Tennessee's State Mathematics Standards | Advanced Algebra and Trigonometry

	Domain	Cluster	Standard
Number and Quantity	Number Expressions (N-NE)	Represent, interpret, compare, and simplify number expressions.	1. Use the laws of exponents and logarithms to expand or collect terms in expressions; simplify expressions or modify them in order to analyze them or compare them. 2. Understand the inverse relationship between exponents and logarithms and use this relationship to solve problems involving logarithms and exponents.* 3. Classify real numbers and order real numbers that include transcendental expressions, including roots and fractions of pi and *e*. 4. Simplify complex radical and rational expressions; discuss and display understanding that rational numbers are dense in the real numbers and the integers are not. 5. 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.
	Complex numbers (N-CN)	Perform complex number arithmetic and understand the representation on the complex plane.	1. Perform arithmetic operations with complex numbers expressing answers in the form a+bi. 2. Find the conjugate of a complex number; use conjugates to find moduli and quotients of complex numbers. 3. 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. 4. Represent addition, subtraction, multiplication, and conjugation of complex numbers geometrically on the complex plane; use properties of this representation for computation. *For example,* $(-1 + \sqrt{3}i)^3 = 8$ *because* $(-1 + \sqrt{3}i)$ *has modulus* 2 *and argument* 120°. 5. 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.
		Use complex numbers in polynomial identities and equations.	6. Extend polynomial identities to the complex numbers. *For example, rewrite* $x^2 + 4$ *as* $(x+2i)(x-2i)$. 7. Know the Fundamental Theorem of Algebra; show that it is true for quadratic polynomials.

Number and Quantity

Domain	Cluster	Standard
Vector and Matrix Quantities (N-VM)	Represent and model with vector quantities.	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 (e.g., $\mathbf{v}$, $\|\mathbf{v}\|$, $\|\|\mathbf{v}\|\|$, v). 2. Find the components of a vector by subtracting the coordinates of an initial point from the coordinates of a terminal point. 3. Solve problems involving velocity and other quantities that can be represented by vectors.
	Understand the graphic representation of vectors and vector arithmetic.	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 $\mathbf{v} - \mathbf{w}$ as $\mathbf{v} + (-\mathbf{w})$, where $-\mathbf{w}$ is the additive inverse of $\mathbf{w}$, with the same magnitude as $\mathbf{w}$ and pointing in the opposite direction. Represent vector subtraction graphically by connecting the tips in the appropriate order, and perform vector subtraction component-wise. 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, e.g., as $c(v_x, v_y) = (cv_x, cv_y)$. b. Compute the magnitude of a scalar multiple $c\mathbf{v}$ using $\|\|c\mathbf{v}\|\| = \|c\|v$. Compute the direction of $c\mathbf{v}$ knowing that when $\|c\|v \neq 0$, the direction of $c\mathbf{v}$ is either along $\mathbf{v}$ (for $c > 0$) or against $\mathbf{v}$ (for $c < 0$). 6. Calculate and interpret the dot product of two vectors.
	Perform operations on matrices and use matrices in applications.	7. Use matrices to represent and manipulate data, e.g., to represent payoffs or incidence relationships in a network. 8. Multiply matrices by scalars to produce new matrices, e.g., as when all of the payoffs in a game are doubled. 9. Add, subtract, and multiply matrices of appropriate dimensions. 10. Understand that, unlike multiplication of numbers, matrix multiplication for square matrices is not a commutative operation, but still satisfies the associative and distributive properties. 11. 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. 12. 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. 13. Work with 2×2 matrices as transformations of the plane, and interpret the absolute value of the determinant in terms of area.

Algebra

Domain	Cluster	Standard
Sequences and Series (A-S)	**Understand and use sequences and series.**	1. Demonstrate an understanding of sequences by representing them recursively and explicitly. 2. Use sigma notation to represent a series; expand and collect expressions in both finite and ininite settings. 3. Derive and use the formulas for the general term and summation of finite or infinite arithmetic and geometric series, if they exist. a. Determine whether a given arithmetic or geometric series converges or diverges. b. Find the sum of a given geometric series (both infinite and finite). c. Find the sum of a finite arithmetic series. 4. Understand that series represent the approximation of a number when truncated; estimate truncation error in specific examples. 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.
Solve Equations and Inequalities (A-REI)	**Solve systems of equations and nonlinear inequalities.**	1. Represent a system of linear equations as a single matrix equation in a vector variable. 2. Find the inverse of a matrix if it exists and use it to solve systems of linear equations (using technology for matrices of dimension 3 × 3 or greater). 3. Solve nonlinear inequalities (quadratic, trigonometric, conic, exponential, logarithmic, and rational) by graphing (solutions in interval notation if one-variable), by hand and with appropriate technology. 4. Solve systems of nonlinear inequalities by graphing.
Conic Sections (A-C)	**Understand the properties of conic sections and apply them to model real-world phenomena.***	1. Display all of the conic sections as portions of a cone. 2. From an equation in standard form, graph the appropriate conic section: ellipses, hyperbolas, circles, and parabolas. Demonstrate an understanding of the relationship between their standard algebraic form and the graphical characteristics. 3. Transform equations of conic sections to convert between general and standard form.

