Bemidji Area Schools
Outcomes in Mathematics – Geometry

	Strand	Standard	No.	Benchmark
9, 10, 11	Geometry & Measurement Geometry & Measurement	Calculate measurements of plane and solid geometric figures; know that physical measurements depend on the choice of a unit and that they are approximations.	9.3.1.1	Determine the surface area and volume of pyramids, cones and spheres. Use measuring devices or formulas as appropriate. *For example*: Measure the height and radius of a cone and then use a formula to find its volume.
			9.3.1.2	Compose and decompose two- and three-dimensional figures; use decomposition to determine the perimeter, area, surface area and volume of various figures. *For example*: Find the volume of a regular hexagonal prism by decomposing it into six equal triangular prisms.
			9.3.1.3	Understand that quantities associated with physical measurements must be assigned units; apply such units correctly in expressions, equations and problem solutions that involve measurements; and convert between measurement systems. *For example*: 60 miles/hour = 60 miles/hour × 5280 feet/mile × 1 hour/3600 seconds = 88 feet/second.
			9.3.1.4	Understand and apply the fact that the effect of a scale factor k on length, area and volume is to multiply each by k, k^2 and k^3, respectively.
			9.3.1.5	Make reasonable estimates and judgments about the accuracy of values resulting from calculations involving measurements. *For example*: Suppose the sides of a rectangle are measured to the nearest tenth of a centimeter at 2.6 cm and 9.8 cm. Because of measurement errors, the width could be as small as 2.55 cm or as large as 2.65 cm, with similar errors for the height. These errors affect calculations. For instance, the actual area of the rectangle could be smaller than 25 cm^2 or larger than 26 cm^2, even though $2.6 \times 9.8 = 25.48$.

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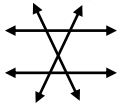
9, 10, 11	Geometry & Measurement	Construct logical arguments, based on axioms, definitions and theorems, to prove theorems and other results in geometry.	9.3.2.1	Understand the roles of axioms, definitions, undefined terms and theorems in logical arguments.
			9.3.2.2	Accurately interpret and use words and phrases in geometric proofs such as "if…then," "if and only if," "all," and "not." Recognize the logical relationships between an "if…then" statement and its inverse, converse and contrapositive. *For example*: The statement "If you don't do your homework, you can't go to the dance" is not logically equivalent to its inverse "If you do your homework, you can go to the dance."
			9.3.2.3	Assess the validity of a logical argument and give counterexamples to disprove a statement.
			9.3.2.4	Construct logical arguments and write proofs of theorems and other results in geometry, including proofs by contradiction. Express proofs in a form that clearly justifies the reasoning, such as two-column proofs, paragraph proofs, flow charts or illustrations. *For example*: Prove that the sum of the interior angles of a pentagon is 540˚ using the fact that the sum of the interior angles of a triangle is 180˚.
			9.3.2.5	Use technology tools to examine theorems, test conjectures, perform constructions and develop mathematical reasoning skills in multi-step problems. The tools may include compass and straight edge, dynamic geometry software, design software or Internet applets.
		Know and apply properties of geometric figures to solve real-world and mathematical problems and to logically justify results in geometry.	9.3.3.1	Know and apply properties of parallel and perpendicular lines, including properties of angles formed by a transversal, to solve problems and logically justify results. *For example*: Prove that the perpendicular bisector of a line segment is the set of all points equidistant from the two endpoints, and use this fact to solve problems and justify other results.
			9.3.3.2	Know and apply properties of angles, including corresponding, exterior, interior, vertical, complementary and supplementary angles, to solve problems and logically justify results. *For example*: Prove that two triangles formed by a pair of intersecting lines and a pair of parallel lines (an "X" trapped between two parallel lines) are similar. 

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	Strand	Standard	No.	Benchmark
9, 10, 11	Geometry & Measurement	Know and apply properties of geometric figures to solve real-world and mathematical problems and to logically justify results in geometry.	9.3.3.3	Know and apply properties of equilateral, isosceles and scalene triangles to solve problems and logically justify results. *For example*: Use the triangle inequality to prove that the perimeter of a quadrilateral is larger than the sum of the lengths of its diagonals.
			9.3.3.4	Apply the Pythagorean Theorem and its converse to solve problems and logically justify results. *For example*: When building a wooden frame that is supposed to have a square corner, ensure that the corner is square by measuring lengths near the corner and applying the Pythagorean Theorem.
			9.3.3.5	Know and apply properties of right triangles, including properties of 45-45-90 and 30-60-90 triangles, to solve problems and logically justify results. *For example*: Use 30-60-90 triangles to analyze geometric figures involving equilateral triangles and hexagons. *Another example*: Determine exact values of the trigonometric ratios in these special triangles using relationships among the side lengths.
			9.3.3.6	Know and apply properties of congruent and similar figures to solve problems and logically justify results. *For example*: Analyze lengths and areas in a figure formed by drawing a line segment from one side of a triangle to a second side, parallel to the third side. *Another example*: Determine the height of a pine tree by comparing the length of its shadow to the length of the shadow of a person of known height. *Another example*: When attempting to build two identical 4-sided frames, a person measured the lengths of corresponding sides and found that they matched. Can the person conclude that the shapes of the frames are congruent?
			9.3.3.7	Use properties of polygons—including quadrilaterals and regular polygons—to define them, classify them, solve problems and logically justify results. *For example*: Recognize that a rectangle is a special case of a trapezoid. *Another example*: Give a concise and clear definition of a kite.
			9.3.3.8	Know and apply properties of a circle to solve problems and logically justify results. *For example*: Show that opposite angles of a quadrilateral inscribed in a circle are supplementary.

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9, 10, 11	Geometry & Measurement	Solve real-world and mathematical geometric problems using algebraic methods.	9.3.4.1	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.
			9.3.4.2	Apply the trigonometric ratios sine, cosine and tangent to solve problems, such as determining lengths and areas in right triangles and in figures that can be decomposed into right triangles. Know how to use calculators, tables or other technology to evaluate trigonometric ratios. *For example*: Find the area of a triangle, given the measure of one of its acute angles and the lengths of the two sides that form that angle.
			9.3.4.3	Use calculators, tables or other technologies in connection with the trigonometric ratios to find angle measures in right triangles in various contexts.
			9.3.4.4	Use coordinate geometry to represent and analyze line segments and polygons, including determining lengths, midpoints and slopes of line segments.
			9.3.4.5	Know the equation for the graph of a circle with radius r and center (h,k), $(x-h)^2 + (y-k)^2 = r^2$, and justify this equation using the Pythagorean Theorem and properties of translations.
			9.3.4.6	Use numeric, graphic and symbolic representations of transformations in two dimensions, such as reflections, translations, scale changes and rotations about the origin by multiples of 90°, to solve problems involving figures on a coordinate grid. *For example*: If the point (3,-2) is rotated 90° counterclockwise about the origin, it becomes the point (2,3).
			9.3.4.7	Use algebra to solve geometric problems unrelated to coordinate geometry, such as solving for an unknown length in a figure involving similar triangles, or using the Pythagorean Theorem to obtain a quadratic equation for a length in a geometric figure.