Precalculus | Tennessee Academic Standards for Mathematics Correlation to *Eureka Math*®

About *Eureka Math*

Created by Great Minds®, a mission-driven Public Benefit Corporation, *Eureka Math*® helps teachers deliver unparalleled math instruction that provides students with a deep understanding and fluency in math. Crafted by teachers and math scholars, the curriculum carefully sequences the mathematical progressions to maximize coherence from Prekindergarten through Precalculus—a principle tested and proven to be essential in students' mastery of math.

Teachers and students using *Eureka Math* find the trademark "Aha!" moments in *Eureka Math* to be a source of joy and inspiration, lesson after lesson, year after year.

Aligned

Great Minds offers detailed analyses that demonstrate how each grade of *Eureka Math* aligns with specific state standards. Access these free alignment studies at greatminds.org/state-studies.

Data

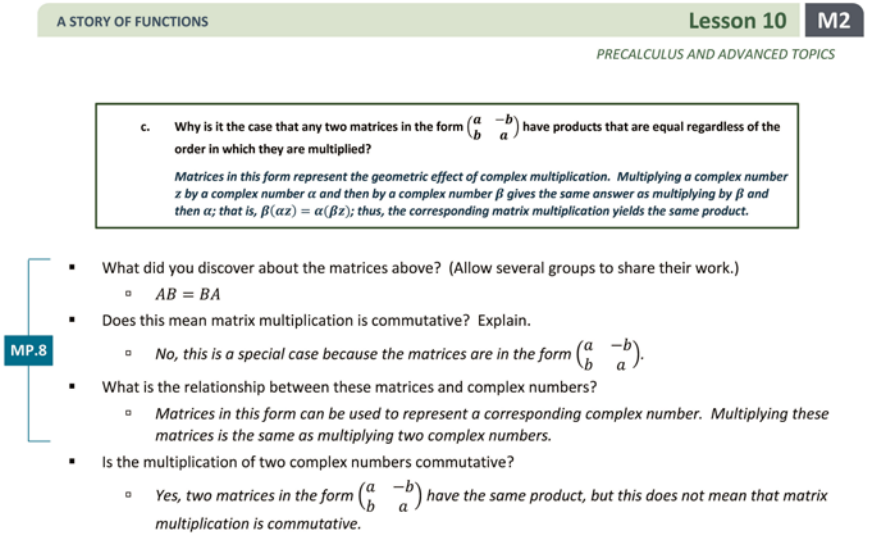
Schools and districts nationwide are experiencing student growth and impressive test scores after using *Eureka Math*. See their stories and data at greatminds.org/data.

Full Suite of Resources

Great Minds offers the *Eureka Math* curriculum as PDF downloads for free, noncommercial use. Access the free PDFs at greatminds.org/math/curriculum.

The teacher–writers who created the curriculum have also developed essential resources, available only from Great Minds, including the following:

- Printed material in English and Spanish
- Digital resources
- Professional development
- Classroom tools and manipulatives
- Teacher support materials
- Parent resources

Standards for Mathematical Practice	Aligned Components of *Eureka Math*
MP.1 Make sense of problems and persevere in solving them.	Lessons in every module engage students in mathematical practices. These are designated in the Module Overview and labeled in lessons. For example: 
MP.2 Reason abstractly and quantitatively.	
MP.3 Construct viable arguments and critique the reasoning of others.	
MP.4 Model with mathematics.	
MP.5 Use appropriate tools strategically.	
MP.6 Attend to precision.	
MP.7 Look for and make use of structure.	
MP.8 Look for and express regularity in repeated reasoning.	

Number Expressions

P.N.NE.A Represent, interpret, compare, and simplify number expressions.

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.N.NE.A.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.	Algebra II M3 Lesson 1: Integer Exponents Algebra II M3 Lesson 4: Properties of Exponents and Radicals Algebra II M3 Lesson 10: Building Logarithmic Tables Algebra II M3 Lesson 11: The Most Important Property of Logarithms Algebra II M3 Lesson 12: Properties of Logarithms Algebra II M3 Lesson 14: Solving Logarithmic Equations Algebra II M3 Lesson 15: Why Were Logarithms Developed?
P.N.NE.A.2 Understand the inverse relationship between exponents and logarithms and use this relationship to solve problems involving logarithms and exponents.	Algebra II M3 Lesson 19: The Inverse Relationship Between Logarithmic and Exponential Functions Precalculus and Advanced Topics M3 Lesson 20: Inverses of Logarithmic and Exponential Functions Precalculus and Advanced Topics M3 Lesson 21: Logarithmic and Exponential Problem Solving
P.N.NE.A.3 Classify real numbers and order real numbers that include transcendental expressions, including roots and fractions of π and e.	*Supplemental material is necessary to address this standard.*
P.N.NE.A.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.	*Supplemental material is necessary to address this standard.*

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.N.NE.A.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.	Precalculus and Advanced Topics M3 Lesson 10: The Structure of Rational Expressions Precalculus and Advanced Topics M3 Lesson 11: Rational Functions

The Complex Number System

P.N.CN.A Perform complex number arithmetic and understand the representation on the complex plane.

