

Trigonometry *Standards of Learning* - 2023 Overview of Revisions

This overview includes a summary of the content embedded in four content strands.

Triangle Trigonometry

- Determine the sine, cosine, tangent, cotangent, secant, and cosecant of the acute angles in a right triangle and use these ratios to solve for missing sides and angle measures, including application in contextual problems
- Find the area of any triangle and solve for the lengths of the sides and measures of the angles in a non-right triangle using the Law of Sines and the Law of Cosines

Circular Trigonometry

- Determine the degree and radian measure of angles; sketch angles in standard position on a coordinate plane; and determine the sine, cosine, tangent, cosecant, secant, and cotangent of an angle, given a point on the terminal side of an angle in standard position or the value of a trigonometric function of the angle
- Develop and apply the properties of the unit circle in degrees and radians

Graphs of Trigonometric Functions

- Graph and analyze trigonometric functions and apply trigonometric functions to represent periodic phenomena
- Graph the six inverse trigonometric functions

Identities and Equations

- Evaluate expressions involving the six trigonometric functions and the inverse sine, cosine, and tangent functions
- Use basic trigonometric identity substitutions to simplify and verify trigonometric identities
- Solve trigonometric equations and inequalities

Comparison of Trigonometry Mathematics *Standards of Learning* – 2016 to 2023

2016 <i>Standards of Learning</i> Essential Knowledge and Skills (EKS) Triangular and Circular Trigonometric Functions	2023 <i>Standards of Learning</i> Knowledge and Skills (KS) Triangle Trigonometry (TT)
<p>T.1 The student, given a point on the terminal side of an angle in standard position, or the value of the trigonometric function of the angle, will determine the sine, cosine, tangent, cotangent, secant, and cosecant of the angle.</p> <ul style="list-style-type: none"> ● Define the six triangular trigonometric functions of an angle in a right triangle. ● Draw a reference right triangle when given a point on the terminal side of the angle in standard position. ● Draw a reference right triangle when given the value of a trigonometric function of the angle. ● Determine the value of any trigonometric function when given a point on the terminal side of an angle in standard position. ● Given one trigonometric function value, determine the other five trigonometric function values. 	<p>T.TT.1 The student will determine the sine, cosine, tangent, cotangent, secant, and cosecant of the acute angles in a right triangle and use these ratios to solve for missing sides and angle measures, including application in contextual problems.</p> <ol style="list-style-type: none"> a) Define and represent the six triangular trigonometric ratios (sine, cosine, tangent, cosecant, secant, and cotangent) of an angle in a right triangle. b) Describe the relationships between side lengths in special right triangles (30°-60°-90° and 45°-45°-90°). c) Use the trigonometric functions, the Pythagorean Theorem, the Law of Sines, and the Law of Cosines to solve contextual problems. d) Represent and solve contextual problems involving right triangles, including problems involving angles of elevation and depression.
<p>[Moved from T.8]</p>	<p>T.TT.2 The student will find the area of any triangle and solve for the lengths of the sides and measures of the angles in a non-right triangle using the Law of Sines and the Law of Cosines.</p> <ol style="list-style-type: none"> a) Apply the Law of Sines, and the Law of Cosines, as appropriate, to find missing sides and angles in non-right triangles. b) Recognize the ambiguous case when applying the Law of Sines and the potential for two triangle solutions in some situations.

