Ohio Tutorials are designed specifically for the Ohio Learning Standards to prepare students for the Ohio State Tests and end-of-course exams.

Math Tutorials offer targeted instruction, practice and review designed to develop computational fluency, deepen conceptual understanding, and apply mathematical practices. They automatically identify and address learning gaps down to elementary-level content, using adaptive remediation to bring students to grade-level no matter where they start. Students engage with the content in an interactive, feedback-rich environment as they progress through standards-aligned modules. By constantly honing the ability to apply their knowledge in abstract and real world scenarios, students build the depth of knowledge and higher order skills required to demonstrate their mastery when put to the test.

In each module, the Learn It and Try It make complex ideas accessible to students through focused content, modeled logic and process, multi-modal representations, and personalized feedback as students reason through increasingly challenging problems. The Review It offers a high impact summary of key concepts and relates those concepts to students' lives. The Test It assesses students' mastery of the module's concepts, providing granular performance data to students and teachers after each attempt. To help students focus on the content most relevant to them, unit-level pretests and posttests can quickly identify where students are strong and where they're still learning.

1. EXPRESSIONS, EQUATIONS, AND INEQUALITIES

- **FORMULATING AND SIMPLIFYING ALGEBRAIC EXPRESSIONS**
  - **OH.Math.HSA.SSE.1a** *Interpret parts of an expression, such as terms, factors, and coefficients.*
  - **OH.Math.HSA.SSE.1b** *Interpret complicated expressions by viewing one or more of their parts as a single entity.*
  - **OH.Math.HSA.SSE.2** *Use the structure of an expression to identify ways to rewrite it.*
  - **OH.Math.HSA.APR.1b** *Extend to polynomial expressions beyond those expressions that simplify to forms that are linear or quadratic.*

- **FORMULATING AND SOLVING EQUATIONS FROM WORD PROBLEMS**
  - **OH.Math.HSF.LE.2** *Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table).*
  - **OH.Math.HSF.LE.1b** *Recognize situations in which one quantity changes at a constant rate per unit interval relative to another.*
  - **OH.Math.HSA.CED.2a** *Focus on applying linear and simple exponential expressions.*
  - **OH.Math.HSF.IF.4a** *Focus on linear and exponential functions.*
  - **OH.Math.HSF.IF.4b** *Focus on linear, quadratic, and exponential functions.*
  - **OH.Math.HSF.BF.1a.i** *Focus on linear and exponential functions.*
  - **OH.Math.HSA.CED.1c** *Extend to include more complicated function situations with the option to solve with technology.*
  - **OH.Math.HSA.CED.3a** *While functions will often be linear, exponential, or quadratic, the types of problems should draw from more complicated situations.*
  - **OH.Math.HSA.SSE.1a** *Interpret parts of an expression, such as terms, factors, and coefficients.*

- **FORMULATING AND SOLVING INEQUALITIES FROM WORD PROBLEMS**
  - **OH.Math.HSA.REI.3** *Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.*
  - **OH.Math.HSA.CED.1a** *Focus on applying linear and simple exponential expressions.*
  - **OH.Math.HSA.CED.1c** *Extend to include more complicated function situations with the option to solve with technology.*
  - **OH.Math.HSA.CED.3a** *While functions will often be linear, exponential, or quadratic, the types of problems should draw from more complicated situations.*
  - **OH.Math.HSA.SSE.1a** *Interpret parts of an expression, such as terms, factors, and coefficients.*

- **LITERAL EQUATIONS**
  - **OH.Math.HSA.REI.3** *Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.*
  - **OH.Math.HSA.CED.1a** *Focus on applying linear and simple exponential expressions.*
  - **OH.Math.HSA.CED.4b** *Focus on formulas in which the variable of interest is linear.*
  - **OH.Math.HSA.CED.4c** *Focus on formulas in which the variable of interest is linear or square.*
  - **OH.Math.HSA.CED.4d** *While functions will often be linear, exponential, or quadratic, the types of problems should draw from more complicated situations.*
  - **OH.Math.HSA.CED.4a** *Focus on formulas in which the variable of interest is linear or square.*

- **SUMS OF GEOMETRIC SEQUENCES**
  - **OH.Math.HSA.SSE.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.*