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.N.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.	Algebra II M1 Lesson 37: A Surprising Boost from Geometry Precalculus and Advanced Topics M1 Lesson 5: An Appearance of Complex Numbers
P.N.CN.A.2 Perform arithmetic operations with complex numbers expressing answers in the form $a + bi$.	Algebra II M1 Lesson 37: A Surprising Boost from Geometry Precalculus and Advanced Topics M1 Lesson 4: An Appearance of Complex Numbers Precalculus and Advanced Topics M1 Lesson 5: An Appearance of Complex Numbers
P.N.CN.A.3 Find the conjugate of a complex number; use conjugates to find moduli and quotients of complex numbers.	Precalculus and Advanced Topics M1 Lesson 7: Complex Number Division Precalculus and Advanced Topics M1 Lesson 8: Complex Number Division Precalculus and Advanced Topics M1 Lesson 9: The Geometric Effect of Some Complex Arithmetic Precalculus and Advanced Topics M1 Lesson 17: The Geometric Effect of Multiplying by a Reciprocal

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.N.CN.A.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.	Precalculus and Advanced Topics M1 Lesson 4: An Appearance of Complex Numbers Precalculus and Advanced Topics M1 Lesson 5: An Appearance of Complex Numbers Precalculus and Advanced Topics M1 Lesson 6: Complex Numbers as Vectors Precalculus and Advanced Topics M1 Lesson 8: Complex Number Division Precalculus and Advanced Topics M1 Topic B: Complex Number Operations and Transformations Precalculus and Advanced Topics M1 Lesson 18: Exploiting the Connection to Trigonometry Precalculus and Advanced Topics M1 Lesson 19: Exploiting the Connection to Trigonometry Precalculus and Advanced Topics M1 Lesson 20: Exploiting the Connection to Cartesian Coordinates
P.N.CN.A.5 Represent addition, subtraction, multiplication, and conjugation of complex numbers geometrically on the complex plane; use properties of this representation for computation (for example, $(-1 + 3i)^3 = 8$ because $(-1 + 3i)$ has modulus 2 and argument $120°$).	Precalculus and Advanced Topics M1 Lesson 6: Complex Numbers as Vectors Precalculus and Advanced Topics M1 Lesson 9: The Geometric Effect of Some Complex Arithmetic Precalculus and Advanced Topics M1 Lesson 10: The Geometric Effect of Some Complex Arithmetic Precalculus and Advanced Topics M1 Lesson 14: Discovering the Geometric Effect of Complex Multiplication Precalculus and Advanced Topics M1 Lesson 15: Justifying the Geometric Effect of Complex Multiplication Precalculus and Advanced Topics M1 Lesson 16: Representing Reflections with Transformations Precalculus and Advanced Topics M1 Lesson 17: The Geometric Effect of Multiplying by a Reciprocal Precalculus and Advanced Topics M1 Lesson 18: Exploiting the Connection to Trigonometry Precalculus and Advanced Topics M1 Lesson 19: Exploiting the Connection to Trigonometry Precalculus and Advanced Topics M1 Lesson 20: Exploiting the Connection to Cartesian Coordinates

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.N.CN.A.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.	Precalculus and Advanced Topics M1 Lesson 11: Distance and Complex Numbers Precalculus and Advanced Topics M1 Lesson 12: Distance and Complex Numbers

The Complex Number System

P.N.CN.B Use complex numbers in polynomial identities and equations.

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.N.CN.B.7 Extend polynomial identities to the complex numbers (for example, rewrite $x^2 + 4$ as $(x + 2i)(x - 2i)$.	Precalculus and Advanced Topics M3 Lesson 1: Solutions to Polynomial Equations Precalculus and Advanced Topics M3 Lesson 2: Does Every Complex Number Have a Square Root? Precalculus and Advanced Topics M3 Lesson 3: Roots of Unity
P.N.CN.B.8 Solve quadratic equations with real coefficients that have complex solutions.	Algebra II M1 Lesson 38: Complex Numbers as Solutions to Equations Algebra II M1 Lesson 39: Factoring Extended to the Complex Realm
P.N.CN.B.9 Know the Fundamental Theorem of Algebra; show that it is true for quadratic polynomials.	Algebra II M1 Lesson 40: Obstacles Resolved—A Surprising Result Precalculus and Advanced Topics M3 Lesson 1: Solutions to Polynomial Equations Precalculus and Advanced Topics M3 Lesson 2: Does Every Complex Number Have a Square Root? Precalculus and Advanced Topics M3 Lesson 3: Roots of Unity

Vector and Matrix Quantities

P.N.VM.A Represent and model with vector quantities.