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Functions	Building Functions (F-BF)	Build new functions from existing functions.	1. Understand how the algebraic properties of an equation transform the geometric properties of its graph. *For example, given a function, describe the transformation of the graph resulting from the manipulation of the algebraic properties of the equation (i.e., translations, stretches, and changes in periodicity and amplitude).* 2. Develop an understanding of functions as elements that can be operated upon to get new functions: addition, subtraction, multiplication, division, and composition of functions. 3. Compose functions. *For example, if T(y) is the temperature in the atmosphere as a function of height, and h(t) is the height of a weather balloon as a function of time, then T(h(t)) is the temperature at the location of the weather balloon as a function of time.* 4. Construct the difference quotient for a given function and simplify the resulting expression. 5. Find inverse functions (including exponential, trigonometric, and logarithmic). a. Calculate the inverse of a function, $f(x)$, with respect to each of the functional operations; in other words, the additive inverse, $-f(x)$, the multiplicative inverse, $\frac{1}{f(x)}$, and the inverse with respect to composition, $f^{-1}(x)$. Understand the algebraic and graphical implications of each type. b. Verify by composition that one function is the inverse of another. c. Read values of an inverse function from a graph or a table, given that the function has an inverse. d. Produce an invertible function from a non-invertible function by restricting the domain. Recognize a function is invertible if and only if it is one-to-one. 6. Explain why the graph of a function and its inverse are reflections of one another over the line y=x.
	Interpreting Functions (F-IF)	Analyze Functions using different representations.	1. Determine whether a function is even, odd, or neither. 2. Identify or analyze the distinguishing properties of exponential, polynomial, logarithmic, trigonometric, and rational functions from tables, graphs, and equations. 3. Identify the real zeros of a function and explain the relationship between the real zeros and the x-intercepts of the graph of a function (polynomial, rational, exponential, logarithmic, and trigonometric). 4. Identify characteristics of graphs based on a set of conditions or on a general equation such as $y= ax^2+ c$. 5. Visually locate critical points on the graphs of functions and determine if each critical point is a minimum, a maximum, or point of inflection. Describe intervals of concavity and increasing and decreasing. 6. Graph rational functions, identifying zeros, asymptotes (including slant), and holes when suitable factorizations are available, and showing end-behavior. 7. Solve real world problems that can be modeled using quadratic, exponential, or logarithmic functions★ (by hand and with appropriate technology).
	Trigonometric Functions (F-TF)	Extend the domain of trigonometric functions using the unit circle.	1. Convert from radians to degrees and from degrees to radians. 2. Use special triangles to determine geometrically the values of sine, cosine, tangent for $\pi/3$, $\pi/4$ and $\pi/6$, and use the unit circle to express the values of sine, cosine, and tangent for $\pi-x$, $\pi+x$, and $2\pi-x$ in terms of their values for x, where x is any real number. 3. Use the unit circle to explain symmetry (odd and even) and periodicity of trigonometric functions.
	Graphing Trigonometric Functions (G-GT)	Model periodic phenomena with trigonometric functions.★	1. Interpret transformations of trigonometric functions. 2. Match a trigonometric equation with its graph. 3. Determine the difference made by choice of units for angle measurement when graphing a trigonometric function. 4. Graph the sine, cosine, and tangent functions and identify characteristics such as period, amplitude, phase shift, and asymptotes.

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Geometry	Applied Trigonometry (G-AT)	Use trigonometry to solve problems.★	1. Use the definitions of the basic trigonometric ratios as ratios of sides in a right triangle to solve problems about lengths of sides and measures of angles. 2. 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. 3. Derive and apply the formulas for the area of sector of a circle. 4. Calculate the arc length of a circle subtended by a central angle. 5. Understand and apply the Law of Sines (including the ambiguous case) and the Law of Cosines to find unknown measurements in right and non-right triangles (e.g., surveying problems, resultant forces).
Geometry	Trigonometric Identities (G-TI)	Apply trigonometric identities to rewrite expressions and solve equations.★	1. Apply trigonometric identities to verify identities and solve equations. Identities include: Pythagorean, quotient, sum/difference, double-angle, and half-angle.
Statistics and Probability	Model with Data★ (S-MD)	Model data using regressions equations.	1. Create scatter plots, analyze patterns and describe relationships for bivariate data (linear, polynomial, trigonometric or exponential) to model real-world phenomena and to make predictions. 2. Determine a regression equation to model a set of bivariate data. Justify why this equation best fits the data. 3. Use a regression equation modeling bivariate data to make predictions. Identify possible considerations regarding the accuracy of predictions when interpolating or extrapolating.