2. EXPONENTIAL AND LOGARITHMIC FUNCTIONS

- **LOGARITHMIC FUNCTIONS**
  - **OH.Math.HSF.IF.7f** *Graph exponential functions, indicating intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.*
  - **OH.Math.HSF.BF.4b** *Read values of an inverse function from a graph or a table, given that the function has an inverse.*
  - **OH.Math.HSF.BF.4d** *Find the inverse of a function algebraically, given that the function has an inverse.*
  - **OH.Math.HSF.BF.5** *Understand the inverse relationship between exponents and logarithms and use this relationship to solve problems involving logarithms and exponents.*
  - **OH.Math.HSF.LE.4** *For exponential models, express as a logarithm the solution to ab to the ct power = d where a, c, and d are numbers and the base b is 2, 10, or e; evaluate the logarithm using technology.*
  - **OH.Math.HSF.IF.4a** *Focus on linear and exponential functions.*
  - **OH.Math.HSF.IF.4b** *Focus on linear, quadratic, and exponential functions.*
  - **OH.Math.HSF.IF.5c** *Emphasize the selection of a type of function for a model based on behavior of data and context.*
  - **OH.Math.HSF.IF.1** *Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then $f(x)$ denotes the output of f corresponding to the input x. The graph of f is the graph of the equation $y = f(x)$.*

- **EVALUATING LOGARITHMIC EXPRESSIONS**
  - **OH.Math.HSA.SSE.1a** *Interpret parts of an expression, such as terms, factors, and coefficients.*
  - **OH.Math.HSA.SSE.1b** *Interpret complicated expressions by viewing one or more of their parts as a single entity.*
  - **OH.Math.HSF.LE.4** *For exponential models, express as a logarithm the solution to ab to the ct power = d where a, c, and d are numbers and the base b is 2, 10, or e; evaluate the logarithm using technology.*

- **SOLVING EXPONENTIAL EQUATIONS**
  - **OH.Math.HSA.SSE.3c** *Use the properties of exponents to transform expressions for exponential functions.*
  - **OH.Math.HSF.IF.7f** *Graph exponential functions, indicating intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.*
  - **OH.Math.HSF.LE.4** *For exponential models, express as a logarithm the solution to ab to the ct power = d where a, c, and d are numbers and the base b is 2, 10, or e; evaluate the logarithm using technology.*
  - **OH.Math.HSA.CED.2a** *Focus on applying linear and simple exponential expressions.*
  - **OH.Math.HSF.IF.4a** *Focus on linear and exponential functions.*
  - **OH.Math.HSF.IF.4b** *Focus on linear, quadratic, and exponential functions.*
  - **OH.Math.HSF.LE.2** *Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table).*
  - **OH.Math.HSF.IF.9a** *Focus on linear and exponential functions.*
  - **OH.Math.HSF.IF.9b** *Focus on linear, quadratic, and exponential functions.*
  - **OH.Math.HSF.BF.1a.i** *Focus on linear and exponential functions.*

- **OH.Math.HSF.BF.1a.ii** *Focus on situations that exhibit quadratic or exponential relationships.*

- **SOLVING LOGARITHMIC EQUATIONS**
  - **OH.Math.HSF.IF.1** *Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then $f(x)$ denotes the output of f corresponding to the input x. The graph of f is the graph of the equation $y = f(x)$.*
  - **OH.Math.HSF.LE.4** *For exponential models, express as a logarithm the solution to ab to the ct power $= d$ where a, c, and d are numbers and the base b is 2, 10, or e; evaluate the logarithm using technology.*
  - **OH.Math.HSA.REI.1** *Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.*

3. POLYNOMIALS

- **POLYNOMIAL BASICS**
  - **OH.Math.HSA.SSE.1a** *Interpret parts of an expression, such as terms, factors, and coefficients.*
  - **OH.Math.HSA.SSE.1b** *Interpret complicated expressions by viewing one or more of their parts as a single entity.*
  - **OH.Math.HSA.SSE.2** *Use the structure of an expression to identify ways to rewrite it.*
  - **OH.Math.HSA.APR.1b** *Extend to polynomial expressions beyond those expressions that simplify to forms that are linear or quadratic.*