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.N.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 (e.g., v, $\|v\|$, $\|\|v\|\|$, $\vec{v}$).	Precalculus and Advanced Topics M2 Lesson 17: Vectors in the Coordinate Plane Precalculus and Advanced Topics M2 Lesson 18: Vectors and Translation Maps Precalculus and Advanced Topics M2 Lesson 20: Vectors and Stone Bridges
P.N.VM.A.2 Find the components of a vector by subtracting the coordinates of an initial point from the coordinates of a terminal point.	Precalculus and Advanced Topics M2 Lesson 19: Directed Line Segments and Vectors
P.N.VM.A.3 Solve problems involving velocity and other quantities that can be represented by vectors.	Precalculus and Advanced Topics M2 Lesson 17: Vectors in the Coordinate Plane Precalculus and Advanced Topics M2 Lesson 20: Vectors and Stone Bridges Precalculus and Advanced Topics M2 Lesson 23: Why Are Vectors Useful?

Vector and Matrix Quantities

P.N.VM.B Understand the graphic representation of vectors and vector arithmetic.

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.N.VM.B.4 Add and subtract vectors.	*This standard is fully addressed by the lessons aligned to its subsections.*
P.N.VM.B.4a 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.	Precalculus and Advanced Topics M2 Lesson 5: Coordinates of Points in Space Precalculus and Advanced Topics M2 Lesson 6: Linear Transformations as Matrices Precalculus and Advanced Topics M2 Lesson 17: Vectors in the Coordinate Plane Precalculus and Advanced Topics M2 Lesson 18: Vectors and Translation Maps Precalculus and Advanced Topics M2 Lesson 19: Directed Line Segments and Vectors Precalculus and Advanced Topics M2 Lesson 20: Vectors and Stone Bridges Precalculus and Advanced Topics M2 Lesson 23: Why Are Vectors Useful? Precalculus and Advanced Topics M2 Lesson 24: Why Are Vectors Useful?
P.N.VM.B.4b Given two vectors in magnitude and direction form, determine the magnitude and direction of their sum.	Precalculus and Advanced Topics M2 Lesson 20: Vectors and Stone Bridges Precalculus and Advanced Topics M2 Lesson 23: Why Are Vectors Useful? Precalculus and Advanced Topics M2 Lesson 24: Why Are Vectors Useful?
P.N.VM.B.4c Understand vector subtraction $\boldsymbol{v} - \boldsymbol{w}$ as $\boldsymbol{v} + (-\boldsymbol{w})$, where $-\boldsymbol{w}$ is the additive inverse of $\boldsymbol{w}$, with the same magnitude as $\boldsymbol{w}$ and pointing in the opposite direction. Represent vector subtraction graphically by connecting the tips in the appropriate order, and perform vector subtraction component-wise.	Precalculus and Advanced Topics M2 Lesson 6: Linear Transformations as Matrices Precalculus and Advanced Topics M2 Lesson 17: Vectors in the Coordinate Plane Precalculus and Advanced Topics M2 Lesson 18: Vectors and Translation Maps Precalculus and Advanced Topics M2 Lesson 19: Directed Line Segments and Vectors Precalculus and Advanced Topics M2 Lesson 23: Why Are Vectors Useful? Precalculus and Advanced Topics M2 Lesson 24: Why Are Vectors Useful?

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.N.VM.B.5 Multiply a vector by a scalar.	*This standard is fully addressed by the lessons aligned to its subsections.*
P.N.VM.B.5a Represent scalar multiplication graphically by scaling vectors and possibly reversing their direction; perform scalar multiplication component-wise (e.g., as $c(v_x, v_y) = (cv_x, cv_y)$.	Precalculus and Advanced Topics M2 Lesson 5: Coordinates of Points in Space Precalculus and Advanced Topics M2 Lesson 6: Linear Transformations as Matrices Precalculus and Advanced Topics M2 Lesson 17: Vectors in the Coordinate Plane Precalculus and Advanced Topics M2 Lesson 18: Vectors and Translation Maps Precalculus and Advanced Topics M2 Lesson 20: Vectors and Stone Bridges
P.N.VM.B.5b Compute the magnitude of a scalar multiple $c\mathbf{v}$ using $\|\|c\mathbf{v}\|\| = \|c\|\mathbf{v}$. Compute the direction of $c\mathbf{v}$ knowing that when $\|c\|\mathbf{v} \neq 0$, the direction of $c\mathbf{v}$ is either along $\mathbf{v}$ (for $c > 0$) or against $\mathbf{v}$ (for $c < 0$).	Precalculus and Advanced Topics M2 Lesson 5: Coordinates of Points in Space Precalculus and Advanced Topics M2 Lesson 6: Linear Transformations as Matrices Precalculus and Advanced Topics M2 Lesson 17: Vectors in the Coordinate Plane Precalculus and Advanced Topics M2 Lesson 18: Vectors and Translation Maps Precalculus and Advanced Topics M2 Lesson 20: Vectors and Stone Bridges
P.N.VM.B.6 Calculate and interpret the dot product of two vectors.	*Supplemental material is necessary to address this standard.*

Vector and Matrix Quantities

P.N.VM.C Perform operations on matrices and use matrices in applications.

