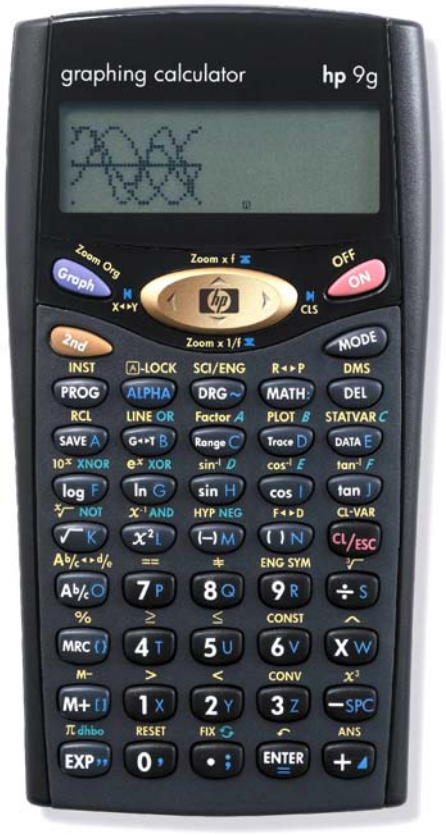
hp calculators



HP 9g Solving Problems Involving Equations

“Equation” Programs on the HP 9g

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The HP 9g provides a most useful way of evaluating an expression containing one or more variables for various values: an entire expression can be ***stored as a program***, which, when executed, will prompt you for values of all the variables used in the expression. In the instruction sheet included with your HP 9g such expressions are called equations. It is perhaps an unfortunate term, since no equal sign can be included, but helps to understand their purpose: to find the numerical value of a formula for specific values of the involved variables.[1] While these equations are stored in program areas, you don't need to know anything about programming: they are written exactly as you would in the entry line.

Example 1: Store the expression $x^2 - 3xy + 4y^2$ in Program 0.

Solution: Equations can only be stored in MAIN mode. So, if MAIN is not the current operating mode on your calculator, press MODE 0 . Now, key in the expression:

ALPHA 1 X x^2 L (−) SPC 3 Z ALPHA 1 X ALPHA 2 Y + 4 T ALPHA 2 Y x^2 L

Th entry line contains the expression $X^2 - 3XY + 4Y^2$. As you well know, if you now press the ENTER key it will be evaluated using the current values of the X and Y variables. Instead, press:

SAVE A PROG 0 ENTER

The expression is now stored in memory, specifically in Program Area no. 0 (remember that there are ten program areas or names available, namely 0 through 9). Note that there's no need to cancel the ALPHA mode (automatically set by the SAVE A key) before pressing PROG . If your calculator displayed the message "EQN SAVE Er" then the expression has not been stored because there is already a program in that area—just store it in another area or delete Prog 0 if you no longer need it.

Answer: The value displayed in the result line is the result of evaluating the expression using the current X and Y values.

Example 2: Calculate the value of the previous expression when X and Y take the values: $-\frac{2}{3}$ and $\frac{\sqrt{3}}{2}$, respectively.

Solution: We'll now see why "equation" programs are so useful. Press:

PROG 0 ENTER

The expression stored in the previous example is displayed in the entry line. Nothing to shout about, so far; retrieving past calculations is what the history stack is all about . But press ENTER one more time: the calculator *prompts for the value of X.* It displays the current value (even if it's zero) so that you can reuse it or edit it—or simply press CL/ESC to clear the old value and then key in the new one. As well as numbers, you can key in almost any expression (which can also include variables), the value of which will be stored in the variable in question. In this example X = $-2/3$, so press:

[1] Array variables (e.g. A[1]) can't be used in the expression to be stored. They generate the error "EQN ARG Er" when prompting for values.

[CL/ESC] [(-)M] [2Y] [ABC] [3Z] [ENTER]

The calculator now prompts for Y:

[CL/ESC] [.;] [5U] [√K] [3Z] [ENTER]

The answer is shown in the result line.

Answer: Rounding to four decimal digits, 5.1765.