- **ADDITION AND SUBTRACTION OF POLYNOMIALS**
  - **OH.Math.HSA.APR.1b** *Extend to polynomial expressions beyond those expressions that simplify to forms that are linear or quadratic.*
  - **OH.Math.HSA.SSE.2** *Use the structure of an expression to identify ways to rewrite it.*

- **MULTIPLICATION OF POLYNOMIALS**
  - **OH.Math.HSA.APR.1b** *Extend to polynomial expressions beyond those expressions that simplify to forms that are linear or quadratic.*
  - **OH.Math.HSA.SSE.2** *Use the structure of an expression to identify ways to rewrite it.*

- **DIVISION OF POLYNOMIALS**
  - **OH.Math.HSA.SSE.2** *Use the structure of an expression to identify ways to rewrite it.*
  - **OH.Math.HSA.APR.1b** *Extend to polynomial expressions beyond those expressions that simplify to forms that are linear or quadratic.*
  - **OH.Math.HSA.APR.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.*
  - **OH.Math.HSA.SSE.1a** *Interpret parts of an expression, such as terms, factors, and coefficients.*
  - **OH.Math.HSA.SSE.1b** *Interpret complicated expressions by viewing one or more of their parts as a single entity.*

4. FACTORING POLYNOMIALS AND THE FACTOR THEOREM

- **FACTORING CUBIC POLYNOMIALS**
  - **OH.Math.HSA.SSE.2** *Use the structure of an expression to identify ways to rewrite it.*
  - **OH.Math.HSA.APR.3** *Identify zeros of polynomials, when factoring is reasonable, and use the zeros to construct a rough graph of the function defined by the polynomial.*
  - **OH.Math.HSA.APR.4** *Prove polynomial identities and use them to describe numerical relationships.*
  - **OH.Math.HSA.SSE.1b** *Interpret complicated expressions by viewing one or more of their parts as a single entity.*

- **FACTORING HIGHER-ORDER POLYNOMIALS**
  - **OH.Math.HSA.APR.3** *Identify zeros of polynomials, when factoring is reasonable, and use the zeros to construct a rough*

graph of the function defined by the polynomial.

- **OH.Math.HSA.SSE.1a** *Interpret parts of an expression, such as terms, factors, and coefficients.*
- **OH.Math.HSA.SSE.1b** *Interpret complicated expressions by viewing one or more of their parts as a single entity.*
- **OH.Math.HSA.SSE.2** *Use the structure of an expression to identify ways to rewrite it.*
- **OH.Math.HSA.APR.4** *Prove polynomial identities and use them to describe numerical relationships.*

FACTOR THEOREM AND REMAINDER THEOREM

- **OH.Math.HSA.APR.3** *Identify zeros of polynomials, when factoring is reasonable, and use the zeros to construct a rough graph of the function defined by the polynomial.*
- **OH.Math.HSA.APR.2** *Understand and apply the Remainder Theorem: For a polynomial $p(x)$ and a number a, the remainder on division by $x - a$ is $p(a)$. In particular, $p(a) = 0$ if and only if $(x - a)$ is a factor of $p(x)$.*
- **OH.Math.HSA.APR.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.*
- **OH.Math.HSF.IF.2** *Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.*

5. POLYNOMIALS AND POLYNOMIAL IDENTITIES

GRAPHS OF POLYNOMIAL FUNCTIONS

- **OH.Math.HSA.APR.3** *Identify zeros of polynomials, when factoring is reasonable, and use the zeros to construct a rough graph of the function defined by the polynomial.*
- **OH.Math.HSF.BF.3a** *Focus on transformations of graphs of quadratic functions, except for $f(kx)$.*
- **OH.Math.HSF.IF.7d** *Graph polynomial functions, identifying zeros, when factoring is reasonable, and indicating end behavior.*

POLYNOMIAL IDENTITIES

- **OH.Math.HSA.APR.4** *Prove polynomial identities and use them to describe numerical relationships.*
- **OH.Math.HSA.REI.4a** *Use the method of completing the square to transform any quadratic equation in x into an equation of the form $(x - p)^2 = q$ that has the same solutions.*
- **OH.Math.HSA.REI.4b** *Solve quadratic equations as appropriate to the initial form of the equation by inspection, e.g., for $x^2 = 49$; taking square roots; completing the square; applying the quadratic formula; or utilizing the Zero-Product Property after factoring.*
- **OH.Math.HSA.REI.4c** *Derive the quadratic formula using the method of completing the square.*
- **OH.Math.HSA.SSE.2** *Use the structure of an expression to identify ways to rewrite it.*
- **OH.Math.HSA.APR.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.*