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.N.VM.C.7 Understand that, unlike multiplication of numbers, matrix multiplication for square matrices is not a commutative operation, but still satisfies the associative and distributive properties.	Precalculus and Advanced Topics M2 Lesson 10: Matrix Multiplication Is Not Commutative Precalculus and Advanced Topics M2 Lesson 12: Matrix Multiplication Is Distributive and Associative
P.N.VM.C.8 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.	Precalculus and Advanced Topics M1 Lesson 24: Matrix Notation Encompasses New Transformations! Precalculus and Advanced Topics M1 Lesson 25: Matrix Multiplication and Addition Precalculus and Advanced Topics M1 Lesson 26: Getting a Handle on New Transformations Precalculus and Advanced Topics M1 Lesson 27: Getting a Handle on New Transformations Precalculus and Advanced Topics M1 Lesson 28: When Can We Reverse a Transformation? Precalculus and Advanced Topics M1 Lesson 29: When Can We Reverse a Transformation? Precalculus and Advanced Topics M1 Lesson 30: When Can We Reverse a Transformation? Precalculus and Advanced Topics M2 Lesson 6: Linear Transformations as Matrices Precalculus and Advanced Topics M2 Lesson 13: Using Matrix Operations for Encryption Precalculus and Advanced Topics M2 Topic C: Systems of Linear Equations

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.N.VM.C.9 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.	Precalculus and Advanced Topics M1 Lesson 21: The Hunt for Better Notation Precalculus and Advanced Topics M1 Lesson 22: Modeling Video Game Motion with Matrices Precalculus and Advanced Topics M1 Lesson 23: Modeling Video Game Motion with Matrices Precalculus and Advanced Topics M2 Lesson 4: Linear Transformations Review Precalculus and Advanced Topics M2 Lesson 7: Linear Transformations Applied to Cubes Precalculus and Advanced Topics M2 Lesson 11: Matrix Addition Is Commutative Precalculus and Advanced Topics M2 Lesson 18: Vectors and Translation Maps Precalculus and Advanced Topics M2 Lesson 21: Vectors and the Equation of a Line Precalculus and Advanced Topics M2 Lesson 22: Linear Transformations of Lines Precalculus and Advanced Topics M2 Lesson 24: Why Are Vectors Useful? Precalculus and Advanced Topics M2 Topic E: First-Person Video Games—Projection Matrices
P.N.VM.C.10 Work with 2×2 matrices as transformations of the plane, and interpret the absolute value of the determinant in terms of area.	Precalculus and Advanced Topics M1 Lesson 21: The Hunt for Better Notation Precalculus and Advanced Topics M1 Lesson 22: Modeling Video Game Motion with Matrices Precalculus and Advanced Topics M1 Lesson 23: Modeling Video Game Motion with Matrices Precalculus and Advanced Topics M1 Lesson 26: Getting a Handle on New Transformations Precalculus and Advanced Topics M1 Lesson 27: Getting a Handle on New Transformations Precalculus and Advanced Topics M1 Lesson 28: When Can We Reverse a Transformation? Precalculus and Advanced Topics M1 Lesson 29: When Can We Reverse a Transformation? Precalculus and Advanced Topics M1 Lesson 30: When Can We Reverse a Transformation? Precalculus and Advanced Topics M2 Lesson 8: Composition of Linear Transformations

Sequences and Series

P.A.S.A Understand and use sequences and series.

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.A.S.A.1 Demonstrate an understanding of sequences by representing them recursively and explicitly.	Algebra I M3 Lesson 2: Recursive Formulas for Sequences Algebra I M3 Lesson 3: Arithmetic and Geometric Sequences Algebra I M3 Lesson 4: Why Do Banks Pay YOU to Provide Their Services? Algebra II M3 Lesson 26: Percent Rate of Change
P.A.S.A.2 Use sigma notation to represent a series; expand and collect expressions in both finite and infinite settings.	Algebra II M3 Lesson 29: The Mathematics Behind a Structured Savings Plan Algebra II M3 Lesson 31: Credit Cards
P.A.S.A.3 Derive and use the formulas for the general term and summation of finite or infinite arithmetic and geometric series, if they exist.	*Supplemental material is necessary to address this standard.*
P.A.S.A.3a Determine whether a given arithmetic or geometric series converges or diverges.	*Supplemental material is necessary to address this standard.*
P.A.S.A.3b Find the sum of a given geometric series (both infinite and finite).	Algebra II M3 Topic E: Geometric Series and Finance *Supplemental material is necessary to address finding the sum of a given infinite geometric series.*

