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Public Education Department

<table>
<tr><td colspan="3">HS: GEOMETRY- SIMILARITY, RIGHT TRIANGLES, & TRIGONOMETRY</td></tr>
<tr><td colspan="3">Cluster Statement: C: Define trigonometric ratios and solve problems involving right triangles

Widely Applicable as Prerequisite for a Range of College Majors, Postsecondary Programs and Careers</td></tr>
<tr><td rowspan="3">Standard Text

HSG.SRT.C.6
Understand that by similarity, side ratios in right triangles are properties of the angles in the triangle, leading to definitions of trigonometric ratios for acute angles.</td><td rowspan="3">Standard for Mathematical Practices

SMP3
Students construct viable arguments and critique reasoning of other by engaging students on discussion of why they agree or disagree with responses, decide whether they make sense, and ask useful questions to clarify or improve the arguments. Students will examine proofs using properties, definitions, and theorems.

SMP4
Students model with mathematics by modeling with right triangles and determine corresponding parts of similar figures when calculating indirect measurements in the context of a given real-world scenario.

SMP6
Students attend to precision by requiring students to calculate efficiently and accurately and to communicate precisely using correct mathematical language

SMP7
Students look for and make use of structure by expecting students to apply rules, look for patterns, and analyze structure. Students identify patterns in tables of values to formulate generalizations about relationships within and between trigonometric ratios. They will also determine how complementary angles and their trigonometric functions are related.</td><td>Students who demonstrate understanding can:
• Use similarity, side ratios, and angles in right triangles to develop and define trigonometric ratios to help in completion of triangles
• Identify the side opposite to and adjacent to an acute angle in a right triangle.
• Write and simplify ratios using the sides of a right triangle.
• Compare side ratios of similar right triangles and identify if they are equivalent.
• Use the definition of sine, cosine, tangent, secant, cosecant, and cotangent to write those trigonometric ratios for a given triangle.</td></tr>
<tr><td>Webb's Depth Of Knowledge: 1-2</td></tr>
<tr><td>Bloom's Taxonomy: understand, apply</td></tr>
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<tr>
<td rowspan="3">Standard Text

HSG.SRT.C.7
Explain and use the relationship between the sine and cosine of complementary angles.</td>
<td rowspan="3">Standard for Mathematical Practices

SMP3
Students construct viable arguments and critique reasoning of other by engaging students on discussion of why they agree or disagree with responses, decide whether they make sense, and ask useful questions to clarify or improve the arguments. Students will examine proofs using properties, definitions, and theorems.

SMP4
Students model with mathematics by modeling with right triangles and determine corresponding parts of similar figures when calculating indirect measurements in the context of a given real-world scenario.

SMP6
Students attend to precision by requiring students to calculate efficiently and accurately and to communicate precisely using correct mathematical language

SMP7
Students look for and make use of structure by expecting students to apply rules, look for patterns, and analyze structure. Students identify patterns in tables of values to formulate generalizations about relationships within and between trigonometric ratios. They will also determine how complementary angles and their trigonometric functions are related.</td>
<td>Students who demonstrate understanding can:
• Use the concept of complementary angles to show how sine and cosine are related
• Identify the opposite leg, adjacent leg, and hypotenuse with respect to an angle in a right triangle.
• Explain the relationship between sine and cosine of complementary angles of right triangles.</td>
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<tr>
<td>Webb’s Depth of Knowledge: 1</td>
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<tr>
<td>Bloom’s Taxonomy: understand</td>
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Standard Text	Standard for Mathematical Practices	Students who demonstrate understanding can:
HSG.SRT.C.8 **Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.**	SMP3 Students construct viable arguments and critique reasoning of other by engaging students on discussion of why they agree or disagree with responses, decide whether they make sense, and ask useful questions to clarify or improve the arguments. Students will examine proofs using properties, definitions, and theorems. SMP4 Students model with mathematics by modeling with right triangles and determine corresponding parts of similar figures when calculating indirect measurements in the context of a given real-world scenario. SMP6 Students attend to precision by requiring students to calculate efficiently and accurately and to communicate precisely using correct mathematical language SMP7 Students look for and make use of structure by expecting students to apply rules, look for patterns, and analyze structure. Students identify patterns in tables of values to formulate generalizations about relationships within and between trigonometric ratios. They will also determine how complementary angles and their trigonometric functions are related.	• Apply the trig ratios and the Pythagorean theorem to solve right triangle models • Identify the unknown parts of a right triangle using the sine/cosine/tangent ratios. • Solve for the unknown angle measures of a right triangle using inverse sine, inverse cosine, and inverse tangent. • Solve for the unknown parts of a right triangle using Pythagorean Theorem. • Solve real world problems using trigonometric ratios and the Pythagorean Theorem. **Webb's Depth of Knowledge:** 1-2 **Bloom's Taxonomy:** understand, apply
Previous Learning Connections • In 8th grade, students applied the Pythagorean Theorem to find unknown side length in right triangles and distance between two points. They will make connections between Pythagorean Theorem and	**Current Learning Connections** • Students will continue to use trigonometric ratios throughout the remainder of the course. A strong procedural fluency is necessary for individuals to apply these ratios to items within future	**Future Learning Connections** • In future courses, trigonometric ratios are used to develop more complex concepts such as relationships within the unit circle. Students will graph the trigonometric functions and observe the