POLYNOMIAL IDENTITIES AND COMPLEX NUMBERS

- **OH.Math.HSA.SSE.2** *Use the structure of an expression to identify ways to rewrite it.*
- **OH.Math.HSA.APR.4** *Prove polynomial identities and use them to describe numerical relationships.*
- **OH.Math.HSA.SSE.1a** *Interpret parts of an expression, such as terms, factors, and coefficients.*
- **OH.Math.HSA.SSE.1b** *Interpret complicated expressions by viewing one or more of their parts as a single entity.*
- **OH.Math.HSN.CN.8** *Extend polynomial identities to the complex numbers.*
- **OH.Math.HSA.REI.4b** *Solve quadratic equations as appropriate to the initial form of the equation by inspection, e.g., for $x^2 = 49$; taking square roots; completing the square; applying the quadratic formula; or utilizing the Zero-Product Property after factoring.*
- **OH.Math.HSN.CN.1** *Know there is a complex number i such that $i^2 = -1$, and every complex number has the form $a + i$ with a and b real.*
- **OH.Math.HSN.CN.7** *Solve quadratic equations with real coefficients that have complex solutions.*
- **OH.Math.HSN.CN.2** *Use the relation $i^2 = -1$ and the commutative, associative, and distributive properties to add, subtract, and multiply complex numbers.*
- **OH.Math.HSN.CN.9** *Know the Fundamental Theorem of Algebra; show that it is true for quadratic polynomials.*

6. QUADRATIC AND SQUARE ROOT EQUATIONS

- **REPRESENTATIONS OF QUADRATIC FUNCTIONS**
  - **OH.Math.HSA.SSE.2** *Use the structure of an expression to identify ways to rewrite it.*
  - **OH.Math.HSA.REI.4c** *Derive the quadratic formula using the method of completing the square.*
  - **OH.Math.HSA.CED.2b** *Focus on applying simple quadratic expressions.*
  - **OH.Math.HSF.IF.1** *Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then $f(x)$ denotes the output of f corresponding to the input x. The graph of f is the graph of the equation $y = f(x)$.*
  - **OH.Math.HSA.CED.2c** *Extend to include more complicated function situations with the option to graph with technology.*
  - **OH.Math.HSF.IF.4b** *Focus on linear, quadratic, and exponential functions.*
  - **OH.Math.HSF.IF.8a.i** *Focus on completing the square to quadratic functions with the leading coefficient of 1.*
  - **OH.Math.HSF.IF.9b** *Focus on linear, quadratic, and exponential functions.*
  - **OH.Math.HSF.BF.1a.ii** *Focus on situations that exhibit quadratic or exponential relationships.*
  - **OH.Math.HSA.SSE.3a** *Factor a quadratic expression to reveal the zeros of the function it defines.*
  - **OH.Math.HSA.REI.4a** *Use the method of completing the square to transform any quadratic equation in x into an equation of the form $(x - p)^2 = q$ that has the same solutions.*
  - **OH.Math.HSF.BF.3a** *Focus on transformations of graphs of quadratic functions, except for $f(kx)$.*

- **COMPLETING THE SQUARE**
  - **OH.Math.HSA.SSE.3b** *Complete the square in a quadratic expression to reveal the maximum or minimum value of the function it defines.*
  - **OH.Math.HSA.REI.4a** *Use the method of completing the square to transform any quadratic equation in x into an equation of the form $(x - p)^2 = q$ that has the same solutions.*
  - **OH.Math.HSA.REI.4b** *Solve quadratic equations as appropriate to the initial form of the equation by inspection, e.g., for $x^2 = 49$; taking square roots; completing the square; applying the quadratic formula; or utilizing the Zero-Product Property after factoring.*
  - **OH.Math.HSA.SSE.2** *Use the structure of an expression to identify ways to rewrite it.*
  - **OH.Math.HSA.CED.2b** *Focus on applying simple quadratic expressions.*
  - **OH.Math.HSA.REI.4c** *Derive the quadratic formula using the method of completing the square.*
  - **OH.Math.HSF.IF.7b** *Graph quadratic functions and indicate intercepts, maxima, and minima.*
  - **OH.Math.HSF.IF.9b** *Focus on linear, quadratic, and exponential functions.*

