Trig missing sides calculator

In this geometry lesson, you're going to learn all about SohCahToa. Jenn, Founder Calcworkshop®, 15+ Years Experience (Licensed & Certified Teacher) It's probably one of the most famous math mnemonics alongside PEMDAS. And it's an essential technique for your mathematical toolbelt. Let's get to it! What Is SohCahToa? It's a mnemonic device to help you remember the three basic trig ratios used to solve for missing sides and angles in a right triangle. It's defined as: SOH: Sin(θ) = Opposite / Hypotenuse CAH: Cos(θ) = Adjacent / Hypotenuse TOA: Tan(θ) = Opposite / Adjacent We'll dive further into the theory behind it in the video below, but essentially it's taken from the AA Similarity Postulate that we learned about previously. It stated that the ratios of the lengths of two sides of similar right triangles are equal. Therefore, the sets of ratios depend only on the measure of the acute angle, not the size of the triangle. Key Point: Regardless of the size of the triangle, these trigonometric ratios will always hold true for right triangles. Remember the three basic ratios are called Sine, Cosine, and Tangent, and they represent the foundational Trigonometric Ratios, after the Greek word for triangle measurement. And these trigonometric ratios allow us to find missing sides of a right triangle, as well as missing angles. How To Remember Trig Functions? So how do we remember these three trig ratios and use them to solve for missing sides and angles? First, we remember how the sides of a right triangle are labeled: Opposite Leg Adjacent Leg Hypotenuse The opposite leg is opposite one of the acute angles, the adjacent leg is next to the acute angle, and the hypotenuse is opposite the right angle, or as Math is Fun nicely states, it's the long one. Right Triangle Diagram Then we use the mnemonic device we talk about earlier: SOHCAHTOA! SOH-CAH-TOA Chart An easy way to remember the order of Sin, Cos, and Tan is to use saying such as: Some Of Her Children Are Having Trouble Over Algebra If you can remember the order of the trigonometric functions, then a quicker saying would be: Oscar Had A Heap Of Apples Modifying our equations from earlier, we have: SOH: Sin(θ) = Oscar / Had CAH: Cos(θ) = A / Heap TOA: Tan(θ) = Of / Apples There are many more fun sayings as well. Few Examples… Given the following right triangle, solve for the missing side length, r: Using Sin to Find the Hypotenuse Sometimes we are given two sides lengths, and we need to determine one of the acute angles of the right triangle. How can we do this? Inverse Trig Ratios allow us to solve for those missing angles quite easily. Consequently, SOHCAHTOA is very versatile as it grants us the ability to solve for sides and angles of a right triangle! Inverse Trig Values In the next example we are asked to "Solve the triangle." This means we are to solve for all missing side lengths and angle measurements. Finding Sides and Angles Using Inverse Trig Common Questions Q: Is sohcahtoa only for right triangles? A: Yes, it only applies to right triangles. If we have an oblique triangle, then we can't assume these trig ratios will work. We have other methods we'll learn about in Math Analysis and Trigonometry such as the laws of sines and cosines to handle those cases. Q: When to use sohcahtoa? A: When you are given a right triangle, where two of the side lengths are given and you are asked to find the third side. Q: Where is the hypotenuse of a right triangle? A: They hypotenuse of a right triangle is always opposite the 90 degree angle, and is the longest side. Q: Where is the adjacent side of a triangle? A: The adjacent side of a triangle is the side (leg) that is touching the angle but is not the hypotenuse. Q: What does it mean to solve a right triangle? A: When you solve a right triangle, or any triangle for that matter, it means