NEW MEXICO
Public Education Department

HS: FUNCTIONS- TRIGONOMETRIC FUNCTIONS

Cluster Statement: B: Model periodic phenomena with trigonometric functions.

Standard Text	**Standard for Mathematical Practices**	**Students who demonstrate understanding can:**
HSF.TF.B.5 Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline.	SMP 4 Students model with mathematics. By demonstrating how trigonometric functions can be used to model real-life periodic phenomena. SMP 8 Students look for and express regularity in repeated reasoning when examining trigonometric functions as periodic in nature. Students will also utilize patterns in problem solving.	• Graph sine and cosine functions using radian and degrees. • Identify properties of the sine function. • Model a real-world situation using trigonometric functions. Students can then use inverse trigonometric functions to find solutions.
		Webb's Depth Of Knowledge: 1-2
		Bloom's Taxonomy: understand, apply

Previous Learning Connections	**Current Learning Connections**	**Future Learning Connections**
In Geometry and Algebra II, students have defined trigonometric ratios using the acute angles of right triangles	In Algebra II, students define inverse functions an	Inverse trigonometric functions play a major role in Calculus, when using operations such as differentiation and integration.

Clarification Statement
Students apply the concept of inverse functions to trigonometric functions and use that concept to solve problems.

Common Misconceptions
Students may mix-up sine and cosine.

Multi-Layered System of Supports (MLSS)/Suggested Instructional Strategies

Pre-Teach

Pre-teach (targeted): *What pre-teaching will prepare students to productively struggle with the mathematics for this cluster within your HQIM?*

- For example, some learners may benefit from targeted pre-teaching that rehearses new mathematical language when studying modelling periodic phenomena with trigonometric functions because there is new vocabulary introduced in this cluster

that relates to the graphs of trigonometric functions. These terms will then be applied to contextual scenarios. By rehearsing how to precisely use these terms to describe graphs can support student's later work in using them to describe scenarios.

Pre-teach (intensive): *What critical understandings will prepare students to access the mathematics for this cluster?*

- F-IF.C.7: This standard provides a foundation for work with modelling periodic phenomena with trigonometric functions because this standard is where students focused on describing key features of other function families. If students have unfinished learning within this standard, based on assessment data, consider ways to provide intensive pre-teaching support prior to the start of the unit to ensure students are ready to access grade level instruction and assignments.

Core Instruction

Access

Interest: How will the learning for students provide multiple options for recruiting student interest?

- For example, learners engaging with modelling periodic phenomena with trigonometric functions benefit when learning experiences include ways to recruit interest such as providing contextualized examples to their lives because many relevant concepts are roughly modeled by periodic functions. This is a perfect opportunity to incorporate student interests and/or social issues into mathematics (e.g. is climate change real or do temperatures just fluctuate naturally?). Students can, therefore, see the power of mathematics and discuss features of periodic functions grounded in context.

Build

Effort and Persistence: How will the learning for students provide options for sustaining effort and persistence?

- For example, learners engaging with modelling periodic phenomena with trigonometric functions benefit when learning experiences attend to students attention and affect to support sustained effort and concentration such as providing alternatives in the mathematics representations and scaffolds because students can reason solutions to real-world problems using tables, graphs, logical reasoning and/or calculations with functions. Allowing students to engage in a variety of representations and looking for connections between them can strengthen their understanding of these functions and their features.

Language and Symbols: How will the learning for students provide alternative representations to ensure accessibility, clarity and comprehensibility for all learners? (e.g., a graph illustrating the relationship between two variables may be informative to one learner and inaccessible or puzzling to another; picture or image may carry very different meanings for learners from differing cultural or familial backgrounds)

- For example, learners engaging with modelling periodic phenomena with trigonometric functions benefit when learning experiences attend to the linguistic and nonlinguistic representations of mathematics to ensure clarity can comprehensibility for all learners such as pre-teaching vocabulary and symbols, especially in ways that promote connection to the learners' experience and prior knowledge because the new vocabulary/key features of these graphs are unique to the family of periodic functions. Showing these terms with definitions and images at the beginning can help students see what the end-goal of the lesson will be.

Expression and Communication: How will the learning provide multiple modalities for students to easily express knowledge, ideas, and concepts in the learning environment?

- For example, learners engaging with modelling periodic phenomena with trigonometric functions benefit when learning experiences attend to the multiple ways students can express knowledge, ideas, and concepts such as providing calculators, graphing calculators, geometric sketchpads, or pre-formatted graph paper because trigonometric functions are frequently graphed with a domain in radians and students may not be efficient yet in setting up a graph by hand in this unit of measurement. Establishing the appropriate domain on a calculator or graphing software and/or providing the set-up of a graph on graph paper can allow students to focus on the key features of the graphs rather than the detail of setting up the problem.