- **ANALYZING GRAPHS OF SQUARE ROOT FUNCTIONS**
  - **OH.Math.HSG.CO.6** *Use geometric descriptions of rigid motions to transform figures and to predict the effect of a given rigid motion on a given figure; given two figures, use the definition of congruence in terms of rigid motions to decide if they are congruent.*
  - **OH.Math.HSF.BF.3a** *Focus on transformations of graphs of quadratic functions, except for $f(kx)$.*
  - **OH.Math.HSF.IF.4a** *Focus on linear and exponential functions.*
  - **OH.Math.HSF.IF.4b** *Focus on linear, quadratic, and exponential functions.*
  - **OH.Math.HSF.IF.5c** *Emphasize the selection of a type of function for a model based on behavior of data and context.*
  - **OH.Math.HSF.IF.7c** *Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions.*
  - **OH.Math.HSF.BF.4b** *Read values of an inverse function from a graph or a table, given that the function has an inverse.*
  - **OH.Math.HSF.BF.4d** *Find the inverse of a function algebraically, given that the function has an inverse.*
  - **OH.Math.HSF.IF.1** *Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then $f(x)$ denotes the output of f corresponding to the input x. The graph of f is the graph of the equation $y = f(x)$.*

- **SOLVING SQUARE ROOT EQUATIONS**
  - **OH.Math.HSA.REI.2** *Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise.*
  - **OH.Math.HSA.REI.1** *Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify*

a solution method.

7. RATIONAL EXPRESSIONS, EQUATIONS, AND FUNCTIONS

- **OPERATIONS WITH RATIONAL EXPRESSIONS**
  - **OH.Math.HSA.SSE.1a** *Interpret parts of an expression, such as terms, factors, and coefficients.*
  - **OH.Math.HSA.SSE.1b** *Interpret complicated expressions by viewing one or more of their parts as a single entity.*
  - **OH.Math.HSA.APR.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.*
  - **OH.Math.HSA.SSE.2** *Use the structure of an expression to identify ways to rewrite it.*
  - **OH.Math.HSA.APR.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.*

- **ANALYZING GRAPHS OF RATIONAL FUNCTIONS**
  - **OH.Math.HSF.BF.3a** *Focus on transformations of graphs of quadratic functions, except for $f(kx)$.*
  - **OH.Math.HSF.IF.1** *Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then $f(x)$ denotes the output of f corresponding to the input x. The graph of f is the graph of the equation $y = f(x)$.*

- **SOLVING RATIONAL EQUATIONS**
  - **OH.Math.HSA.REI.1** *Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.*
  - **OH.Math.HSF.IF.1** *Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then $f(x)$ denotes the output of f corresponding to the input x. The graph of f is the graph of the equation $y = f(x)$.*
  - **OH.Math.HSA.CED.3a** *While functions will often be linear, exponential, or quadratic, the types of problems should draw from more complicated situations.*
  - **OH.Math.HSA.REI.2** *Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise.*

- **MODELING SITUATIONS WITH RATIONAL FUNCTIONS**
  - **OH.Math.HSA.SSE.1a** *Interpret parts of an expression, such as terms, factors, and coefficients.*
  - **OH.Math.HSA.SSE.1b** *Interpret complicated expressions by viewing one or more of their parts as a single entity.*
  - **OH.Math.HSA.REI.2** *Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise.*
  - **OH.Math.HSA.CED.2c** *Extend to include more complicated function situations with the option to graph with technology.*
  - **OH.Math.HSA.CED.3a** *While functions will often be linear, exponential, or quadratic, the types of problems should draw from more complicated situations.*

8. TRIGONOMETRY

- **RADIANS AND THE UNIT CIRCLE**
  - **OH.Math.HSG.C.6** *Derive formulas that relate degrees and radians, and convert between the two.*
  - **OH.Math.HSF.TF.1** *Understand radian measure of an angle as the length of the arc on the unit circle subtended by the angle.*
  - **OH.Math.HSF.TF.2** *Explain how the unit circle in the coordinate plane enables the extension of trigonometric functions to all real numbers, interpreted as radian measures of angles traversed counterclockwise around the unit circle.*
  - **OH.Math.HSG.C.5a** *Apply similarity to relate the length of an arc intercepted by a central angle to the radius. Use the relationship to solve problems.*
  - **OH.Math.HSF.TF.3** *Use special triangles to determine geometrically the values of sine, cosine, tangent for π/3, π/4, and π/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.

