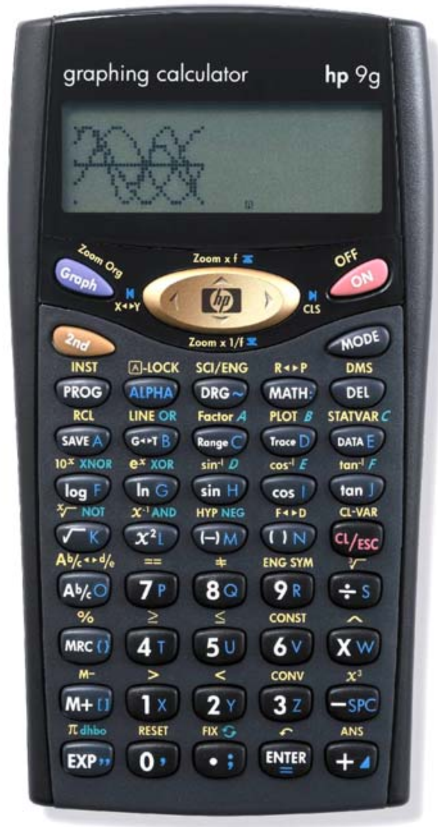
# hp calculators




## HP 9g Solving Trigonometry Problems

The Trigonometric Functions

The Angle Mode

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 360º, and tangent and its reciprocal (cotangent), whose period is 180º. All these functions have their corresponding 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 9g provides the three basic functions [sin H], [cos I] and [tan J], and their inverse: the "arc" functions [2nd] [$\sin^{-1}$ D], [2nd] [$\cos^{-1}$ E], [2nd] [$\tan^{-1}$ F]. All these functions work in degrees, radians and grads. In addition, π is provided as a shortcut on the shifted [EXP] key ([2nd] [π dhbo]).

The R↔P menu provides the related rectangular/polar conversions, which are discussed in the HP 9g learning module entitled *Polar/Rectangular Coordinate Conversions.*

## The angle mode

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 bottom of the display: you will see a D, an R or a G corresponding to the current angular mode. 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 menu DMS ([2nd] [DMS]). For example: sin(30º) (i.e. [sin H] [3] [0] [2nd] [DMS] [ENTER] [ENTER]) will always return 0.5 regardless of the angular setting.

Refer to the HP 9g 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, press

[sin H] [2nd] [π dhbo] [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 [2nd] [π dhbo] actually returns an approximation to twenty-four digits: 3.141592653589793238462643. Is the sine of this number smaller than $10^{-99}$? If so, the HP 9g would automatically substitute the number zero. But, that's not the case, sin( 3.141592653589793238462643 ) is approximately $-5 \cdot 10^{-19}$. So, what's happening? The HP 9g evaluates to 0 the sine of any number *x* such that:

$$3.14159265358979323798 \le x \le 3.14159265358979323894$$ (*x* is expressed in radians).[1]

[1] Numbers with more than thirteen significant digits can be entered by splitting them: e.g. 3.141592653589 + 7.9323798E-13.

That's not cheating, but a way of producing *exact* answers by implementing a very important property of $\pi$, which is that its sine *is* zero.

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

Solution: From the figure we know that:

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

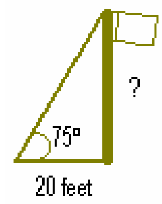


Figure 1.

Press [DRG~] select DEG and press [ENTER] to set DEG mode.
Then simply press:

[2 Y] [0 ,] [tan J] [7 P] [5 U] [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:

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

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

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

[2nd] [cos I] [1 X] [− SPC] [2 Y] [× W] [• ;] [4 T] [5 U] [4 T] [6 V] [ENTER]

Answer: 84.7904°, 1.4799r or 94.2115g

Example 4: Show that the double angle formula for the tangent holds for $\alpha$ is 30°

Solution: The double angle identity can be written as:

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

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

[tan J] [2 Y] [× W] [3 Z] [0 ,] [)] [− SPC] [2 Y] [× W] [tan J] [3 Z] [0 ,] [)] [÷ S] [( ) N] [1 X] [− SPC] [tan J] [3 Z] [0 ,] [)] [x² L] [ENTER]

<u>Answer:</u> 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 determine whether they are equal, the result might well be slightly different than zero. Also, we can determine whether or not an expression like the above formula is an identity by plotting both sides – refer to the HP 9g learning module *Graphing Functions – Part Two.*

<u>Example 5:</u> 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?

<u>Solution:</u> 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:

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

Therefore, the keystroke sequence on the HP 9g is:

[2nd] [cos] [( )] [3] [x²] [+] [5] [x²] [−] [7] [x²] [▶] [÷] [( )] [2] [×] [3] [×] [5] [ENTER]

<u>Answer:</u> 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.