<table>
<tr><td>GEOMETRY Curriculum Map</td><td colspan="2">Course Title : GEOMETRY
Course Description: This course is designed to emphasize the study of the properties and applications of common geometric figures in two and three dimensions. It includes the study of transformations and right triangle trigonometry. Inductive and deductive thinking skills are used in problem solving situations, and applications to the real world are stressed. It also emphasizes writing proofs to solve (prove) properties of geometric figures. Students who complete Geometry should take Algebra II next.
Length of Course : One (1) Year / Two (2) Semesters</td></tr>
<tr><td><u>Unit-1:</u>
An Informal Introduction to Geometry
Essential Questions</td><td colspan="2">Draw and name geometry shapes and things
Know how a drawing and a construction in geometry are the same and how they are not the same.
Use geometry software to draw and learn about many geometric figures.
Find things that do not change in geometry, numbers and in space.
Make conjectures about parallel lines, angles in a triangle, and angles in polygons.
Make conjectures about concurrence of lines, and collinearity of points.</td></tr>
<tr><td>Standards</td><td colspan="2">G-CO.12 Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.).
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).
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).

MP-1 Make sense of problems and persevere in solving them (tinkering)
MP-7 Look for and make use of structure (reducing problems to simpler ones)</td></tr>
<tr><td>Concepts and Skills</td><td>An Informal Introduction to Geometry</td><td>● Picturing and Drawing
● Constructing
● Geometry Software
● Invariants</td></tr>
<tr><td>Content Objectives

SWBAT:</td><td colspan="2">Visualize objects and draw two and three-dimensional objects.
Discover the difference between a drawing and a geometry construction.
Use geometry software to learn about the features of many geometric figures.
Look for numerical, geometric and spatial invariants and make conjectures about parallel lines, angles in a triangle, angles in polygons, concurrence of lines, and collinearity of points</td></tr>
</table>

Assessments/ Products	Summative assessments: ● Unit Common Assessment (Common mid-year and final exams.) ● Regular (weekly) assessments/quizzes ● Performance tasks (semester/quarter) Formative assessments: ● Presentation of student work ● Student notebooks ● Facilitated student discourse ● Questioning (T>S, S>S) of randomly called students ● Open Response questions, writing prompts ● Probing for multiple (4) representations ● Peer assessment ● Student-developed problems and solutions ● Exit ticket/poll question Using Mathematical Habits: Folding Squares pg. 65
Texts, Materials, and Resources	CME Geometry Text LHS Math Website (includes study guides, performance tasks, formative and summative assessment ideas) Khan Academy videos and assessments Glencoe Geometry Text (optional) Illustrative Mathematics Project Standards of Mathematical Practice Problem solving strategy: *Noticing* and *Wondering* Geometer's Sketchpad Geogebra.org Geogebratube.org
Vocabulary	Unit vocabulary and notation: CME Text - page 3 Point, Line, Plane, Endpoint, Segment, Intersect, Angle, Area, Volume, Density, Ratio, Proportion, Square, Cubic, Compass, Protractor, Dimension, Ideal, Infinite, Length, Distance, Vertex, Ray, Adjacent, Acute, Right, Straight, Obtuse, Reflex, Clockwise, Counter-clockwise, Vertical, Complementary, Supplementary, Linear Pair, Triangle, Isosceles, Equilateral, Quadrilateral, Parallelogram, Interior, Exterior, Collinear, Coplanar, Skew, Invariant, Congruence

<table>
<tr><td><u>Unit-2:</u>
Congruence and Proof
Essential Questions</td><td colspan="2">Compare congruent shapes using congruence notation.
Apply the fact that corresponding parts of congruent triangles are congruent (CPCTC).
Prove two theorems:
The Alternate Interior Parallel Theorem (AIP Theorem)
The Parallel Alternate Interior Theorem (PAI Theorem)
Write proofs in different ways and prove that the sum of the measures of the angles of a triangle is 180^{o}.
Analyze and explain your way of proving properties of quadrilaterals.
Explain and show examples of the difference between a statement and its converse.</td></tr>
<tr><td>Standards</td><td colspan="2">G-CO.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.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.8 Explain how the criteria for triangle congruence (ASA, SAS, and SSS) follow from the definition of congruence in terms of rigid motions.
G-CO.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.
G-CO.10 Prove theorems about triangles. Theorems include: measures of interior angles of a triangle sum to 180 degrees; 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.11 Prove 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.
MA.11a. Prove theorems about polygons. Theorems include: measures of interior and exterior angles, properties of inscribed polygons.
MP-3 Construct viable arguments and critique the reasoning of others.
MP-8 Look for and express regularity in repeated reasoning (generalizing repeated calculations)</td></tr>
<tr><td>Concepts and Skills</td><td>Congruence and Proof</td><td>• The Congruence Relationship
• Proof and Parallel Lines
• Writing Proofs
• Quadrilaterals and Their Properties</td></tr>
<tr><td>Content Objectives