- **OH.Math.HSF.TF.4** *Use the unit circle to explain symmetry (odd and even) and periodicity of trigonometric functions.*
- **OH.Math.HSG.SRT.8a** *Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems if one of the two acute angles and a side length is given.*

- **TRIGONOMETRIC FUNCTIONS**
  - **OH.Math.HSF.IF.7f** *Graph exponential functions, indicating intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.*
  - **OH.Math.HSF.TF.2** *Explain how the unit circle in the coordinate plane enables the extension of trigonometric functions to all real numbers, interpreted as radian measures of angles traversed counterclockwise around the unit circle.*
  - **OH.Math.HSF.TF.5** *Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline.*
  - **OH.Math.HSF.TF.8** *Prove the Pythagorean identity $\sin^2(\theta) + \cos^2(\theta) = 1$, and use it to find $\sin(\theta)$, $\cos(\theta)$, or $\tan(\theta)$ given $\sin(\theta)$, $\cos(\theta)$, or $\tan(\theta)$ and the quadrant of the angle.*

- **LAWS OF SINE AND COSINE**
  - **OH.Math.HSG.SRT.9** *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.*
  - **OH.Math.HSG.SRT.8a** *Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems if one of the two acute angles and a side length is given.*
  - **OH.Math.HSG.SRT.8b** *Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.*
  - **OH.Math.HSG.SRT.10** *Explain proofs of the Laws of Sines and Cosines and use the Laws to solve problems.*
  - **OH.Math.HSG.SRT.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.*

9. FUNCTIONS

- **DOMAIN AND RANGE**
  - **OH.Math.HSF.IF.1** *Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then $f(x)$ denotes the output of f corresponding to the input x. The graph of f is the graph of the equation $y = f(x)$.*
  - **OH.Math.HSF.IF.5c** *Emphasize the selection of a type of function for a model based on behavior of data and context.*
  - **OH.Math.HSF.IF.5b** *Focus on linear, quadratic, and exponential functions.*
  - **OH.Math.HSF.IF.5a** *Focus on linear and exponential functions.*

- **ARITHMETIC OPERATIONS ON FUNCTIONS**
  - **OH.Math.HSF.BF.1b** *Combine standard function types using arithmetic operations.*

- **MULTIPLE REPRESENTATIONS OF FUNCTIONS**
  - **OH.Math.HSF.LE.2** *Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table).*
  - **OH.Math.HSA.CED.2c** *Extend to include more complicated function situations with the option to graph with technology.*
  - **OH.Math.HSF.IF.4a** *Focus on linear and exponential functions.*
  - **OH.Math.HSF.IF.4b** *Focus on linear, quadratic, and exponential functions.*
  - **OH.Math.HSF.IF.9a** *Focus on linear and exponential functions.*
  - **OH.Math.HSF.IF.9b** *Focus on linear, quadratic, and exponential functions.*
  - **OH.Math.HSA.CED.2b** *Focus on applying simple quadratic expressions.*
  - **OH.Math.HSF.LE.1a** *Show that linear functions grow by equal differences over equal intervals and that exponential functions grow by equal factors over equal intervals.*

- **INVERSE FUNCTIONS**
  - **OH.Math.HSF.BF.4b** *Read values of an inverse function from a graph or a table, given that the function has an inverse.*

- **OH.Math.HSF.BF.4c** *Verify by composition that one function is the inverse of another.*
- **OH.Math.HSF.BF.4d** *Find the inverse of a function algebraically, given that the function has an inverse.*
- **OH.Math.HSF.BF.4a** *Informally determine the input of a function when the output is known.*
- **OH.Math.HSF.BF.4e** *Produce an invertible function from a non-invertible function by restricting the domain.*