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.A.S.A.3c Find the sum of a finite arithmetic series.	Algebra II M3 Lesson 29: The Mathematics Behind a Structured Savings Plan
P.A.S.A.4 Understand that series represent the approximation of a number when truncated; estimate truncation error in specific examples.	*Supplemental material is necessary to address this standard.*
P.A.S.A.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.	Precalculus and Advanced Topics M3 Lesson 4: The Binomial Theorem Precalculus and Advanced Topics M3 Lesson 5: The Binomial Theorem

Reasoning with Equations and Inequalities

P.A.REI.A Solve systems of equations and nonlinear inequalities.

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.A.REI.A.1 Represent a system of linear equations as a single matrix equation in a vector variable.	Precalculus and Advanced Topics M2 Topic C: Systems of Linear Equations

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.A.REI.A.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).	Precalculus and Advanced Topics M2 Topic C: Systems of Linear Equations
P.A.REI.A.3 Solve rational and radical equations in one variable, and identify extraneous solutions when they exist.	Algebra II M1 Lesson 22: Equivalent Rational Expressions Algebra II M1 Lesson 23: Comparing Rational Expressions Algebra II M1 Lesson 26: Solving Rational Equations Algebra II M1 Lesson 27: Word Problems Leading to Rational Equations Algebra II M1 Lesson 28: A Focus on Square Roots Algebra II M1 Lesson 29: Solving Radical Equations
P.A.REI.A.4 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.	*Supplemental material is necessary to address this standard.*
P.A.REI.A.5 Solve systems of nonlinear inequalities by graphing.	*Supplemental material is necessary to address this standard.*

Parametric Equations

P.A.PE.A Describe and use parametric equations.

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.A.PE.A.1 Graph curves parametrically (by hand and with appropriate technology).	*Supplemental material is necessary to address this standard.*
P.A.PE.A.2 Eliminate parameters by rewriting parametric equations as a single equation.	*Supplemental material is necessary to address this standard.*

Conic Sections

P.A.C.A Understand the properties of conic sections and model real-world phenomena.

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.A.C.A.1 Display all of the conic sections as portions of a cone.	*Supplemental material is necessary to address this standard.*
P.A.C.A.2 Know and write the equation of a circle of given center and radius using the Pythagorean Theorem.	Geometry M5 Lesson 17: Writing the Equation for a Circle Geometry M5 Lesson 18: Recognizing Equations of Circles

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.A.C.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.	Precalculus and Advanced Topics M3 Lesson 6: Curves in the Complex Plane Precalculus and Advanced Topics M3 Lesson 7: Curves from Geometry Precalculus and Advanced Topics M3 Lesson 8: Curves from Geometry
P.A.C.A.4 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.	Algebra II M1 Lesson 31: Systems of Equations Algebra II M1 Lesson 32: Graphing Systems of Equations Algebra II M1 Lesson 34: Are All Parabolas Congruent? Precalculus and Advanced Topics M3 Lesson 7: Curves from Geometry Precalculus and Advanced Topics M3 Lesson 8: Curves from Geometry
P.A.C.A.5 Transform equations of conic sections to convert between general and standard form.	Algebra II M1 Lesson 32: Graphing Systems of Equations Algebra II M1 Lesson 34: Are All Parabolas Congruent? Precalculus and Advanced Topics M3 Lesson 8: Curves from Geometry

Building Functions

P.F.BF.A Build new functions from existing functions.

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.F.BF.A.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 such as translations, stretches, reflections, and changes in periodicity and amplitude).	Algebra I M3 Lesson 17: Four Interesting Transformations of Functions Algebra I M3 Lesson 18: Four Interesting Transformations of Functions Algebra I M3 Lesson 19: Four Interesting Transformations of Functions Algebra I M3 Lesson 20: Four Interesting Transformations of Functions Algebra I M4 Lesson 19: Translating Graphs of Functions Algebra I M4 Lesson 20: Stretching and Shrinking Graphs of Functions Algebra I M4 Lesson 21: Transformations of the Quadratic Parent Function, $f(x) = x^2$ Algebra II M3 Lesson 20: Transformations of the Graphs of Logarithmic and Exponential Functions Precalculus and Advanced Topics M3 Lesson 15: Transforming Rational Functions
P.F.BF.A.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.	Algebra II M3 Lesson 28: Newton's Law of Cooling, Revisited Algebra II M3 Lesson 30: Buying a Car Algebra II M3 Lesson 33: The Million Dollar Problem Precalculus and Advanced Topics M4 Lesson 6: Waves, Sinusoids, and Identities
P.F.BF.A.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).	Precalculus and Advanced Topics M3 Lesson 16: Function Composition Precalculus and Advanced Topics M3 Lesson 17: Solving Problems by Functions Composition