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trigonometric ratios to continue solving right triangles in this cluster.	clusters. Pythagorean Theorem and the trigonometric ratios are used to find lengths necessary for finding surface areas and volumes. Students use similarity concepts when defining properties of circles, arc lengths, and sector areas.	cyclic patterns that arise from the trigonometric ratio relationships.

Clarification Statement

This cluster builds on the concepts of similarity to define the trigonometric ratios. Using Pythagorean Theorem and trigonometric ratios, students solve for unknown side lengths and angle measures in right triangles.

Common Misconceptions

Students may confuse side lengths with angle measurements and will place values as the wrong substitutions in the ratios.

Students may think that right triangles must be oriented a particular way. They may not realize that opposite and adjacent sides need to be identified with reference to a particular acute angle in a right triangle.

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 introduces new representations when studying trigonometric ratios because < students will be able to draw prior knowledge of trigonometric ratios by representing proportional relationships between quantities learned prior to this cluster.

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

- 7.RP.A.2- Recognize and represent proportional relationships between quantities: This standard provides a foundation for work with trigonometric ratios because the ratios explored in graphing linear relationships can be explored by now exposing students to trigonometric ratios within a right triangle. 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 defining trigonometric ratios and solving problems involving right triangles benefit when learning experiences include ways to recruit interest such as providing contextualized examples to their lives because right triangles can be seen any a variety of applications (surveying, architecture, construction working, estimating height, etc.). Providing a variety of contexts can help attend to student interest.

Build

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

- For example, learners engaging with defining trigonometric ratios and solving problems involving right triangles benefit when learning experiences attend to students attention and affect to support sustained effort and concentration such as providing feedback that models how to incorporate evaluation, including identifying patterns of errors and wrong answers, into positive strategies for future success because in setting up the initial ratio, students may write a reciprocal relationship and/or incorrectly place an angle measurement as a side length (or vice versa). These are simple errors that students will make repeatedly. Providing feedback on that pattern of errors will allow students to progress with success.

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 defining trigonometric ratios and solving problems involving right triangles 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 students frequently struggle with correctly identifying "opposite" and "adjacent" sides in a triangle. Without that key piece of understanding mastered, students cannot correctly set up or identify appropriate trigonometric ratios to model scenarios. Pre-teaching what opposite and adjacent mean as well as how that relationship is dependent upon a reference angle can help students easily progress to identifying and writing trigonometric ratios.

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 defining trigonometric ratios and solving problems involving right triangles benefit when learning experiences attend to the multiple ways students can express knowledge, ideas, and concepts such as providing scaffolds that can be gradually released with increasing independence and skills (e.g., embedded into digital programs) because students may initially struggle to create their own visual representation of a scenario/visualize a scenario. Beginning with problems that provide a visual and then progressing into modelling creating a visual can encourage students to eventually create their own visuals.

Internalize

Comprehension: *How will the learning for students support transforming accessible information into usable knowledge, knowledge that is accessible for future learning and decision-making?*

- For example, learners engaging with defining trigonometric ratios and solving problems involving right triangles benefit when learning experiences attend to students by intentionally building connections to prior understandings and experiences; relating important information to the learning goals; providing a process for meaning making of new learning; and, applying learning to new contexts such as providing explicit, supported opportunities to generalize learning to new situations (e.g., different types of problems that can be solved with linear equations) because complex scenarios can often be broken down into right triangles. Once students comprehend this structure, they can apply their understanding of right triangles efficiently in new contexts.