you need to find all missing sides and angles. Therefore, you will use Trig Ratios, the Triangle Sum Theorem, and/or the Pythagorean Theorem to find any missing angle or side length measures. In the video below, you'll progress through harder examples involving trig ratios, calculating missing side lengths and angles, inverse trig, and much more! Video – Lesson & Examples 1 hr 34 min 00:17:38 – Find the three trig ratios for both acute angles (Examples #1-4) 00:39:35 – Complete the table using Soh-Cah-Toa (Examples #5-6) 00:53:12 – How to solve for an angle using a calculator? (Examples #7-12) 01:05:22 – Solve the right triangle by finding all missing sides and angles (Examples #13-14) 01:18:37 – Solve the word problem involving a right triangle and trig ratios (Example #15) 01:27:34 – Solve for x by using SOH CAH TOA (Examples #16-19) Practice Problems with Step-by-Step Solutions Chapter Tests with Video Solutions Get access to all the courses and over 150 HD videos with your subscription Monthly, Half-Yearly, and Yearly Plans Available Get My Subscription Now Not yet ready to subscribe? Take Calcworkshop for a spin with our FREE limits course The Pythagorean Theorem, [latex]{\displaystyle a^{2}+b^{2}=c^{2},}[/latex] can be used to find the length of any side of a right triangle. Use the Pythagorean Theorem to find the length of a side of a right triangle Key Takeaways Key Points The Pythagorean Theorem, [latex]{\displaystyle a^{2}+b^{2}=c^{2},}[/latex] is used to find the length of any side of a right triangle. In a right triangle, one of the angles has a value of 90 degrees. The longest side of a right triangle is called the hypotenuse, and it is the side that is opposite the 90 degree angle. If the length of the hypotenuse is labeled [latex]c[/latex], and the lengths of the other sides are labeled [latex]a[/latex] and [latex]b[/latex], the Pythagorean Theorem states that [latex]{\displaystyle a^{2}+b^{2}=c^{2}}[/latex]. Key Terms legs: The sides adjacent to the right angle in a right triangle. right triangle: A [latex]3[/latex]-sided shape where one angle has a value of [latex]90[/latex] degrees hypotenuse: The side opposite the right angle of a triangle, and the longest side of a right triangle. Pythagorean theorem: The sum of the areas of the two squares on the legs ([latex]a[/latex] and [latex]b[/latex]) is equal to the area of the square on the hypotenuse ([latex]c[/latex]). The formula is [latex]a^2+b^2=c^2[/latex]. A right angle has a value of 90 degrees ([latex]90^\circ[/latex]). A right triangle is a triangle in which one angle is a right angle. The relation between the sides and angles of a right triangle is the basis for trigonometry. The side opposite the right angle is called the hypotenuse (side [latex]c[/latex] in the figure). The sides adjacent to the right angle are called legs (sides [latex]a[/latex] and [latex]b[/latex]). Side [latex]a[/latex] may be identified as the side adjacent to angle [latex]B[/latex] and opposed to (or opposite) angle [latex]A[/latex]. Side [latex]b[/latex] is the side adjacent to angle [latex]A[/latex] and opposed to angle [latex]B[/latex]. Right triangle: The Pythagorean Theorem can be used to find the value of a missing side length in a right triangle. If the lengths of all three sides of a right triangle are whole numbers, the triangle is said to be a Pythagorean triangle and its side lengths are collectively known as a Pythagorean triple. The Pythagorean Theorem The Pythagorean Theorem, also known as Pythagoras' Theorem, is a fundamental relation in Euclidean geometry. It defines the relationship among the three sides of a right triangle. It states that the square of the hypotenuse (the side opposite the right angle) is equal to the sum of the squares of the other two sides. The theorem can be written as an equation relating the lengths of the sides [latex]a[/latex], [latex]b[/latex] and [latex]c[/latex], often called the "Pythagorean equation":[1] [latex]{\displaystyle a^{2}+b^{2}=c^{2}} [/latex] In this equation, [latex]c[/latex] represents the length of the hypotenuse and [latex]a[/latex] and [latex]b[/latex] the lengths of the triangle's other two sides. Although it is often said that the knowledge of the theorem predates him,[2] the theorem is named after the ancient Greek mathematician Pythagoras (c. 570 – c. 495 BC). He is credited with its first recorded proof. The Pythagorean Theorem: The sum of the areas of the two squares on the legs ([latex]a[/latex] and [latex]b[/latex]) is equal to the area of the square on the hypotenuse ([latex]c[/latex]). The formula is [latex]a^2+b^2=c^2[/latex]. Finding a Missing Side Length Example 1: A right triangle has a side length of [latex]10[/latex] feet, and a hypotenuse length of [latex]20[/latex] feet. Find the other side length. (round to the nearest tenth of a foot) Substitute [latex]a=10[/latex] and [latex]c=20[/latex] into the Pythagorean Theorem and solve for [latex]b[/latex]. [latex]\displaystyle{ \begin{align} a^{2}+b^{2} &=c^{2} \\ (10)^2+b^2 &=(20)^2 \\ 100+b^2 &=400 \\ b^2 &=300 \\ \sqrt{b^2} &=\sqrt{300} \\ b &=17.3 ~\mathrm{feet} \end{align} }[/latex] Example 2: A right triangle has side lengths [latex]3[/latex] cm and [latex]4[/latex] cm. Find the length of the hypotenuse. Substitute [latex]a=3[/latex] and [latex]b=4[/latex] into the Pythagorean Theorem and solve for [latex]c[/latex]. [latex]\displaystyle{ \begin{align} a^{2}+b^{2} &=c^{2} \\ 3^2+4^2 &=c^2 \\ 9+16 &=c^2 \\ 25 &=c^2\\ c^2 &=25 \\ \sqrt{c^2} &=\sqrt{25} \\ c &=5~\mathrm{cm} \end{align} }[/latex] How Trigonometric Functions Work Trigonometric functions can be used to solve for missing side lengths in right triangles. Recognize how trigonometric functions are used for solving problems about right triangles, and identify their inputs and outputs Key Takeaways Key Points A right triangle has one angle with a value of 90 degrees ([latex]90^{\circ}[/latex])The three trigonometric functions most often used to solve for a missing side of a right triangle are: [latex]\displaystyle{\sin{t}=\frac {opposite}{hypotenuse}}[/latex], [latex]\displaystyle{\cos{t} = \frac {adjacent}{hypotenuse}}[/latex], and [latex]\displaystyle{\tan{t} = \frac {opposite}{adjacent}}[/latex] We can define the trigonometric functions in terms an angle [latex]t[/latex] and the lengths of the sides of the triangle. The adjacent side is the side closest to the angle. (Adjacent means "next to.") The opposite side is the side across from the angle. The hypotenuse is the side of the triangle opposite the right angle, and it is the longest. Right triangle: The sides of a right triangle in relation to angle [latex]t[/latex]. When solving for a missing side of a right triangle, but the only given information is an acute angle measurement and a side length, use the trigonometric functions listed below: Sine [latex]\displaystyle{\sin{t} = \frac {opposite}{hypotenuse}}[/latex] Cosine [latex]\displaystyle{\cos{t} = \frac {adjacent}{hypotenuse}}[/latex] Tangent [latex]\displaystyle{\tan{t} = \frac {opposite}{adjacent}}[/latex] The trigonometric functions are equal to ratios that relate certain side lengths of a right triangle. When solving for a missing side, the first step is to identify what sides and what angle are given, and then select the appropriate function to use to solve the problem. Evaluating a Trigonometric Function of a Right Triangle Sometimes you know the length of one side of a triangle and an angle, and need to find other measurements. Use one of the trigonometric functions ([latex]\sin{}[/latex], [latex]\cos{}[/latex], [latex]\tan{}[/latex]), identify the sides and angle given, set up the equation and use the calculator and algebra to find the missing side length. Example 