Internalize
Self-Regulation: How will the design of the learning strategically support students to effectively cope and engage with the environment?

- For example, learners engaging with modelling periodic phenomena with trigonometric functions benefit when learning experiences set personal goals that increase ownership of learning goals and support healthy responses and interactions (e.g., learning from mistakes), such as supporting students with metacognitive approaches to frustration when working on mathematics because the concept of periodic functions will be new to many students and, therefore, students may be tempted to stop working when they feel stuck. Prompting students to look for the key features (midline as middle point, amplitude as how high does it go, etc.) can allow students to begin to "unstick" themselves. If we set up cooperative learning groups, this can further allow students to learn from each other and share/critique their reasoning.

Re-teach

Re-teach (targeted): *What formative assessment data (e.g., tasks, exit tickets, observations) will help identify content needing to be revisiting during a unit?*

- For example, students may benefit from re-engaging with content during a unit on modelling periodic phenomena with trigonometric functions by critiquing student approaches/solutions to make connections through a short mini-lesson because students may formulate solutions from multiple perspectives (table, graph, calculation, logical reasoning). Presenting multiple solution methods allows students to think from a new perspective and analyze the features of these functions in a new way. This may illuminate errors in their own work or in the work of others.

Re-teach (intensive): *What assessment data will help identify content needing to be revisited for intensive interventions?*

- For example, some students may benefit from intensive extra time during and after a unit modelling periodic phenomena with trigonometric functions by offering opportunities to understand and explore different strategies because students may, at times, have an easier time solving a problem using a table rather than a graph or equation and vice versa. Allowing students, the opportunity to explore these different strategies and to discuss their usefulness will help students deepen their understanding of the concepts as well as build their skills of using different representations to solve problems. ...

Extension

What type of extension will offer additional challenges to 'broaden' your student's knowledge of the mathematics developed within your HQIM?

- For example, some learners may benefit from an extension such as <open ended tasks linking multiple disciplines when studying modelling periodic phenomena with trigonometric functions because once a student has a conceptual understanding of periodic functions, the applications are easy to see in science and career specific scenarios. Linking these can allow students to explore their interests beyond the mathematics.

Culturally and Linguistically Responsive Instruction:
Validate/Affirm: How can you design your mathematics classroom to intentionally and purposefully legitimize the home culture and languages of students and reverse the negative stereotypes regarding the mathematical abilities of students of marginalized cultures and languages?
Build/Bridge: How can you create connections between the cultural and linguistic behaviors of your students' home culture and language the culture and language of school mathematics to support students in creating mathematical identities as capable mathematicians that can use mathematics within school and society?

Task: When planning with your HQIM consider how to modify tasks to represent the prior experiences, culture, language and interests of your students to "portray mathematics as useful and important in students' lives and promote students' lived experiences as important in mathematics class." Tasks can also be designed to "promote social justice [to] engage students in using mathematics to understand and eradicate social inequities (Gutstein 2006)." For example, when studying modelling periodic phenomena with trigonometric functions the types of mathematical tasks are critical because we often experience patterns in the real-world, whether it be related to science or societal issues. This is an opportunity for students to explore claims like "climate change is not real" or "the violent crime rate always rises in the warmer months" mathematically by attempting to apply features of periodic functions to describe them, or showing that these features do not exist within the data.

Standards Aligned Instructionally Embedded Formative Assessment Resources:
http://tasks.illustrativemathematics.org/content-standards/HSF/TF/B/5/tasks/816

This type of assessment question requires students to model the population of two species using trigonometric functions given a table of data. Since students may use positive or negative sine and cosine functions to model the data, consider having students work in cooperate groups and comparing solutions between groups. Students will engage with SMP 1, SMP 4 and if comparing work with other groups, SMP 3.

Relevance to families and communities:

During a unit focused on modelling periodic phenomena with trigonometric functions, consider options for learning from your families and communities the cultural and linguistic ways this mathematics exists outside of school to create stronger home to school connections for students, have students provide examples of music they enjoy and discuss how music creates sound waves that are modeled by trigonometric functions. Using free online tools, you can create sound wave images (as a class or on an individual basis) and discuss the features of these images as they relate to periodic functions.

Cross-Curricular Connections:
Many of the Navajo rug designs you will discover by following the project will be good examples of symmetrical balance. Symmetrical balance is a type of visual balance where the overall composition is arranged to look like it is the same on both sides of the center of the design. In other words, it is a design which could be folded in half, and as the design folds, each part of the design would match up with its symmetrical counterpart on the opposite side of the center. The rug design on the right is symmetrical left-to-right. If a line was drawn vertically down the center of the rug, the arrangement of shapes and colors would appear to be exactly the opposite of each other on both sides of that line.
Design a Navajo Rug