<p align="center">2016 Standards of Learning Essential Knowledge and Skills (EKS) Triangular and Circular Trigonometric Functions</p>	<p align="center">2023 Standards of Learning Knowledge and Skills (KS) Triangle Trigonometry (TT)</p>
	<p>c) Solve problems that integrate the use of the Law of Sines and the Law of Cosines and the triangle area formula ($\text{Area} = \frac{1}{2}ab\sin C$, where a and b are triangle sides and C is the included angle) to find the area of any triangle, including those in contextual problems.</p>

<p align="center">2016 Standards of Learning Essential Knowledge and Skills (EKS) Graphs of Trigonometric Functions</p>	<p align="center">2023 Standards of Learning Knowledge and Skills (KS) Circular Trigonometry (CT)</p>
<p>[Moved from T.1 and T.9a]</p>	<p>T.CT.1 The student will determine the degree and radian measure of angles; sketch angles in standard position on a coordinate plane; and determine the sine, cosine, tangent, cosecant, secant, and cotangent of an angle, given a point on the terminal side of an angle in standard position or the value of a trigonometric function of the angle.</p> <ul style="list-style-type: none"> a) Define a radian as a unit of angle measure and determine the relationship between the radian measure of an angle and the length of the intercepted arc in a circle. b) Determine the degree and radian measure of angles to include both negative and positive rotations in the coordinate plane. c) Find both positive and negative coterminal angles for a given angle. d) Identify the quadrant or axis in/on which the terminal side of an angle lies.

<p align="center">2016 Standards of Learning Essential Knowledge and Skills (EKS) Graphs of Trigonometric Functions</p>	<p align="center">2023 Standards of Learning Knowledge and Skills (KS) Circular Trigonometry (CT)</p>
	<ul style="list-style-type: none"> e) Draw a reference right triangle when given a point on the terminal side of an angle in standard position. f) Draw a reference right triangle when given the value of a trigonometric function of an angle (sine, cosine, tangent, cosecant, secant, and cotangent). g) Determine the value of any trigonometric function (sine, cosine, tangent, cosecant, secant, and cotangent) when given a point on the terminal side of an angle in standard position. h) Given one trigonometric function value, determine the other five trigonometric function values. i) Calculate the length of an arc of a circle in radians. j) Calculate the area of a sector of a circle.
<p>T.2 The student will develop and apply the properties of the unit circle in degrees and radians.</p> <ul style="list-style-type: none"> ● Define the six circular trigonometric functions of an angle in standard position. ● Apply the properties of the unit circle to determine trigonometric function values of special angles and their related angles in both degrees and radians without using a graphing utility. ● Apply the properties of the unit circle to convert between special angles expressed in radians and degrees, without using a graphing utility. 	<p>T.CT.2 The student will develop and apply the properties of the unit circle in degrees and radians.</p> <ul style="list-style-type: none"> a) Convert between radian and degree measure of special angles of the unit circle without the use of technology. b) Define the six circular trigonometric functions of an angle in standard position on the unit circle. c) Apply knowledge of right triangle trigonometry, special right triangles, and the properties of the unit circle to determine trigonometric functions values of special angles (0°, 30°, 45°, 60°, and 90°) and their related angles in degree and radians without the use of technology.

<p style="text-align: center;">2016 Standards of Learning Essential Knowledge and Skills (EKS) Graphs of Trigonometric Functions</p>	<p style="text-align: center;">2023 Standards of Learning Knowledge and Skills (KS) Graphs of Trigonometric Functions (GT)</p>
<p>T.3 The student, given one of the six trigonometric functions in standard form, will</p> <ol style="list-style-type: none"> a) state the domain and the range of the function; b) determine the amplitude, period, phase shift, vertical shift, and asymptotes; c) sketch the graph of the function by using transformations for at least a two-period interval; and d) investigate the effect of changing the parameters in a trigonometric function on the graph of the function. <ul style="list-style-type: none"> ● State the domain and the range of a trigonometric function written in standard form. (a) ● Determine the amplitude, period, phase shift, vertical shift, and asymptotes of a trigonometric function from the equation of the function and from the graph of the function. (b) ● Describe the effect of changing A, B, C, or D in the standard form of a trigonometric equation. (d) ● Sketch the graph of a function written in standard form by using transformations for at least a two-period interval, including both positive and negative values for the domain. (c) 	<p>T.GT.1 The student will graph and analyze trigonometric functions and apply trigonometric functions to represent periodic phenomena.</p> <ol style="list-style-type: none"> a) Sketch the graph of the six parent trigonometric functions (sine, cosine, tangent, cosecant, secant, and cotangent) for at least a two-period interval. b) Determine the domain and range, amplitude, period, and asymptote locations for a trigonometric function, given a graph or an equation. c) Describe the effects of changing the parameters (A, B, C, or D in the standard form of a trigonometric equation) on the graph of the function using graphing technology. d) Sketch the graph of a transformed sine, cosine, and tangent function written in standard form by using transformations for at least a two-period interval, including both positive and negative values for the domain. <ol style="list-style-type: none"> a) Apply trigonometric functions and their graphs to represent periodic phenomena.
<p>T.4 The student will graph the six inverse trigonometric functions.</p> <ul style="list-style-type: none"> ● Determine the domain and range of the inverse trigonometric functions. ● Use the restrictions on the domains of the inverse trigonometric functions in determining the values of the inverse trigonometric functions. 	<p>T.GT.2 The student will graph the six inverse trigonometric functions.</p> <ol style="list-style-type: none"> a) Determine the domain and range of the inverse trigonometric functions.