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 solving problems involving right triangles by clarifying mathematical ideas and/or concepts through a short mini-lesson because polygons other than triangles are not necessarily similar if each pair of corresponding angles is congruent. For example, all

- rectangles have congruent corresponding angles, but the corresponding sides of all rectangles do not have the same ratio.

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 on solving problems involving right triangles by offering opportunities to understand and explore different strategies because by investigating patterns of association in bivariate data students can use scatter plots and linear models

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 to define trigonometric ratios because students can make connections between engineering practices such as building electronics such as TVs. Understanding how trigonometric ratios are an intricate part of the development of tv screens will create a real-life extension for students.

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?

Using and Connecting Mathematical Representations: The standard for mathematical practice, use appropriate tools strategically, provides a strong foundation to validate and bridge for students. Mathematical representations are mathematical tools. The linguistic and cultural experiences of students provide different and varied types of representations for solving mathematical problems. By explicitly encouraging students to use multiple mathematical representations students can draw on their "mathematical, social, and cultural competence". By valuing these representations and discussing them we can connect student representations to the representations of school mathematics and build a bridge for students to position them as competent and capable mathematicians. For example, when studying trigonometric ratios and solving problems involving right triangles the use of mathematical representations within the classroom is critical because students will relate the background knowledge within cross-curricular activities and relate it to the different mathematical representations needed for this cluster.

Standards Aligned Instructionally Embedded Formative Assessment Resources:

SAT Item #4169029: The linked assessment question addresses G-SRT.C, specifically the question requires students to take a provided trigonometric ratio and use it to find another ratio.

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CollegeBoard	Question ID 4169029						
SAT	Math	Additional Topics in Math	Medium	Additional Topics in Math	Right triangles and trigonometry	4. Solve problems using the relationship between sine and cosine of complementary angles.	Calculator

In a right triangle, the tangent of one of the two acute angles is $\frac{\sqrt{3}}{3}$. What is the tangent of the other acute angle?

Question Difficulty: Medium

A. $-\frac{\sqrt{3}}{3}$

B. $-\frac{3}{\sqrt{3}}$

C. $\frac{\sqrt{3}}{3}$

D. $\frac{3}{\sqrt{3}}$

Choice D is correct. The tangent of a nonright angle in a right triangle is defined as the ratio of the length of the leg opposite the angle to the length of the leg adjacent to the angle. Using that definition for tangent, in a right triangle with legs that have lengths a and b, the tangent of one acute angle is $\frac{a}{b}$ and the tangent for the other acute angle is $\frac{b}{a}$. It follows that the tangents of the acute angles in a right triangle are reciprocals of each other. Therefore, the tangent of the other acute angle in the given triangle is the reciprocal of $\frac{\sqrt{3}}{3}$ or $\frac{3}{\sqrt{3}}$.

Choice A is incorrect and may result from assuming that the tangent of the other acute angle is the negative of the tangent of the angle described. Choice B is incorrect and may result from assuming that the tangent of the other acute angle is the negative of the reciprocal of the tangent of the angle described. Choice C is incorrect and may result from interpreting the tangent of the other acute angle as equal to the tangent of the angle described.

Additional Assessment:
http://tasks.illustrativemathematics.org/content-standards/HSG/SRT/C/tasks/1316
The linked assessment question addresses G-SRT.C, specifically the question requires students to apply right triangle geometry to the context of points on a map. Students will need to visualize points on a map forming a right triangle and then apply formulas and concepts they are familiar with to solve contextual problems. This assessment should be given to students after they've been introduced to the formal definition of trigonometric ratios and applications of Pythagorean theorem and similar triangles. Students will engage in SMP 1, SMP 4, and potentially SMP 5 if students are required to generate their own maps using tools.

Relevance to families and communities:	**Cross-Curricular Connections:**
During a unit focused on trigonometric ratios and solving problems involving right triangles, 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, For example: when looking at trigonometric ratios of right triangles, students can relate the ratios of the triangle if we focus on sports. Shooting a basketball from 5 feet away vs. shooting a basketball from 10 ft away will show you congruence. Scaling down the basket by ½ the	STEM: Connect to engineering and construction use of trigonometry to determine accurate angles and/or missing lengths.

height can provide a transition into trigonometric ratios.	