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.F.BF.A.4 Construct the difference quotient for a given function and simplify the resulting expression.	*Supplemental material is necessary to address this standard.*
P.F.BF.A.5 Find inverse functions (including exponential, logarithmic, and trigonometric).	*This standard is fully addressed by the lessons aligned to its subsections.*
P.F.BF.A.5a 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, $1/f(x)$, and the inverse with respect to composition, $f^{-1}(x)$. Understand the algebraic and graphical implications of each type.	Precalculus and Advanced Topics M3 Topic C: Inverse Functions
P.F.BF.A.5b Verify by composition that one function is the inverse of another.	Precalculus and Advanced Topics M3 Lesson 19: Restricting the Domain Precalculus and Advanced Topics M3 Lesson 20: Inverses of Logarithmic and Exponential Functions
P.F.BF.A.5c Read values of an inverse function from a graph or a table, given that the function has an inverse.	Precalculus and Advanced Topics M3 Lesson 18: Inverse Functions Precalculus and Advanced Topics M3 Lesson 19: Restricting the Domain Precalculus and Advanced Topics M3 Lesson 20: Inverses of Logarithmic and Exponential Functions

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.F.BF.A.5d Recognize a function is invertible if and only if it is one-to-one. Produce an invertible function from a non-invertible function by restricting the domain.	Precalculus and Advanced Topics M3 Lesson 19: Restricting the Domain Precalculus and Advanced Topics M4 Lesson 12: Inverse Trigonometric Functions
P.F.BF.A.6 Explain why the graph of a function and its inverse are reflections of one another over the line $y = x$.	Precalculus and Advanced Topics M3 Lesson 19: Restricting the Domain

Interpreting Functions

P.F.IF.A Analyze functions using different representations.

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.F.IF.A.1 Determine whether a function is even, odd, or neither.	Precalculus and Advanced Topics M4 Lesson 2: Properties of Trigonometric Functions *Supplemental material is necessary to fully address this standard.*
P.F.IF.A.2 Analyze qualities of exponential, polynomial, logarithmic, trigonometric, and rational functions and solve real-world problems that can be modeled with these functions (by hand and with appropriate technology).	Algebra II M1 Lesson 16: Modeling with Polynomials—An Introduction Algebra II M1 Lesson 17: Modeling with Polynomials—An Introduction Precalculus and Advanced Topics M3 Lesson 21: Logarithmic and Exponential Problem Solving Precalculus and Advanced Topics M4 Lesson 11: Revisiting the Graphs of Trigonometric Functions Precalculus and Advanced Topics M4 Lesson 13: Modeling with Inverse Trigonometric Functions *Supplemental material is necessary to address rational functions.*

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.F.IF.A.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 (exponential, polynomial, logarithmic, trigonometric, and rational).	Algebra I M4 Lesson 9: Graphing Quadratic Functions from Factored Form, $f(x) = a(x - m)(x - n)$ Algebra I M4 Lesson 15: Using the Quadratic Formula Algebra II M1 Lesson 11: The Special Role of Zero in Factoring
P.F.IF.A.4 Identify characteristics of graphs based on a set of conditions or on a general equation such as $y = ax^2 + c$.	Algebra II M1 Lesson 15: Structure in Graphs of Polynomial Functions
P.F.IF.A.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 where the function is increasing or decreasing and where different types of concavity occur.	*Supplemental material is necessary to address this standard.*
P.F.IF.A.6 Graph rational functions, identifying zeros, asymptotes (including slant), and holes (when suitable factorizations are available) and showing end-behavior.	Precalculus and Advanced Topics M3 Lesson 12: End Behavior of Rational Functions Precalculus and Advanced Topics M3 Lesson 13: Horizontal and Vertical Asymptotes of Graphs of Rational Functions Precalculus and Advanced Topics M3 Lesson 14: Graphing Rational Functions Precalculus and Advanced Topics M3 Lesson 15: Transforming Rational Functions

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.F.IF.A.7 Recognize that sequences are functions, sometimes defined recursively, whose domain is a subset of the integers (for example, the Fibonacci sequence is defined recursively by $f(0) = f(1) = 1$, $f(n+1) = f(n) + f(n-1)$ for $n \geq 1$).	Algebra I M3 Lesson 2: Recursive Formulas for Sequences Algebra I M3 Lesson 3: Arithmetic and Geometric Sequences Algebra I M3 Lesson 4: Why Do Banks Pay YOU to Provide Their Services? Algebra II M3 Lesson 26: Percent Rate of Change

Trigonometric Functions

P.F.TF.A Extend the domain of trigonometric functions using the unit circle.

