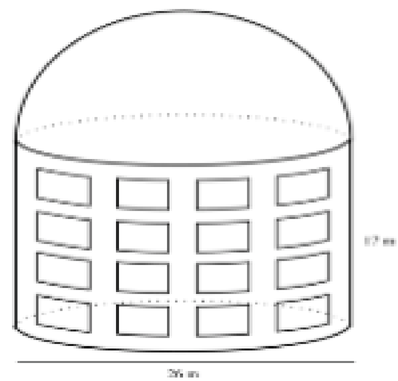
G.GPE.B.7 Use coordinates to compute perimeters of polygons and areas of triangles and rectangles, e.g., using the distance formula.	MP.5 Use appropriate tools strategically.	**<u>Example</u>**: Calculate the area of triangle ABC with altitude CD, given A (-4,-2), B(8,7), C(1, 8) and D(4, 4). **<u>Example</u>**: Find the perimeter and area of a rectangle with vertices at C (-1, 1), D(3,4), E(6, 0), F (2, -3). Round your answer to the nearest hundredth.

Geometry: Geometric Measurement and Dimension		
College and Career Readiness Cluster		
Explain Volume Formulas and Use them to Solve Problems.		
Mathematically proficient students communicate precisely by engaging in discussion about their reasoning using appropriate mathematical language. The terms students should learn to use with increasing precision with this cluster are: **area, surface area, lateral area, volume.**		
Enduring Understandings: Volume is related to area of the base and the height of a solid. **Essential Question:** How are the dimensions of a solid related to its volume?		
College and Career Readiness Standards *Students are expected to:*	**Mathematical Practices**	**Unpacking Explanations and Examples** *What does this standard mean that a student will know and be able to do?*
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	MP.3 Construct viable arguments and critique the reasoning of others.	**Example:** Circumference of a circle: Students begin with the measure of the diameter of the circle or the radius of the circle. They can use string or pipe cleaner to represent the measurement. Next, students measure the distance around the circle using the measure of the diameter. They discover that there are 3 diameters around the circumference with a small gap remaining. Through discussion, students conjecture that the circumference is the length of the diameter π times. Therefore, the circumference can be written as $C=\pi d$. When measuring the circle using the radius, students discover there are 6 radii around the circumference with a small gap remaining. Students conjecture that the circumference is the length of the radius 2π times. Therefore, the circumference of the circle can also be expressed using $C=2\pi r$. Area of a circle: Students may use dissection arguments for the area of a circle.

principle, and informal limit arguments.		 Dissect portions of the circle like pieces of a pie and arrange the pieces into a figure resembling a parallelogram as indicated below. Reason that the base is half of the circumference and the height is the radius. Students use the formula for the area of a parallelogram to derive the area of the circle. Volume of a cylinder: Students develop the formula for the volume of a cylinder based on the area of a circle stacked over and over again until the cylinder has the given height.

Therefore the formula for the volume of a cylinder is $V=Bh$. This approach is similar to Cavalieri's principle. In Cavalieri's principle, the cross-sections of the cylinder are circles of equal area, which stack to a

specific height. Volume of a pyramid or cone: For pyramids and cones, the factor $1/3$ will need some explanation. An informal demonstration can be done using a volume relationship set of plastic shapes that permit one to pour liquid or sand from one shape into another. Another way to do this for pyramids is with Geoblocks. The set includes three pyramids with equal bases and altitudes that will stack to form a cube. An algebraic approach involves the formula for the sum of squares ($12 + 22 + \cdots + n2$). After the coefficient $1/3$ has been justified for the formula of the volume of the pyramid ($A = 1/3Bh$), one can argue that it must also apply to the formula of the volume of the cone by considering a cone to be a pyramid that has a base with infinitely many sides. Informal limit arguments are not the intent at this level.

G.GMD.A.3 Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.	MP.5 Use appropriate tools strategically.	**<u>Example</u>**: The Southern African Large Telescope (SALT) is housed in a cylindrical building with a domed roof in the shape of a hemisphere. The height of the building wall is 17 m and the diameter is 26 m. To program the ventilation system for heat, air conditioning, and dehumidifying, the engineers need the amount of air in the building. What is the volume of air in the building? 

Trigonometry: Trigonometric Functions		
College and Career Readiness Cluster		
Model periodic phenomena with trigonometric functions.		
Mathematically proficient students communicate precisely by engaging in discussion about their reasoning using appropriate mathematical language. The terms students should learn to use with increasing precision with this cluster are: **sine, inverse sine, cosine, inverse cosine, tangent, inverse tangent.**		
Enduring Understandings: Inverse functions can be used to solve trigonometric equations. **Essential Question:** How can we use known side measurements to determine an angle's measure in a right triangle? How can I tell if my calculator is in radians?		
College and Career Readiness Standards *Students are expected to:*	**Mathematical Practices**	**Unpacking Explanations and Examples** *What does this standard mean that a student will know and be able to do?*
T.TF.B.7 Use inverse functions to solve trigononmetric equations that arise in a modeling context; evaluate the solutions using technology, and interpret them in terms of the context.	MP.3 Construct viable arguments and critique the reasoning of others.	**Example:** Given right triangle ABC whose hypotenuse, AB = 10 feet, and whose leg BC = 7 feet, find the measure of angle B.