1: Given a right triangle with acute angle of [latex]34^{\circ}[/latex] and a hypotenuse length of [latex]25[/latex] feet, find the length of the side opposite the acute angle (round to the nearest tenth): Right triangle: Given a right triangle with acute angle of [latex]34[/latex] degrees and a hypotenuse length of [latex]25[/latex] feet, find the opposite side length. Looking at the figure, solve for the side opposite the acute angle of [latex]34[/latex] degrees. The ratio of the sides would be the opposite side and the hypotenuse. The ratio that relates those two sides is the sine function. [latex]\displaystyle{ \begin{align} \sin{t} &=\frac {opposite}{hypotenuse} \\ \sin{\left(34^{\circ}\right)} &=\frac{x}{25} \\ 25\cdot \sin{ \left(34^{\circ}\right)} &=x\\ x &= 25\cdot \sin{ \left(34^{\circ}\right)}\\ x &= 25 \cdot \left(0.559\dots\right)\\ x &=14.0 \end{align} }[/latex] The side opposite the acute angle is [latex]14.0[/latex] feet. Example 2: Given a right triangle with an acute angle of [latex]83^{\circ}[/latex] and a hypotenuse length of [latex]300[/latex] feet, find the hypotenuse length (round to the nearest tenth): Right Triangle: Given a right triangle with an acute angle of [latex]83[/latex] degrees and a hypotenuse length of [latex]300[/latex] feet, find the hypotenuse length. Looking at the figure, solve for the hypotenuse to the acute angle of [latex]83[/latex] degrees. The ratio of the sides would be the adjacent side and the hypotenuse. The ratio that relates these two sides is the cosine function. [latex]\displaystyle{ \begin{align} \cos{t} &= \frac {adjacent}{hypotenuse} \\ \cos{ \left(83 ^{\circ}\right)} &= \frac {300}{x} \\ x \cdot \cos{\left(83^{\circ}\right)} &=300 \\ x &=\frac{300}{\cos{\left(83^{\circ}\right)}} \\ x &= \frac{300}{\left(0.1218\dots\right)} \\ x &=2461.7~\mathrm{feet} \end{align} }[/latex] Sine, Cosine, and Tangent The mnemonic SohCahToa can be used to solve for the length of a side of a right triangle. Use the acronym SohCahToa to define Sine, Cosine, and Tangent in terms of right triangles Key Takeaways Key Points A common mnemonic for remembering the relationships between the Sine, Cosine, and Tangent functions is SohCahToa. SohCahToa is formed from the first letters of "Sine is opposite over hypotenuse (Soh), Cosine is adjacent over hypotenuse (Cah), Tangent is opposite over adjacent (Toa)." Given a right triangle with an acute angle of [latex]t[/latex], the first three trigonometric functions are: Sine [latex]\displaystyle{ \sin{t} = \frac {opposite}{hypotenuse} }[/latex] Cosine [latex]\displaystyle{ \cos{t} = \frac {adjacent}{hypotenuse} }[/latex] Tangent [latex]\displaystyle{ \tan{t} = \frac {opposite}{adjacent} }[/latex] A common mnemonic for remembering these relationships is SohCahToa, formed from the first letters of "Sine is opposite over hypotenuse (Soh), Cosine is adjacent over hypotenuse (Cah), Tangent is opposite over adjacent (Toa)." Right triangle: The sides of a right triangle in relation to angle [latex]t[/latex]. The hypotenuse is the long side, the opposite side is across from angle [latex]t[/latex], and the adjacent side is next to angle [latex]t[/latex]. Evaluating a Trigonometric Function of a Right Triangle Example 1: Given a right triangle with an acute angle of [latex]62^{\circ}[/latex] and an adjacent side of [latex]45[/latex] feet, solve for the opposite side length. (round to the nearest tenth) Right triangle: Given a right triangle with an acute angle of [latex]62[/latex] degrees and an adjacent side of [latex]45[/latex] feet, solve for the opposite side length. First, determine which trigonometric function to use when given an adjacent side, and you need to solve for the opposite side. Always determine which side is given and which side is unknown from the acute angle ([latex]62[/latex] degrees). Remembering the mnemonic, "SohCahToa", the