10. PARENT FUNCTIONS AND TRANSFORMATIONS

- **PARENT FUNCTIONS**
  - **OH.Math.HSF.IF.7c** *Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions.*
  - **OH.Math.HSF.IF.4b** *Focus on linear, quadratic, and exponential functions.*
  - **OH.Math.HSF.IF.1** *Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then $f(x)$ denotes the output of f corresponding to the input x. The graph of f is the graph of the equation $y = f(x)$.*
  - **OH.Math.HSF.LE.2** *Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table).*
  - **OH.Math.HSF.IF.4a** *Focus on linear and exponential functions.*
  - **OH.Math.HSF.IF.7f** *Graph exponential functions, indicating intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.*
  - **OH.Math.HSF.IF.7d** *Graph polynomial functions, identifying zeros, when factoring is reasonable, and indicating end behavior.*
  - **OH.Math.HSF.BF.3a** *Focus on transformations of graphs of quadratic functions, except for $f(kx)$.*

- **TRANSFORMATIONS OF PARENT FUNCTIONS**
  - **OH.Math.HSG.CO.2** *Represent transformations in the plane using, e.g., transparencies and geometry software; describe transformations as functions that take points in the plane as inputs and give other points as outputs. Compare transformations that preserve distance and angle to those that do not, e.g., translation versus horizontal stretch.*
  - **OH.Math.HSG.CO.6** *Use geometric descriptions of rigid motions to transform figures and to predict the effect of a given rigid motion on a given figure; given two figures, use the definition of congruence in terms of rigid motions to decide if they are congruent.*
  - **OH.Math.HSF.BF.3a** *Focus on transformations of graphs of quadratic functions, except for $f(kx)$.*
  - **OH.Math.HSF.IF.1** *Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then $f(x)$ denotes the output of f corresponding to the input x. The graph of f is the graph of the equation $y = f(x)$.*
  - **OH.Math.HSF.IF.7c** *Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions.*
  - **OH.Math.HSF.IF.7f** *Graph exponential functions, indicating intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.*
  - **OH.Math.HSF.IF.7d** *Graph polynomial functions, identifying zeros, when factoring is reasonable, and indicating end behavior.*
  - **OH.Math.HSF.IF.4a** *Focus on linear and exponential functions.*
  - **OH.Math.HSF.IF.5c** *Emphasize the selection of a type of function for a model based on behavior of data and context.*

- **MULTIPLE TRANSFORMATIONS OF PARENT FUNCTIONS**
  - **OH.Math.HSG.CO.2** *Represent transformations in the plane using, e.g., transparencies and geometry software; describe transformations as functions that take points in the plane as inputs and give other points as outputs. Compare transformations that preserve distance and angle to those that do not, e.g., translation versus horizontal stretch.*
  - **OH.Math.HSG.CO.6** *Use geometric descriptions of rigid motions to transform figures and to predict the effect of a given rigid motion on a given figure; given two figures, use the definition of congruence in terms of rigid motions to decide if they are congruent.*
  - **OH.Math.HSG.CO.5** *Given a geometric figure and a rotation, reflection, or translation, draw the transformed figure using items such as graph paper, tracing paper, or geometry software. Specify a sequence of transformations that will carry a given figure onto another.*
  - **OH.Math.HSF.BF.3a** *Focus on transformations of graphs of quadratic functions, except for $f(kx)$.*
  - **OH.Math.HSF.IF.7c** *Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions.*

- **OH.Math.HSF.IF.7f** *Graph exponential functions, indicating intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.*
- **OH.Math.HSF.IF.7d** *Graph polynomial functions, identifying zeros, when factoring is reasonable, and indicating end behavior.*
- **OH.Math.HSF.IF.4a** *Focus on linear and exponential functions.*
- **OH.Math.HSF.IF.5c** *Emphasize the selection of a type of function for a model based on behavior of data and context.*

ABSOLUTE VALUE FUNCTIONS

- **OH.Math.HSF.IF.1** *Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then f(x) denotes the output of f corresponding to the input x. The graph of f is the graph of the equation y = f(x).*
- **OH.Math.HSF.BF.3a** *Focus on transformations of graphs of quadratic functions, except for f(kx).*
- **OH.Math.HSF.IF.7c** *Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions.*
- **OH.Math.HSF.IF.4b** *Focus on linear, quadratic, and exponential functions.*