SWBAT:</td><td colspan="2">Determine that two figures are congruent using the correct congruence notation, as well as understand that the corresponding parts of congruent triangles are congruent (CPCTC).
Prove two important theorems:
• The Alternate Interior Parallel Theorem (AIP Theorem)
• The Parallel Alternate Interior Theorem (PAI Theorem)
Write proofs using several different methods and prove the statement that the sum of the measures of the angles of a triangle is 180^{o}.
Apply their skills of analysis and exposition to the proof of some important properties of quadrilaterals.
Comprehend the difference between a statement and its converse.</td></tr>
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Assessments/ Products	Summative assessments: • Unit Common Assessment (Common mid-year and final exams.) • Regular (weekly) assessments/quizzes • Performance tasks (semester/quarter) Formative assessments: • Presentation of student work • Student notebooks • Facilitated student discourse • Questioning (T>S, S>S) of randomly called students • Open Response questions, writing prompts • Probing for multiple (4) representations • Peer assessment • Student-developed problems and solutions • Exit ticket/poll question Using Mathematical Habits Dividing Into Congruent Pieces pg. 161
Texts, Materials, and Resources	CME Geometry Text LHS Math Website (includes study guides, performance tasks, formative and summative assessment ideas) Khan Academy videos and assessments Glencoe Geometry Text (optional) Illustrative Mathematics Project Standards of Mathematical Practice Problem solving strategy: *Noticing* and *Wondering* Geometer's Sketchpad Geogebra.org Geogebratube.org
Vocabulary	Unit vocabulary and notation: CME Text - page 71 Transversal, Alternate, Consecutive, Perpendicular Bisector, Median, Triangle, Isosceles, Scalene, Equilateral, Equilateral, Midpoint, Base, Leg, Invariant, Congruence, Corresponding, Deduction, Proof, Parallel, Perpendicular, Concurrent, Identical, Polygon, Inscribed, Quadrilateral, Square, Rectangle, Parallelogram, Rhombus, Kite, Diagonal, Midsegment, Bisect, Equidistant

Unit-3: Dissections and Area **Essential Questions**	Cut and combine figures to make figures with the same area. Explain the method you used to cut and combine figures (dissections). Create area formulas for a parallelogram, a triangle and a trapezoid using dissections. Understand and explain how to create the area formulas. Analyze different drawings of the Pythagorean Theorem. Explain how surface area and volume are alike and different. Explain how special types of solids are alike and different. Explain how you created the formulas that you use. Explain how to estimate measurements. Explain how to make sense of a formula and its parts.	
Standards	**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. *Use dissection arguments, Cavalieri's principle, and informal limit arguments.* **MP-1** Make sense of problems and persevere in solving them (tinkering) **MP-4** Model with mathematics. **MP-6** Attend to precision. **MP-7** Look for and make use of structure (reducing problems to simpler ones) **MP-8** Look for and express regularity in repeated reasoning (generalizing repeated calculations)	
Concepts and Skills	**Dissections and Area**	• Cut and Rearrange • Area Formulas • Proof by Dissection • Measuring Solids
Content Objectives **SWBAT:**	Cut and rearrange figures to make equal-area figures (or scissor-congruent figures). Analyze the algorithms they used for these dissections. Use their dissections to derive area formulas for a parallelogram, a triangle and a trapezoid. Understand the derivations of the area formulas. Analyze several pictorial proofs of the Pythagorean Theorem. Find relationships between surface area and volume and relationships between special types of solids. Derive the formulas that they use. Find ways to estimate measurements or make sense of a given formula.	

