Indiana Mathematics

Precalculus: Trigonometry: Grades 9, 10, 11, 12

Adopted 2020

Process Standards For Mathematics

1. **Make sense of problems and persevere in solving them.** PS.1
2. **Reason abstractly and quantitatively.** PS.2
3. **Construct viable arguments and critique the reasoning of others.** PS.3
4. **Model with mathematics.** PS.4
5. **Use appropriate tools strategically.** PS.5
6. **Attend to precision.** PS.6
7. **Look for and make use of structure.** PS.7
8. **Look for and express regularity in repeated reasoning.** PS.8

Unit Circle

1. **Understand radian measure of an angle as the length of the arc on the unit circle subtended by the angle.** TR.UC.1
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.** TR.UC.2
3. **Use special triangles to determine the values of sine, cosine, and tangent for π/3, π/4, and π/6. Apply special right triangles to the unit circle and use them to express the values of sine, cosine, and tangent for x, π ± x, and 2π ± x in terms of their values for x, where x is any real number.** TR.UC.3

Triangles

1. **Define and use the trigonometric ratios (sine, cosine, tangent, cotangent, secant, cosecant) in terms of angles of right triangles and the coordinates on the unit circle.** TR.T.1
2. **Solve real-world problems with and without technology that can be modeled using right triangles, including problems that can be modeled using trigonometric ratios. Interpret the solutions and determine whether the solutions are reasonable.** TR.T.2

	3. Explain and use the relationship between the sine and cosine of complementary angles TR.T.3
	4. Prove the Laws of Sines and Cosines. TR.T.4
	5. Understand and apply the Laws of Sines and Cosines to solve real-world and other mathematical problems involving right and non-right triangles. TR.T.5
	6. Derive the formula A = ½ ab sin(C) for the area of a triangle by drawing an auxiliary line. Use the formula to find areas of triangles. TR.T.6
Periodic Functions	1. Graph trigonometric functions with and without technology. Use the graphs to model and analyze periodic phenomena, stating amplitude, period, frequency, phase shift, and midline (vertical shift). TR.PF.1
	2. Model a data set with periodicity using a sinusoidal function and explain the parameters of the model. TR.PF.2
	3. Use the unit circle to explain symmetry (odd and even) and periodicity of trigonometric functions. TR.PF.3
	4. Construct the inverse trigonometric functions of sine, cosine, and tangent by restricting the domain. TR.PF.4
	5. 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. TR.PF.5
Identities	1. Prove the Pythagorean identity $\sin^2(x) + \cos^2(x) = 1$ and use it to find trigonometric ratios, given sin(x), cos(x), or tan(x), and the quadrant of the angle. TR.ID.1
	2. Verify trigonometric identities and simplify expressions using trigonometric identities. TR.ID.2
	3. Prove the addition and subtraction identities for sine, cosine, and tangent. Use the identities to solve problems. TR.ID.3
	4. Prove the double- and half-angle identities for sine, cosine, and tangent. Use the identities to solve problems. TR.ID.4
Polar Coordinates and Complex Numbers	1. Understand and use complex numbers, including real and imaginary numbers, on the complex plane in rectangular and polar form, and explain why the rectangular and polar forms of a given complex number represent the same number. TR.PC.1
	2. State, prove, and use DeMoivre's Theorem. TR.PC.2

3. **Define polar coordinates and relate polar coordinates to Cartesian coordinates.** TR.PC.3

4. **Translate equations from rectangular coordinates to polar coordinates and from polar coordinates to rectangular coordinates. Graph equations in the polar coordinate plane.** TR.PC.4

Vectors

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||).** TR.V.1

2. **Find the components of a vector by subtracting the coordinates of an initial point from the coordinates of a terminal point.** TR.V.2

3. **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.** TR.V.3

4. **Understand vector subtraction v -w as v + (-w), where -w is the additive inverse of w, with the same magnitude as w and pointing in the opposite direction. Represent vector subtraction graphically by connecting the tips in the appropriate order, and perform vector subtraction component-wise.** TR.V.4

5. **Represent scalar multiplication graphically by scaling vectors and possibly reversing their direction; perform scalar multiplication component-wise, e.g., as c(vx, vy) = (cvx, cvy).** TR.V.5

6. **Compute the magnitude of a scalar multiple cv using ||cv|| = |c|v. Compute the direction of cv knowing that when |c|v ≠ 0, the direction of cv is either along v (for c > 0) or against v (for c < 0).** TR.V.6

7. **Solve problems involving velocity and other quantities that can be represented by vectors.** TR.V.7