11. SYSTEMS OF EQUATIONS

SOLVING THREE-VARIABLE SYSTEMS OF LINEAR EQUATIONS

- **OH.Math.HSA.REI.5** *Verify that, given a system of two equations in two variables, replacing one equation by the sum of that equation and a multiple of the other produces a system with the same solutions.*
- **OH.Math.HSA.CED.2a** *Focus on applying linear and simple exponential expressions.*
- **OH.Math.HSA.CED.2c** *Extend to include more complicated function situations with the option to graph with technology.*
- **OH.Math.HSA.CED.3a** *While functions will often be linear, exponential, or quadratic, the types of problems should draw from more complicated situations.*
- **OH.Math.HSA.REI.6b** *Extend to include solving systems of linear equations in three variables, but only algebraically.*

SYSTEMS OF NONLINEAR EQUATIONS

- **OH.Math.HSA.REI.7** *Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically.*
- **OH.Math.HSA.REI.5** *Verify that, given a system of two equations in two variables, replacing one equation by the sum of that equation and a multiple of the other produces a system with the same solutions.*
- **OH.Math.HSA.REI.11** *Explain why the x-coordinates of the points where the graphs of the equation y = f(x) and y = (x) intersect are the solutions of the equation f(x) = g(x); find the solutions approximately, e.g., using technology to graph the functions, making tables of values, or finding successive approximations.*
- **OH.Math.HSA.CED.3a** *While functions will often be linear, exponential, or quadratic, the types of problems should draw from more complicated situations.*
- **OH.Math.HSF.LE.2** *Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table).*

12. SURFACE AREA

SURFACE AREA AND VOLUME OF SPHERES

- **OH.Math.HSG.GMD.2** *Give an informal argument using Cavalieri's principle for the formulas for the volume of a sphere and other solid figures.*
- **OH.Math.HSG.GMD.3** *Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.*
- **OH.Math.HSG.GMD.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.*
- **OH.Math.HSG.MG.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.*

SURFACE AREA OF COMPOSITE SOLIDS

- **OH.Math.HSG.MG.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.*

- **SURFACE AREA OF SIMILAR SOLIDS**
  - **OH.Math.HSG.MG.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.*

13. THREE-DIMENSIONAL GEOMETRY

- **RELATING TWO-DIMENSIONAL FIGURES TO THREE-DIMENSIONAL SOLIDS**
  - **OH.Math.HSG.GMD.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.*
  - **OH.Math.HSG.CO.14** *Classify two-dimensional figures in a hierarchy based on properties.*

- **MODELING SITUATIONS WITH GEOMETRY**
  - **OH.Math.HSG.MG.2** *Apply concepts of density based on area and volume in modeling situations, e.g., persons per square mile, BTUs per cubic foot.*
  - **OH.Math.HSG.MG.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.*

14. STATISTICAL DESIGN AND ANALYSIS

- **ANALYZING STATISTICAL SAMPLES**
  - **OH.Math.HSS.IC.1** *Understand statistics as a process for making inferences about population parameters based on a random sample from that population.*
  - **OH.Math.HSS.IC.2** *Decide if a specified model is consistent with results from a given data-generating process, e.g., using simulation.*
  - **OH.Math.HSS.IC.4** *Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling.*

- **EXPERIMENTAL AND OBSERVATIONAL DESIGN**
  - **OH.Math.HSS.IC.3** *Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.*

- **CONCLUSIONS IN DATA**
  - **OH.Math.HSS.IC.5** *Use data from a randomized experiment to compare two treatments; use simulations to decide if differences between sample statistics are statistically significant.*
  - **OH.Math.HSS.IC.6** *Evaluate reports based on data.*

15. STATISTICS AND PROBABILITY

- **NORMAL DISTRIBUTION**
  - **OH.Math.HSS.ID.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.*
  - **OH.Math.HSS.IC.4** *Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling.*

- **ANALYZING DECISIONS IN PROBABILITY**
  - **OH.Math.HSS.MD.6** *Use probabilities to make fair decisions, e.g., drawing by lots, using a random number generator.*
  - **OH.Math.HSS.MD.7** *Analyze decisions and strategies using probability concepts, e.g., product testing, medical testing, pulling a hockey goalie at the end of a game.*