Assessments/ Products	Summative assessments: • Unit Common Assessment (common mid-year and final exams.) • Regular (weekly) assessments/quizzes • Performance tasks (semester/quarter) Formative assessments: • Presentation of student work • Student notebooks • Facilitated student discourse • Questioning (T>S, S>S) of randomly called students • Open Response questions, writing prompts • Probing for multiple (4) representations • Peer assessment • Student-developed problems and solutions • Exit ticket/poll question Using Mathematical Habits Surface Area and Volume of a Sphere pg. 254
Texts, Materials, and Resources	CME Geometry Text LHS Math Website (includes study guides, performance tasks, formative and summative assessment ideas) Khan Academy videos and assessments Glencoe Geometry Text (optional) Illustrative Mathematics Project Standards of Mathematical Practice Problem solving strategy: *Noticing* and *Wondering* Geometer's Sketchpad Geogebra.org Geogebratube.org
Vocabulary	Unit vocabulary and notation: CME Text - page 169 Perimeter, Square, Rectangle, Triangle, Circle, Base Length, Width, Height, Altitude, Radius, Diameter, Diagonal, Perpendicular, Hypotenuse, Volume, Solid, Cubic, Total Surface Area, Lateral Surface Area, Net, Slant Height, Height, Base, Pyramid, Cone, Cylinder, Circumference, Area,

Unit-4: Similarity **Essential Questions**	Find and explain the scale factors of a copy of a figure. Analyze and apply ratios and proportions between figures. Create tests to see which figures are scaled copies of each other. Construct dilations in two ways: The ratio method The parallel method Apply the Parallel and Proportional Side-Splitter Theorems to: Know if polygons are scaled copies of each other. To prove other geometric results. Adapt the tests for congruent triangles to make tests for similar triangles. Compare the ratio of the corresponding sides of two similar figures and the ratio of the areas of the figures.	
Standards	**G-SRT.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. 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 and the proportionality of all corresponding pairs of sides. 3. Use the properties of similarity transformations to establish the Angle-Angle criterion (AA) for two triangles to be similar. 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.* 5 Use congruence and similarity criteria for triangles to solve problems and to prove relationships in geometric figures. **MP-1** Make sense of problems and persevere in solving them (tinkering) **MP-4** Model with mathematics. **MP-5** Use appropriate tools strategically. **MP-8** Look for and express regularity in repeated reasoning.	
Concepts and Skills	**Similarity**	● Scaled Copies ●Curved or Straight? Just Dilate! ●The Side-Splitter Theorems ● Defining Similarity
Content Objectives **SWBAT:**	Recognize the attributes of a well-scaled copy of a figure. Develop the idea of proportionality between figures. Develop tests to decide whether figures are scaled copies of each other. Construct dilations using two techniques: The ratio method	

	The parallel method Apply the Parallel and Proportional Side-Splitter Theorems in order to identify polygons as scaled copies of each other as well as to prove other geometric results. Adapt the familiar tests for triangle congruence to develop a set of tests for triangle similarity. See the relationship between the ratio of the corresponding sides of two similar figures and the ratio of the areas of the figures.
Assessments/ Products	Summative assessments: • Unit Common Assessment (common mid-year and final exams.) • Regular (weekly) assessments/quizzes • Performance tasks (semester/quarter) Formative assessments: • Presentation of student work • Student notebooks • Facilitated student discourse • Questioning (T>S, S>S) of randomly called students • Open Response questions, writing prompts • Probing for multiple (4) representations • Peer assessment • Student-developed problems and solutions • Exit ticket/poll question • Using Mathematical Habits Midpoint Quadrilaterals pg. 344
Texts, Materials, and Resources	CME Geometry Text LHS Math Website (includes study guides, performance tasks, formative and summative assessment ideas) Khan Academy videos and assessments Glencoe Geometry Text (optional) Illustrative Mathematics Project Standards of Mathematical Practice Problem solving strategy: *Noticing* and *Wondering* Geometer's Sketchpad Geogebra.org Geogebratube.org
Vocabulary	Unit vocabulary and notation: CME Text - page 261 Dilation, Center, Scale Factor, Stretch, Expand, Contract, Reduce, Ratio, Proportion, Similar, Congruent, Corresponding, Transformation, Similar Transformation, Congruent Transformation