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.F.TF.A.1 Understand radian measure of an angle as the length of the arc on the unit circle subtended by the angle.	Algebra II M2 Lesson 9: Awkward! Who Chose the Number 360, Anyway?
P.F.TF.A.2 Convert from radians to degrees and from degrees to radians.	Algebra II M2 Lesson 9: Awkward! Who Chose the Number 360, Anyway?
P.F.TF.A.3 Use special triangles to determine geometrically the values of sine, cosine, tangent for $\frac{\pi}{3}$, $\frac{\pi}{4}$ and $\frac{\pi}{6}$, and explain how to 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.	Algebra II M2 Lesson 4: From Circle-ometry to Trigonometry Algebra II M2 Lesson 5: Extending the Domain of Sine and Cosine to All Real Numbers Algebra II M2 Lesson 6: Why Call It Tangent? Algebra II M2 Lesson 10: Basic Trigonometric Identities from Graphs Precalculus and Advanced Topics M4 Lesson 1: Special Triangles and the Unit Circle

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.F.TF.A.4 Use the unit circle to explain symmetry (odd and even) and periodicity of trigonometric functions.	Precalculus and Advanced Topics M4 Lesson 2: Properties of Trigonometric Functions
P.F.TF.A.5 Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline.	Algebra II M2 Lesson 12: Ferris Wheels—Using Trigonometric Functions to Model Cyclical Behavior Algebra II M2 Lesson 13: Tides, Sound Waves, and Stock Markets Precalculus and Advanced Topics M4 Lesson 6: Waves, Sinusoids, and Identities

Graphing Trigonometric Functions

P.F.GT.A Model periodic phenomena with trigonometric functions.

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.F.GT.A.1 Interpret transformations of trigonometric functions.	Algebra II M2 Lesson 11: Transforming the Graph of the Sine Function Algebra II M2 Lesson 14: Graphing the Tangent Function Precalculus and Advanced Topics M4 Lesson 11: Revisiting the Graphs of the Trigonometric Functions
P.F.GT.A.2 Determine the difference made by choice of units for angle measurement when graphing a trigonometric function.	*Supplemental material is necessary to address this standard.*

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.F.GT.A.3 Graph the six trigonometric functions and identify characteristics such as period, amplitude, phase shift, and asymptotes.	Algebra II M2 Lesson 1: Ferris Wheels—Tracking the Height of a Passenger Car Algebra II M2 Lesson 2: The Height and Co-Height Functions of a Ferris Wheel Algebra II M2 Lesson 3: The Motion of the Moon, Sun, and Stars—Motivating Mathematics Algebra II M2 Lesson 4: From Circle-ometry to Trigonometry Algebra II M2 Lesson 5: Extending the Domain of Sine and Cosine to All Real Numbers Algebra II M2 Lesson 7: Secant and the Co-Functions Precalculus and Advanced Topics M4 Lesson 11: Revisiting the Graphs of the Trigonometric Functions
P.F.GT.A.4 Find values of inverse trigonometric expressions (including compositions), applying appropriate domain and range restrictions.	Precalculus and Advanced Topics M4 Lesson 12: Inverse Trigonometric Functions *Supplemental material is necessary to address finding values of compositions.*
P.F.GT.A.5 Understand that restricting a trigonometric function to a domain on which it is always increasing or always decreasing allows its inverse to be constructed.	Precalculus and Advanced Topics M4 Lesson 12: Inverse Trigonometric Functions
P.F.GT.A.6 Determine the appropriate domain and corresponding range for each of the inverse trigonometric functions.	Precalculus and Advanced Topics M4 Lesson 12: Inverse Trigonometric Functions

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.F.GT.A.7 Graph the inverse trigonometric functions and identify their key characteristics.	Precalculus and Advanced Topics M4 Lesson 12: Inverse Trigonometric Functions
P.F.GT.A.8 Use inverse functions to solve trigonometric equations that arise in modeling contexts; evaluate the solutions using technology and interpret them in terms of the context.	Precalculus and Advanced Topics M4 Lesson 12: Inverse Trigonometric Functions Precalculus and Advanced Topics M4 Lesson 13: Modeling with Inverse Trigonometric Functions Precalculus and Advanced Topics M4 Lesson 14: Modeling with Inverse Trigonometric Functions

Applied Trigonometry

P.G.AT.A Use trigonometry to solve problems.

