

Trigonometry

Trigonometry comes from the Greek words *trigon* (triangle) and *metron* (measure). It is the study of triangles. Trigonometry is usually needed to find measurements of sides and angles of triangles with or points on a unit circle. The measures of angles are usually represented by letters from the Greek alphabet such as θ , α , β , and γ .

Right Triangles

Definitions & the Pythagorean Theorem

- Right triangle:** Triangle with exactly one 90° (right) angle.
 - Hypotenuse:** Longest side of a right triangle; always located opposite the right angle.
 - Legs:** The two shorter sides of a right triangle.
- EX: Triangle ABC is a right triangle.
AC and BC are legs, and AB is the hypotenuse.



- The Pythagorean Theorem states that the sum of the squares of the legs of a right triangle is equal to the square of the hypotenuse:

Symbolically, this is represented as $a^2 + b^2 = c^2$, where a and b are the lengths of the legs of a right triangle, and c is the length of the hypotenuse.

EX: Solve for x in right triangle RST.



Solution:
Use the Pythagorean Theorem.
 $a^2 + b^2 = c^2$
 $x^2 + (24)^2 = (26)^2$
 $x^2 + 576 = 676$
 $x^2 = 100$
 $x = 10$ cm

Special Right Triangles

There are two special right triangles with properties that are very useful in problems solving. These triangles occur in enough applications that their side length relationships should be memorized.

- A 30° - 60° - 90° triangle has a 30° angle, a 60° angle, and a right angle. In a 30° - 60° - 90° triangle, the sides are in the ratio $1 : \sqrt{3} : 2$. In other words, if the shorter

leg has length x , then the longer leg is $x\sqrt{3}$ units long, and the hypotenuse is 2 units long.

EX: If $x = 15$ ft, then $A = 15\sqrt{3}$ ft, and $c = 30$ ft.



- A 45° - 45° - 90° triangle has two 45° angles and a right angle. In a 45° - 45° - 90° triangle, the sides are in the ratio $1 : 1 : \sqrt{2}$. If the legs each have length x , then the hypotenuse is $x\sqrt{2}$ units long.

EX: If $x = 6.4$ mm, then $c = 6.4\sqrt{2}$ mm, and $a = 6.4\sqrt{2}$ mm.



Trigonometric Ratios

- Ratio of the length of two sides of a right triangle relative to a given angle. These include the sine, cosine, and tangent ratios.
- In right triangle ABC (with acute angles A and B), the ratios are defined as follows:

- Sine ratio:** Ratio of the opposite leg to the hypotenuse.
- Cosine ratio:** Ratio of the adjacent leg to the hypotenuse.
- Tangent ratio:** Ratio of the opposite leg to the adjacent leg.



Trigonometric Ratios

Sine ratios	Cosine ratios	Tangent ratios
$\sin A = \frac{a}{c}$	$\cos A = \frac{b}{c}$	$\tan A = \frac{a}{b}$
$\sin B = \frac{b}{c}$	$\cos B = \frac{a}{c}$	$\tan B = \frac{b}{a}$

EX: Find the sine, cosine, and tangent ratios for the acute angles in right triangle RST.



Right Triangle Trigonometry

$$\begin{aligned}\sin A &= \frac{a}{c} & \cos A &= \frac{b}{c} \\ \sin B &= \frac{b}{c} & \cos B &= \frac{a}{c} \\ \tan A &= \frac{a}{b} & \tan B &= \frac{b}{a}\end{aligned}$$

- The reciprocal trigonometric ratios are the cosecant, secant, and tangent ratios.

Reciprocal Trigonometric Ratios

Cosecant (reciprocal of sine)	$\csc A = \frac{1}{\sin A} = \frac{\text{hypotenuse}}{\text{opposite}}$
Secant (reciprocal of cosine)	$\sec A = \frac{1}{\cos A} = \frac{\text{hypotenuse}}{\text{adjacent}}$
Cotangent (reciprocal of tangent)	$\cot A = \frac{1}{\tan A} = \frac{\text{adjacent}}{\text{opposite}}$

Trigonometric Functions

- The trigonometric ratios define trigonometric functions of an angle measure, θ . For example, the functions $y = \sin \theta$, $y = \cos \theta$, $y = \tan \theta$, $y = \csc \theta$, $y = \sec \theta$, and $y = \cot \theta$ can be used to describe the particular ratio for a given angle measure. You can use a scientific calculator to

$$\begin{aligned}\sin(35^\circ) &= 0.574 \\ \cos(35^\circ) &= 0.819 \\ \tan(35^\circ) &= 0.700 \\ \csc(35^\circ) &= 1.736 \\ \sec(35^\circ) &= 1.221 \\ \cot(35^\circ) &= 1.107\end{aligned}$$

estimate the values of trigonometric functions for a given angle measure.

- Inverse trigonometric functions** take a given ratio and "undo" the corresponding trigonometric function to determine the angle measure. These functions are denoted by the prefix *inv-* or by an exponent of -1 .

EX: The three functions $y = \sin x$, $y = \cos x$, and $y = \tan x$ represent the inverses of the sine, cosine, and tangent functions, respectively.

NOTE: The -1 exponent used in the notation $y = \sin^{-1} x$ indicates the inverse sine function, not the reciprocal of the sine function. Thus, $\sin^{-1} x \neq (\sin x)^{-1}$. Be careful to recognize the correct notation when solving problems involving inverse trigonometric functions.

Solving for Unknown Sides & Angles

- Trigonometric ratios and inverse trigonometric functions can be used to find unknown side lengths and angle measures in right triangles.

EX: Find $m\angle A$ and $m\angle C$ in the figure. Round to the nearest tenth of a degree.



Trigonometry Reference Guide

Roman Wölfel



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