<p align="center">2016 Standards of Learning Essential Knowledge and Skills (EKS) Graphs of Trigonometric Functions</p>	<p align="center">2023 Standards of Learning Knowledge and Skills (KS) Graphs of Trigonometric Functions (GT)</p>
<ul style="list-style-type: none"> ● Graph inverse trigonometric functions. 	<ul style="list-style-type: none"> b) Use the restrictions on the domain of an inverse trigonometric function to determine a value of the inverse trigonometric function. c) Graph inverse trigonometric functions.

<p align="center">2016 Standards of Learning Essential Knowledge and Skills (EKS) Equations and Identities</p>	<p align="center">2023 Standards of Learning Knowledge and Skills (KS) Identities and Equations (IE)</p>
<p>[Moved from T.7]</p>	<p>T.IE.1 The student will evaluate expressions involving the six trigonometric functions and the inverse sine, cosine, and tangent functions.</p> <ul style="list-style-type: none"> a) Determine the values of trigonometric functions, with and without graphing technology. b) Determine angle measures by using the inverse trigonometric functions, with and without a graphing technology. c) Evaluate composite functions that involve trigonometric functions and inverse trigonometric functions.
<p>T.5 The student will verify basic trigonometric identities and make substitutions, using the basic identities.</p> <ul style="list-style-type: none"> ● Use trigonometric identities to make algebraic substitutions to simplify and verify trigonometric identities. The basic trigonometric identities include 	<p>T.IE.2 The student will use basic trigonometric identity substitutions to simplify and verify trigonometric identities.</p> <ul style="list-style-type: none"> a) Use trigonometric identities to make algebraic substitutions to simplify and verify trigonometric identities. The basic trigonometric identities include

<p align="center">2016 <i>Standards of Learning</i> Essential Knowledge and Skills (EKS) Equations and Identities</p>	<p align="center">2023 <i>Standards of Learning</i> Knowledge and Skills (KS) Identities and Equations (IE)</p>
<ul style="list-style-type: none"> o reciprocal identities; o Pythagorean identities; o sum and difference identities; o double-angle identities; and o half-angle identities. 	<ul style="list-style-type: none"> i) reciprocal identities; ii) Pythagorean identities; iii) sum and difference identities; iv) double-angle identities; and v) half-angle identities. <p>b) Apply the sum, difference, and half-angle identities to evaluate trigonometric function values of angles that are not integer multiples of the special angles to solve problems, including contextual situations.</p>
<p>T.6 The student will solve trigonometric equations and inequalities.</p> <ul style="list-style-type: none"> ● Solve trigonometric equations with and without restricted domains algebraically and graphically. ● Solve trigonometric inequalities algebraically and graphically. ● Verify algebraic solutions, using a graphing utility. 	<p>T.IE.3 The student will solve trigonometric equations and inequalities.</p> <ul style="list-style-type: none"> a) Solve trigonometric equations with and without restricted domains algebraically and graphically. b) Solve trigonometric inequalities algebraically and graphically. c) Verify and justify algebraic solutions to trigonometric equations and inequalities, using graphing technology.
<p>T.7 The student will determine the value of any trigonometric function and inverse trigonometric function.</p> <ul style="list-style-type: none"> ● Use a graphing utility to determine the trigonometric function values of any angle in either degrees or radians. ● Define inverse trigonometric functions. ● Determine angle measures by using the inverse trigonometric functions when the trigonometric function values are given. 	<p>[Moved to T.IE.1]</p>