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.G.AT.A.1 Use the definitions of the six trigonometric ratios as ratios of sides in a right triangle to solve problems about lengths of sides and measures of angles.	Geometry M2 Lesson 25: Incredibly Useful Ratios Geometry M2 Lesson 26: The Definition of Sine, Cosine, and Tangent Geometry M2 Lesson 29: Applying Tangents Algebra II M2 Lesson 7: Secant and the Co-Functions
P.G.AT.A.2 Derive the formula $A = \frac{1}{2}ab\sin(C)$ for the area of a triangle by drawing an auxiliary line from a vertex perpendicular to the opposite side.	Precalculus and Advanced Topics M4 Lesson 7: An Area Formula for Triangles

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.G.AT.A.3 Derive and apply the formulas for the area of sector of a circle.	Geometry M5 Lesson 9: Arc Length and Areas of Sectors Geometry M5 Lesson 10: Unknown Length and Area Problems
P.G.AT.A.4 Calculate the arc length of a circle subtended by a central angle.	Geometry M5 Lesson 9: Arc Length and Areas of Sectors Geometry M5 Lesson 10: Unknown Length and Area Problems
P.G.AT.A.5 Prove the Laws of Sines and Cosines and use them to solve problems.	Precalculus and Advanced Topics M4 Lesson 8: Law of Sines Precalculus and Advanced Topics M4 Lesson 9: Law of Cosines Precalculus and Advanced Topics M4 Lesson 10: Putting the Law of Cosines and the Law of Sines to Use
P.G.AT.A.6 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 (such as surveying problems and resultant forces).	Precalculus and Advanced Topics M4 Lesson 8: Law of Sines Precalculus and Advanced Topics M4 Lesson 9: Law of Cosines Precalculus and Advanced Topics M4 Lesson 10: Putting the Law of Cosines and the Law of Sines to Use

Trigonometric Identities

P.G.TI.A Apply trigonometric identities to rewrite expressions and solve equations.

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.G.TI.A.1 Apply trigonometric identities to verify identities and solve equations. Identities include: Pythagorean, reciprocal, quotient, sum/difference, double-angle, and half-angle.	Algebra II M2 Lesson 17: Trigonometric Identity Proofs Precalculus and Advanced Topics M4 Lesson 3: Addition and Subtraction Formulas Precalculus and Advanced Topics M4 Lesson 4: Addition and Subtraction Formulas
P.G.TI.A.2 Prove the addition and subtraction formulas for sine, cosine, and tangent and use them to solve problems.	Precalculus and Advanced Topics M4 Lesson 3: Addition and Subtraction Formulas Precalculus and Advanced Topics M4 Lesson 4: Addition and Subtraction Formulas Precalculus and Advanced Topics M4 Lesson 6: Waves, Sinusoids, and Identities

Polar Coordinates

P.G.PC.A Use polar coordinates.

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.G.PC.A.1 Graph functions in polar coordinates.	*Supplemental material is necessary to address this standard.*
P.G.PC.A.2 Convert between rectangular and polar coordinates.	*Supplemental material is necessary to address this standard.*
P.G.PC.A.3 Represent situations and solve problems involving polar coordinates.	*Supplemental material is necessary to address this standard.*

Model with Data

P.S.MD.A Model data using regressions equations.

Tennessee Academic Standards for Mathematics	Aligned Components of *Eureka Math*
P.S.MD.A.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.	Algebra I M2 Topic D: Numerical Data on Two Variables Algebra I M5 Lesson 7: Modeling a Context from Data Algebra II M1 Lesson 20: Modeling Riverbeds with Polynomials Algebra II M1 Lesson 21: Modeling Riverbeds with Polynomials Algebra II M2 Lesson 13: Tides, Sound Waves, and Stock Markets Precalculus and Advanced Topics M3 Lesson 21: Logarithmic and Exponential Problem Solving *Supplemental material is necessary to address trigonometric models.*
P.S.MD.A.2 Determine a regression equation to model a set of bivariate data. Justify why this equation best fits the data.	Algebra I M2 Lesson 12: Relationships Between Two Numerical Variables Algebra I M2 Lesson 13: Relationships Between Two Numerical Variables Algebra I M2 Lesson 19: Interpreting Correlation Algebra I M5 Lesson 7: Modeling a Context from Data Algebra II M1 Lesson 16: Modeling with Polynomials—An Introduction Algebra II M1 Lesson 17: Modeling with Polynomials—An Introduction Algebra II M1 Lesson 20: Modeling Riverbeds with Polynomials Algebra II M1 Lesson 21: Modeling Riverbeds with Polynomials Algebra II M2 Lesson 13: Tides, Sound Waves, and Stock Markets
P.S.MD.A.3 Use a regression equation, modeling bivariate data, to make predictions. Identify possible considerations regarding the accuracy of predictions when interpolating or extrapolating.	Algebra II M1 Lesson 17: Modeling with Polynomials—An Introduction Algebra II M1 Lesson 21: Modeling Riverbeds with Polynomials Algebra II M2 Lesson 13: Tides, Sound Waves, and Stock Markets