Unit-5: Circles **Essential Questions**	Estimate the areas of blobs (i.e. irregular shapes with rounded sides). Prove Theorem 5.4 which says that the area of a circle with radius r is kr^2, where k is the area of a circle with a radius of one unit. Explore geometric probability using the Monte Carlo Method. Explain what a probability of 0 means.	
Standards	**G-C.1** Prove that all circles are similar. **G-C.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.3.** Construct the inscribed and circumscribed circles of a triangle, and prove properties of angles for a quadrilateral inscribed in a circle. MA.3a. Derive the formula for the relationship between the number of sides and sums of the interior and sums of the exterior angles of polygons and apply to the solutions of mathematical and contextual problems. **G-C.4.** (+) Construct a tangent line from a point outside a given circle to the circle. **MP-4** Model with mathematics. **MP-8** Look for and express regularity in repeated reasoning	
Concepts and Skills	**Circles**	• Area and Circumference • Circles and π • Classical Results About Circles • Geometric Probability
Content Objectives **SWBAT:**	Estimate the areas of blobs (i.e. irregular shapes with rounded edges). Prove Theorem 5.4 which states the area of a circle with radius r is kr^2, where k is the area of a circle and with radius one. Explore geometric probability using the Monte Carlo Method. Discuss whether a probability of 0 implies that a certain event is impossible.	
Assessments/ Products	Summative assessments: • Unit Common Assessment (practice version attached) • Regular (weekly) assessments/quizzes • Performance tasks (semester/quarter)	

	Formative assessments: • Presentation of student work • Student notebooks • Facilitated student discourse • Questioning (T>S, S>S) of randomly called students • Open Response questions, writing prompts • Probing for multiple (4) representations • Peer assessment • Student-developed problems and solutions • Exit ticket/poll question • Using Mathematical Habits Another Interesting Curve pg. 434
Texts, Materials, and Resources	CME Geometry Text LHS Math Website (includes study guides, performance tasks, formative and summative assessment ideas) Khan Academy videos and assessments Glencoe Geometry Text (optional) Illustrative Mathematics Project Standards of Mathematical Practice Problem solving strategy: *Noticing* and *Wondering* Geometer's Sketchpad Geogebra.org Geogebratube.org
Vocabulary	Unit vocabulary and notation: CME Text – page 353 Circle, Diameter, Radius, Circumference, Area, Chord, Center, Equidistant, Central, Inscribed, Circumscribed, Tangent, Polygon, Convex, Concave, Regular, Interior Angle, Extended Side, Exterior Angle, Diagonal

Unit-6: Using Similarity Essential Questions	Understand proofs using similarity, including: new proofs of the Pythagorean Theorem, concurrence of medians, and The Arithmetic-Geometric Mean Inequality. Know and apply trigonometry using ratios of sides in triangles. Use these trig ratios and their inverses to: find the lengths of sides, and Find the measures of angles in triangles. Explain the volume formulas that were used in chapter 4 using Cavalieri's Principle.	
Standards	**G-SRT.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. 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 and the proportionality of all corresponding pairs of sides. 3. Use the properties of similarity transformations to establish the Angle-Angle criterion (AA) for two triangles to be similar. 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.* 5 Use congruence and similarity criteria for triangles to solve problems and to prove relationships in geometric figures. **MP-1** Make sense of problems and persevere in solving them (tinkering) **MP-5** Use appropriate tools strategically. **MP-8** Look for and express regularity in repeated reasoning.	
Concepts and Skills	**Using Similarity**	●Some Uses of Similarity ●Exploring Right Triangles ●Volume Formulas
Content Objectives **SWBAT:**	Study classical geometry proofs using similarity, including new proofs of the Pythagorean Theorem and concurrence of medians, as well as the Arithmetic-Geometric Mean Inequality. Focus on the definition of trigonometric functions as ratios of side lengths in triangles. Use these functions and their inverses to determine unknown side lengths and angle measures in triangles. Justify the volume formulas that were previously presented in chapter 4 using Cavalieri's Principle.	

