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The Most Comprehensive Review of Algebra I

By

Reza Nazari

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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.

HSA – SSE.B.4	Derive the formula for the sum of a finite geometric series (when the common ratio is not 1) and use the formula to solve problems.
Arithmetic with Polynomials and Rational Expressions	**HSA – APR**
A. Perform arithmetic operations on polynomials	
HSA – APR.A.1	Understand that polynomials form a system analogous to the integers, namely they are closed under the operations of addition, subtraction, and multiplication; add, subtract, and multiply polynomials.
B. Understand the relationship between zeros and factors of polynomials	
HSA – APR.B.2	Know and apply the Remainder Theorem: For a polynomial $p(x)$ and a number a, the remainder on division by $x - a$ is $p(a)$, so $p(a) = 0$ if and only if $(x - a)$ is a factor of $p(x)$.
HSA – APR.B.3	Identify zeros of polynomials when suitable factorizations are available and use the zeros to construct a rough graph of the function defined by the polynomial.
C. Use polynomial identities to solve problems	
HSA – APR.C.4	Prove polynomial identities and use them to describe numerical relationships.
HSA – APR.C.5	Know and apply the Binomial Theorem for the expansion of $(x + y)^n$ in powers of x and y for a positive integer n, where x and y are any numbers, with coefficients determined for example by Pascal's Triangle.
D. Rewrite rational expressions	
HSA – APR.D.6	Rewrite simple rational expressions in different forms; write $a(x)/b(x)$ in the form $q(x) + r(x)/b(x)$, where $a(x), b(x), q(x)$, and $r(x)$ are polynomials with the degree of $r(x)$ less than the degree of $b(x)$, using inspection, long division, or, for the more complicated examples, a computer algebra system.
HSA – APR.D.7	Understand that rational expressions form a system analogous to the rational numbers, closed under addition, subtraction, multiplication, and division by a nonzero rational expression; add, subtract, multiply, and divide rational expressions.
Creating Equations	**HSA – CED**
A. Create equations that describe numbers or relationships	
HSA – 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.
HSA – CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.

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).

Statistics	
Interpreting Categorical and Quantitative Data	**HSS – ID**
A. Summarize, represent, and interpret data on a single count or measurement variable	
HSS – ID.A.1	Represent data with plots on the real number line (dot plots, histograms, and box plots).
HSS – ID.A.2	Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.
HSS – ID.A.3	Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).
HSS – ID.A.4	Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.
B. Summarize, represent, and interpret data on two categorical and quantitative variables	
HSS – ID.B.5	Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.
HSS – ID.B.6	Represent data on two quantitative variables on a scatter plot and describe how the variables are related. a. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models. b. Informally assess the fit of a function by plotting and analyzing residuals. c. Fit a linear function for a scatter plot that suggests a linear association.
C. Interpret linear models	
HSS – ID.C.7	Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.
HSS – ID.C.8	Compute (using technology) and interpret the correlation coefficient of a linear fit.
HSS – ID.C.9	Distinguish between correlation and causation.