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Reza Nazari

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The Most Comprehensive Review of Algebra I

By

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Number and Quantity	
The Real Number System	**HSN – RN**
A. Extend the properties of exponents to rational exponents.	
HSN – RN.A.1	Explain how the definition of the meaning of rational exponents follows from extending the properties of integer exponents to those values, allowing for a notation for radicals in terms of rational exponents.
HSN – RN.A.2	Rewrite expressions involving radicals and rational exponents using the properties of exponents.
B. Use properties of rational and irrational numbers.	
HSN – RN.B.3	Explain why the sum or product of two rational numbers is rational; that the sum of a rational number and an irrational number is irrational; and that the product of a nonzero rational number and an irrational number is irrational.
Quantities	**HSN – Q**
A. Reason quantitatively and use units to solve problems.	
HSN – Q.A.1	Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
HSN – Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
HSN – Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
The Complex Number System	**HSN – CN**
A. Perform arithmetic operations with complex numbers.	
HSN – CN.A.1	Know there is a complex number i such that $i^2 = -1$, and every complex number has the form $a + bi$ with a and b real.
HSN – CN.A.2	Use the relation $i^2 = -1$ and the commutative, associative, and distributive properties to add, subtract, and multiply complex numbers.
HSN – CN.A.3	Find the conjugate of a complex number; use conjugates to find moduli and quotients of complex numbers.
B. Represent complex numbers and their operations on the complex plane.	
HSN – CN.B.4	Represent complex numbers on the complex plane in rectangular and polar form (including real and imaginary numbers), and explain why the rectangular and polar forms of a given complex number represent the same number.

HSN − CN.B.5	Represent addition, subtraction, multiplication, and conjugation of complex numbers geometrically on the complex plane; use properties of this representation for computation.
HSN − CN.B.6	Calculate the distance between numbers in the complex plane as the modulus of the difference, and the midpoint of a segment as the average of the numbers at its endpoints.
C. Use complex numbers in polynomial identities and equations.	
HSN − CN.C.7	Solve quadratic equations with real coefficients that have complex solutions.
HSN − CN.C.8	Extend polynomial identities to the complex numbers.
HSN − CN.C.9	Know the Fundamental Theorem of Algebra; show that it is true for quadratic polynomials.
Vector and Matrix Quantities	**HSN − VM**
A. Represent and model with vector quantities.	
HSN − VM.A.1	Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes
HSN − VM.A.2	Find the components of a vector by subtracting the coordinates of an initial point from the coordinates of a terminal point.
HSN − VM.A.3	Solve problems involving velocity and other quantities that can be represented by vectors.
B. Perform operations on vectors.	
HSN − VM.B.4	Add and subtract vectors. a. Add vectors end-to-end, component-wise, and by the parallelogram rule. Understand that the magnitude of a sum of two vectors is typically not the sum of the magnitudes. b. Given two vectors in magnitude and direction form, determine the magnitude and direction of their sum. c. Understand vector subtraction $v - w$ as $v + (-w)$, where $-w$ is the additive inverse of w, with the same magnitude as w and pointing in the opposite direction. Represent vector subtraction graphically by connecting the tips in the appropriate order and perform vector subtraction component-wise.
HSN − VM.B.5	Multiply a vector by a scalar. a. Represent scalar multiplication graphically by scaling vectors and possibly reversing their direction; perform scalar multiplication component-wise. b. Compute the magnitude of a scalar multiple cv using $\|\|cv\|\| = \|c\|v$. Compute the direction of cv knowing that when $\|c\|v \neq 0$, the direction of cv is either along v (for $c > 0$) or against v (for $c < 0$).

C. Perform operations on matrices and use matrices in applications.	
HSN – VM. C. 6	Use matrices to represent and manipulate data, e.g., to represent payoffs or incidence relationships in a network.
HSN – VM. C. 7	Multiply matrices by scalars to produce new matrices, e.g., as when all of the payoffs in a game are doubled.
HSN – VM. C. 8	Add, subtract, and multiply matrices of appropriate dimensions.
HSN – VM. C. 9	Understand that, unlike multiplication of numbers, matrix multiplication for square matrices is not a commutative operation, but still satisfies the associative and distributive properties.
HSN – VM. C. 10	Understand that the zero and identity matrices play a role in matrix addition and multiplication similar to the role of 0 and 1 in the real numbers. The determinant of a square matrix is nonzero if and only if the matrix has a multiplicative inverse.
HSN – VM. C. 11	Multiply a vector (regarded as a matrix with one column) by a matrix of suitable dimensions to produce another vector. Work with matrices as transformations of vectors.
HSN – VM. C. 12	Work with 2 × 2 matrices as transformations of the plane and interpret the absolute value of the determinant in terms of area.