Assessments/ Products	Summative assessments: • Unit Common Assessment (common mid-year and final exams) • Regular (weekly) assessments/quizzes • Performance tasks (semester/quarter) Formative assessments: • Presentation of student work • Student notebooks • Facilitated student discourse • Questioning (T>S, S>S) of randomly called students • Open Response questions, writing prompts • Probing for multiple (4) representations • Peer assessment • Student-developed problems and solutions • Exit ticket/poll question • Using Mathematical Habits Demonstrating a Volume Relationship pg 527
Texts, Materials, and Resources	CME Geometry Text LHS Math Website (includes study guides, performance tasks, formative and summative assessment ideas) Khan Academy videos and assessments Glencoe Geometry Text (optional) Illustrative Mathematics Project Standards of Mathematical Practice Problem solving strategy: *Noticing* and *Wondering* Geometer's Sketchpad Geogebra.org Geogebratube.org
Vocabulary	Unit vocabulary and notation: CME Text – page 441 Midsegment, median, centroid, concurrent, parallel, proportional, similar, congruent, corresponding, scale factor, dilation, right triangle, leg, hypotenuse, sine, cosine, tangent, opposite, adjacent, dissect, combine, rectangle square, triangle, parallelogram, quadrilateral, diagonal

Unit-7: Coordinates and Vectors **Essential Questions**	Use paper folding and constructions to draw reflections and combinations of reflections. Make translations and rotations of figures. Use midpoints and distance to find lengths of segments. Prove if three points are collinear (on the same line). Show which lines are parallel or perpendicular. Use points on a graph to add and to multiply any number. Use vectors to find an equivalent equation of a line.
Standards	**G.CO Experiment with transformations in the plane.** 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. 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). 3. Given a rectangle, parallelogram, trapezoid, or regular polygon, describe the rotations and reflections that carry it onto itself. 4. Develop definitions of rotations, reflections, and translations in terms of angles, circles, perpendicular lines, parallel lines, and line segments. 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. **Understand congruence in terms of rigid motions.** 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. 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. 8. Explain how the criteria for triangle congruence (ASA, SAS, and SSS) follow from the definition of congruence in terms of rigid motions. **Prove geometric theorems.** [1] 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.* 10. Prove theorems about triangles. *Theorems include: measures of interior angles of a triangle sum to 180 degrees; 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.*

<table>
<tr><td></td><td colspan="2">G.GPE Expressing Geometric Properties with Equations Translate between the geometric description and the equation for a conic section.
1. Derive the equation of a circle of given center and radius using the Pythagorean Theorem; complete the square to find the center and radius of a circle given by an equation.
2. Derive the equation of a parabola given a focus and a directrix.
Use coordinates to prove simple geometric theorems algebraically.
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 the point (1,) lies on the circle centered at the origin and containing the point (0, 2).
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).
6. Find the point on a directed line segment between two given points that partitions the segment in a given ratio.
7. Use coordinates to compute perimeters of polygons and areas of triangles and rectangles, e.g., using the distance formula.

MP-1 Make sense of problems and persevere in solving them (tinkering)
MP-4 Model with mathematics.</td></tr>
<tr><td>Concepts and Skills</td><td>Coordinates and Vectors</td><td>●Transformations
●Geometry in the Coordinate Plane
●Connections to Algebra</td></tr>
<tr><td>Content Objectives

SWBAT:</td><td colspan="2">Use paper folding and constructions to explore reflections and compositions of reflections.
Generate translations and rotations.
Study midpoint and distance formulas.
Prove whether three points are collinear.
Identify parallel and perpendicular lines.
Use points on the coordinate plane as algebraic objects to which they can add and by which they can multiply any real number.
Use vectors to find a new form for an equation of a line.</td></tr>
</table>

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Texts, Materials, and Resources	CME Geometry Text LHS Math Website (includes study guides, performance tasks, formative and summative assessment ideas) Khan Academy videos and assessments Glencoe Geometry Text (optional) Illustrative Mathematics Project Standards of Mathematical Practice Problem solving strategy: *Noticing* and *Wondering* Geometer's Sketchpad Geogebra.org Geogebratube.org
Vocabulary	Unit vocabulary and notation: CME Text – page 535 Collinear, composition, congruent, direction, equivalent vectors, fixed point, head, image, preimage, line of reflection, line of symmetry, maps to, ordered triple, reflection, rigid motion, rotation, slope, subscript, tail, transformation, translation, vector, prime, double prime.