<p style="text-align: center;">2016 Standards of Learning Essential Knowledge and Skills (EKS) Applications of Trig Functions</p>	<p style="text-align: center;">2023 Standards of Learning Knowledge and Skills (KS) Applications of Trig Functions (AT)</p>
<p>T.8 The student will create and solve practical problems involving triangles.</p> <ul style="list-style-type: none"> ● Create and solve practical problems involving triangles. ● Use the trigonometric functions, Pythagorean Theorem, Law of Sines, and Law of Cosines to solve practical problems. ● Use the trigonometric functions to model practical situations. ● Identify a solution technique associated with triangles that could be used with a given problem. ● Apply the sum and difference identities for sine, cosine, and tangent to solve problems. 	<p>[Moved to T.TT.2]</p>
<p>T.9 The student will solve problems, including practical problems, involving</p> <p>a) arc length and area of sectors in circles using radians and degrees; and</p> <p>b) linear and angular velocity.</p> <ul style="list-style-type: none"> ● Convert between any angle expressed in radians and degrees without the use of technology. (a) ● Derive the relationship between the radian measure of an angle and the length of the intercepted arc. (a) ● Calculate the length of an arc in radians. (a) ● Calculate the area of sectors in circles. (a) ● Solve practical problems involving linear and angular velocity. (b) 	<p>[T.9a moved to T.CT.1] [T.9b Included in Physics PH.2]</p>

2023 Trigonometry Mathematics SOL – Summary of Changes

Trigonometry (2016 SOL to 2023 SOL Numbering)	Parameter Changes/Clarifications (2023 SOL)
<ul style="list-style-type: none"> ● T.1 → T.TT.1, T.CT.1 ● T.2 → T.CT.2 ● T.3a-d → T.GT.1 ● T.4 → T.GT.2 ● T.5 → T.IE.2 ● T.6 → T.IE.3 ● T.7 → T.IE.1 ● T.8 → T.TT.2 ● T.9a → T.CT.1 ● T.9b → [Included in Physics] 	<ul style="list-style-type: none"> ● T.TT.2 [KS] - Recognize the ambiguous case when applying the Law of Sines

Deletions from Trigonometry (2016 SOL)	Additions to Trigonometry (2023 SOL)
<ul style="list-style-type: none"> ● T.9b - Linear and angular velocity [Included in Physics] 	<ul style="list-style-type: none"> ● T.TT.1 [KS] - Relationships between side lengths in special right triangles ● T.TT.1 [KS] - Model and solve problems, including contextual problems, involving angles of elevation and depression ● T.TT.2 [KS] - Solve problems that integrate the triangle area formula ($\text{Area} = \frac{1}{2}ab\sin C$, where a and b are triangle sides and C is the included angle) ● T.IE.1 [KS] - Evaluate composite functions that involve trigonometric functions and inverse trigonometric functions

KEY: TT = Triangle Trigonometry; CT = Circular Trigonometry; GT = Graphs of Trigonometric Functions; IE = Identities and Equations; AT = Applications of Trig Functions; EKS = Essential Knowledge and Skills (2016); KS = Knowledge and Skills (2023); US = Understanding the Standard