Algebra	
Seeing Structure in Expressions	**HSA – SSE**
A. Interpret the structure of expressions	
HSA – SSE. A. 1	Interpret expressions that represent a quantity in terms of its context. a. Interpret parts of an expression, such as terms, factors, and coefficients. b. Interpret complicated expressions by viewing one or more of their parts as a single entity.
HSA – SSE. A. 2	Use the structure of an expression to identify ways to rewrite it.
B. Write expressions in equivalent forms to solve problems	
HSA – SSE. B. 3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. a. Factor a quadratic expression to reveal the zeros of the function it defines. b. Complete the square in a quadratic expression to reveal the maximum or minimum value of the function it defines. c. Use the properties of exponents to transform expressions for exponential functions.

HSG – CO.C.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.
D. Make geometric constructions	
HSG – CO.D.12	Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.). Copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.
HSG – CO.D.13	Construct an equilateral triangle, a square, and a regular hexagon inscribed in a circle.
Similarity, Right Triangles, and Trigonometry	**HSG – SRT**
A. Understand similarity in terms of similarity transformations	
HSG – SRT.A.1	Verify experimentally the properties of dilations given by a center and a scale factor: a. A dilation takes a line not passing through the center of the dilation to a parallel line and leaves a line passing through the center unchanged. b. The dilation of a line segment is longer or shorter in the ratio given by the scale factor.
HSG – 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 and the proportionality of all corresponding pairs of sides.
HSG – SRT.A.3	Use the properties of similarity transformations to establish the *AA* criterion for two triangles to be similar.
B. Prove theorems involving similarity	
HSG – 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.
HSG – SRT.B.5	Use congruence and similarity criteria for triangles to solve problems and to prove relationships in geometric figures.
C. Define trigonometric ratios and solve problems involving right triangles	
HSG – 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.

HSG – SRT.C.7	Explain and use the relationship between the sine and cosine of complementary angles.
HSG – SRT.C.8	Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems
D. Apply trigonometry to general triangles	
HSG – SRT.D.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.
HSG – SRT.D.10	Prove the Laws of Sines and Cosines and use them to solve problems.
HSG – SRT.D.11	Understand and apply the Law of Sines and the Law of Cosines to find unknown measurements in right and non-right triangles (e.g., surveying problems, resultant forces).
Circles	**HSG – C**
A. Understand and apply theorems about circles	
HSG – C.A.1	Prove that all circles are similar.
HSG – C.A.2	Identify and describe relationships among inscribed angles, radii, and chords. Include the relationship between central, inscribed, and circumscribed angles; inscribed angles on a diameter are right angles; the radius of a circle is perpendicular to the tangent where the radius intersects the circle.
HSG – C.A.3	Construct the inscribed and circumscribed circles of a triangle and prove properties of angles for a quadrilateral inscribed in a circle.
HSG – C.A.4	Construct a tangent line from a point outside a given circle to the circle.
B. Find arc lengths and areas of sectors of circles	
HSG – C.B.5	Derive using similarity the fact that the length of the arc intercepted by an angle is proportional to the radius and define the radian measure of the angle as the constant of proportionality; derive the formula for the area of a sector.
Expressing Geometric Properties with Equations	**HSG – GPE**
A. Translate between the geometric description and the equation for a conic section	
HSG – GPE.A.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.
HSG – GPE.A.2	Derive the equation of a parabola given a focus and directrix.
HSG – GPE.A.3	Derive the equations of ellipses and hyperbolas given the foci, using the fact that the sum or difference of distances from the foci is constant.

B. Use coordinates to prove simple geometric theorems algebraically	
HSG – 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 the point $(1, \sqrt{3})$ lies on the circle centered at the origin and containing the point $(0, 2)$.
HSG – 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).
HSG – GPE.B.6	Find the point on a directed line segment between two given points that partitions the segment in a given ratio.
HSG – GPE.B.7	Use coordinates to compute perimeters of polygons and areas of triangles and rectangles, e.g., using the distance formula
Geometric Measurement and Dimension	**HSG – GMD**
A. Explain volume formulas and use them to solve problems	
HSG – GMD.A.1	Give an informal argument for the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid, and cone. Use dissection arguments, Cavalieri's principle, and informal limit arguments.
HSG – GMD.A.2	Give an informal argument using Cavalieri's principle for the formulas for the volume of a sphere and other solid figures.
HSG – GMD.A.3	Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.
B. Visualize relationships between two-dimensional and three-dimensional objects	
HSG – GMD.B.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.
Modeling with Geometry	**HSG – MG**
A. Apply geometric concepts in modeling situations	
HSG – MG.A.1	Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
HSG – MG.A.2	Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).
HSG – MG.A.3	Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).