



hp calculators



HP 30S Solving Trigonometry Problems

The Trigonometric Functions

The Angular Unit

Practice Solving Problems Involving Trigonometric Functions

The trigonometric functions

The trigonometric functions are sine, cosine and their reciprocals (cosecant and secant, respectively) which repeat their values every 360° , and tangent and its reciprocal (cotangent), whose period is 180° . All these functions have their inverse functions (e.g. $\sin^{-1} x$ or $\arcsin x$) which are defined for specific ranges. The trigonometric functions are also known as circular functions because they are defined in geometric terms. These functions are extensively used in geometry, surveying, astronomy, building, design, etc. They play a lead role in electromagnetism. In fact, they describe the alternating current as well as the movement of a pendulum!

The HP 30S provides the three basic functions \sin , \cos and \tan , and their inverse: the "arc" functions \sin^{-1} , \cos^{-1} , \tan^{-1} . All these functions work in degrees, radians and grads. In addition, π is provided as a shortcut on the primary key π .

The $R \leftrightarrow P$ (2nd $R \leftrightarrow P$) menu provides the related rectangular/polar conversions, which are discussed in the HP 30S learning module entitled *Polar/Rectangular Coordinate Conversions*.

The angular unit

In a complete circle there are 360 degrees, 2π radians (used in mathematical analysis) or 400 grads (which are common in surveying). Before doing any calculation involving trigonometric functions, you should always make sure that the appropriate angle unit is set. Just look at the top of the display: where the angle unit annunciator is located. DEG, RAD or GRAD is always lit. To change the mode, press DRG , select the desired mode and press ENTER . The current setting can be overridden by specifying a unit using the DMS menu (2nd DMS). For example: $\sin(30^\circ)$ (i.e. \sin 3 0 2nd DMS ENTER ENTER) will always return 0.5 regardless of the angular setting.

Refer to the HP 30S learning module *Converting Angles and Times* for additional information on angular modes.

Practice solving problems involving trigonometric functions

Example 1: What is the sine of π ?

Solution: In Radian mode, enter

\sin π ENTER

Answer: 0. The value returned is **exact**! Indeed, the sine of the *irrational* number π (which has an infinite number of significant digits) is zero, but π actually returns an approximation to twenty-one decimal digits: 3.141592653589793238462.¹ Is the sine of that number smaller than 10^{-99} ? If so, the HP 30S would automatically substitute the number zero. But, that's not the case, the sine in question is approximately $-5 \cdot 10^{-19}$. So, what's happening? The HP 30S evaluates to 0 the sine of any number x such that:

$$3.141592653589793237976281 \leq x \leq 3.141592653589793238945133 \quad (x \text{ is expressed in radians}).$$

¹ Numbers with more than twelve significant digits can be entered by splitting them: e.g. 3.14159265358 + 9.79323893E-12.

That's not exactly cheating, but a way of producing *exact* answers by implementing a very important property of π , which is that its sine *is* zero. The question was: what is the sine of π ? Will you ever interested in the sine of 3. 141592653589793238462?

Example 2: Find the height of the flag pole shown in Figure 1.

Solution: From the figure we know that:

$$\tan 75^\circ = \frac{\text{height}}{20} \Rightarrow \text{height} = 20 \cdot \tan 75^\circ$$

Press DRG , select DEG and press ENTER . Press CL to clear the previous entry (which is retrieved automatically, because you may wish to repeat the calculation in another angular mode). Then simply press:

$\text{2} \text{0} \text{tan} \text{7} \text{5} \text{ENTER}$

Note the implicit multiplication.

Answer: 74.64 feet, rounded to two decimal digits.

Example 3: Find the angle whose haversine is 0.4546

Solution: The versine, coversine, haversine and exsecant functions are frequently used in spherical trigonometry and, for example, in finding the courses of ships. They are defined as:

$$\text{vers } x = 1 - \cos x, \quad \text{covers } x = 1 - \sin x, \quad \text{hav } x = \frac{1 - \cos x}{2}, \quad \text{ex sec } x = \sec x - 1 = \frac{1}{\cos x} - 1$$

If the known value is the haversine, solving for x gives:

$$x = \arccos(1 - 2 \text{hav } x)$$

Press DRG and set RAD mode. To find the angle press:

$\text{CL} \text{2nd} \text{cos}^{-1} \text{1} \text{-} \text{2} \text{X} \text{.} \text{4} \text{5} \text{4} \text{6} \text{ENTER}$

Answer: Rounded to four decimal digits, 1.4799 radians (or 84.7904°, or 94.2115°).

Example 4: Show that the double angle formula for the tangent holds for α is 30°

Solution: The double angle identity can be written as:

$$\tan 2\alpha = \frac{2 \tan \alpha}{1 - \tan^2 \alpha}$$

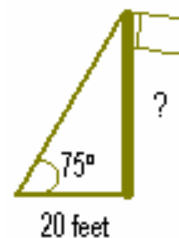


Figure 1.

Let's work out the difference between both sides of the equation. Make sure that Degree mode is active and press:

CL tan 2 \times 3 0 \blacktriangleright $-$ 2 tan 3 0 \blacktriangleright \div $($ 1 $-$ tan 3 0 \blacktriangleright x^2 ENTER

Answer: We obtain 0 which means that both sides are equal within the accuracy of the calculator. It is important to note that a non-zero result would not have necessarily meant that the formula is wrong. We should always take the roundoff into account when subtracting two numbers to check if they are equal, the result might well be slightly different than zero.

Example 5: A designer wants to use triangular tiles with sides 3 inches, 5 inches and 7 inches long, to put a mosaic on a floor. What is the angle opposite the 7 inch side? Will it be possible to lay three tiles next to each other with this angle pointing inwards?

Solution: The law of cosines states that for a triangle with sides a , b , and c and C being the angle opposite side c :

$$c^2 = a^2 + b^2 - 2ab \cos C$$

C may be calculated as:

$$C = \arccos \frac{a^2 + b^2 - c^2}{2ab}$$

Therefore, the keystroke sequence on the HP 30S is:

CL 2^{nd} cos^{-1} $($ 3 x^2 $+$ 5 x^2 $-$ 7 x^2 \blacktriangleright \div $($ 2 \times 3 \times 5 ENTER

Answer: The angle opposite the 7 inch side is 120 degrees. This means that three tiles will fit together exactly with this angle pointing inwards, as they would make up 360 degrees.