sides given are opposite and adjacent or "o" and "a", which would use "T", meaning the tangent trigonometric function. [latex]\displaystyle{ \begin{align} \tan{t} &= \frac {opposite}{adjacent} \\ \tan{\left(62^{\circ}\right)} &=\frac{x}{45} \\ 45\cdot \tan{\left(62^{\circ}\right)} &=x \\ x &= 45\cdot \tan{\left(62^{\circ}\right)}\\ x &= 45\cdot \left(1.8807\dots \right) \\ x &=84.6 \end{align} }[/latex] Example 2: A ladder with a length of [latex]30~\mathrm{feet}[/latex] is leaning against a building. The angle the ladder makes with the ground is [latex]32^{\circ}[/latex]. How high up the building does the ladder reach? (round to the nearest tenth of a foot) Right triangle: After sketching a picture of the problem, we have the triangle shown. The angle given is [latex]32^\circ[/latex], the hypotenuse is 30 feet, and the missing side length is the opposite leg, [latex]x[/latex] feet. Determine which trigonometric function to use when given the hypotenuse, and you need to solve for the opposite side. Remembering the mnemonic, "SohCahToa", the sides given are the hypotenuse and opposite or "h" and "o", which would use "S" or the sine trigonometric function. [latex]\displaystyle{ \begin{align} \sin{t} &= \frac {opposite}{hypotenuse} \\ \sin{ \left(32^{\circ} \right) } & =\frac{x}{30} \\ 30\cdot \sin{ \left(32^{\circ}\right)} &=x \\ x &= 30\cdot \sin{ \left(32^{\circ}\right)}\\ x &= 30\cdot \left(0.5299\dots \right) \\ x &= 15.9 ~\mathrm{feet} \end{align} }[/latex] Finding Angles From Ratios: Inverse Trigonometric Functions The inverse trigonometric functions can be used to find the acute angle measurement of a right triangle. Use inverse trigonometric functions in solving problems involving right triangles Key Takeaways Key Points A missing acute angle value of a right triangle can be found when given two side lengths. To find a missing angle value, use the trigonometric functions sine, cosine, or tangent, and the inverse key on a calculator to apply the inverse function ([latex]\arcsin{}[/latex], [latex]\arccos{}[/latex], [latex]\arctan{}[/latex]), [latex]\sin^{-1}[/latex], [latex]\cos^{-1}[/latex], [latex]\tan^{-1}[/latex]. Using the trigonometric functions to solve for a missing side when given an acute angle is as simple as identifying the sides in relation to the acute angle, choosing the correct function, setting up the equation and solving. Finding the missing acute angle when given two sides of a right triangle is just as simple. Inverse Trigonometric Functions In order to solve for the missing acute angle, use the same three trigonometric functions, but, use the inverse key ([latex]^{-1}[/latex]on the calculator) to solve for the angle ([latex]A[/latex]) when given two sides. [latex]\displaystyle{ A^{\circ} = \sin^{-1}{ \left(\frac {\text{opposite}}{\text{hypotenuse}} \right) } }[/latex] [latex]\displaystyle{ A^{\circ} = \cos^{-1}{ \left(\frac {\text{adjacent}}{\text{hypotenuse}} \right) } }[/latex] [latex]\displaystyle{ A^{\circ} = \tan^{-1}{\left(\frac {\text{opposite}}{\text{adjacent}} \right) }}[/latex] Example For a right triangle with hypotenuse length [latex]25~\mathrm{feet}[/latex] and acute angle [latex]A^\circ[/latex]with opposite side length [latex]12~\mathrm{feet}[/latex], find the acute angle to the nearest degree: Right triangle: Find the measure of angle [latex]A[/latex], when given the opposite side and hypotenuse. From angle [latex]A[/latex], the sides opposite and hypotenuse are given. Therefore, use the sine trigonometric function. (Soh from SohCahToa) Write the equation and solve using the inverse key for sine. [latex]\displaystyle{ \begin{align} \sin{A^{\circ}} &= \frac {\text{opposite}}{\text{hypotenuse}} \\ \sin{A^{\circ}} &= \frac{12}{25} \\ A^{\circ} &= \sin^{-1}{\left(\frac{12}{25} \right)} \\ A^{\circ} &= \sin^{-1}{\left(0.48 \right)} \\ A &=29^{\circ} \end{align} }[/latex]