Example 3: Calculate $f(z,t) = e^{-\frac{z+t}{2}}$ for z =10 and t = π, and for z = 8 and t = 0.001400682.

Solution: We'll store f(z, t) in Prog 0:

[2nd] [e^x XOR] [(-)M] [.;] [5U] [()N] [ALPHA] [3Z] [+] [ALPHA] [4T] [▶] [▶] [SAVE A] [PROG] [0,] [ENTER]

Yes, there was no error this time! f(z, t) overwrote the previous expression. The "EQN SAVE Er" message appears only when attempting to store an equation in a standard program (i.e. one created in Program Mode[2]): there's no error or warning message if an "equation" program overwrites another "equation" program (Why? Well, equation programs are meant to be used frequently and there are very few program areas. Also, equations can't be long enough to upset the user terribly when lost!).

Let's find f(10, π):

[PROG] [0,] [ENTER] [ENTER] [CL/ESC] [1X] [0,] [ENTER] [CL/ESC] [2nd] [EXP,,] [ENTER]

The result, 0.001400682, is displayed. We can press [PROG] [0,] [ENTER] [ENTER] again to find f(8, 0.001400682), but there's a quicker way: just press [↑] [↑] and Z=10 appears in the entry line. Let's enter its new value: [CL/ESC] [8O] [ENTER]. Notice that the value calculated for f(10, π) is the same as the value that t must take now. We can use the ANS variable to enter it, even though we have already keyed in the Z value, because values keyed in when prompting messages are displayed are not stored in ANS!

[CL/ESC] [2nd] [ANS] [ENTER]

Answer: f(10, π) = 0.001400682 and f(8, 0.001400682) = 0.018302816.

Example 4: Calculate $f(x,y) = \sqrt{x} \cdot 10^{y}$ for x = 2 and $y = \sin\left(\frac{5\pi}{3}\right)$, and for x = 2 and y = 0.1.

Solution: We'll store f(x, y) in Prog 0:

[Range C] [1X] [▶] [2nd] [10^x XNOR] [ALPHA] [2Y] [▶] [SAVE A] [PROG] [0,]

[2] An equation program is a special *type* of program. Note the letters *EQN* displayed while editing an equation program in Program mode (where you can't *create* them, though). Note also that there are no INPUT statements in them, which saves a few program steps!

Oops! "DOMAIN Er"?? What's wrong? Even when stored in a program, expressions are evaluated using the present values, and the result appears in the result line. Trouble is that this evaluation is done *before* storing the expression, so any error generated during the evaluation prevents the SAVE command from working. In this case, the error was caused by the square root because X contains a negative number, stored in the example 2. Other likely errors are DIVIDE BY 0, OVERFLOW Er and MEMORY Er. This is an unfortunate side effect (bug?) that we'll have to learn to live with.

We have to store a valid value in X, then. To do so press:

CL/ESC 0 , SAVE A 1 X ENTER

At least, the expression is still in the history stack:

▲ ▲ ENTER

Now, let's find $f(2, \sin(5\pi/3))$. Press:

PROG 0 , ENTER ENTER 2 Y CL/ESC ENTER

We now have to enter the y value, which is expressed in radians, but notice that you can set the angle unit *while* the prompting message is displayed (if needed, press DRG~ select RAD and press ENTER):

DEL sin H 5 U 2nd π dhbo ÷ S 3 Z ENTER

Since x is still 2 in the second evaluation, f(2, 0.1), we have to press the ▲ key only once:

▲ . ; 1 X CL/ESC ENTER

Answer: Rounding to four decimal digits, $f(2, \sin(5\pi/3))$ = 0.1925 and f(2, 0.1) = 1.7803

Example 5: Write an equation program which returns the real roots of the quadratic equation: $ax^2 + bx + c = 0$

Solution: What we have to store in a program is the well-known quadratic equation formula:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

In this case, the program will prompt for three variables, but will have to return *two* values (provided that the discriminant is greater than or equal to zero, otherwise an error occurs. The HP 9g learning module *Solving Problems Involving Complex Numbers* includes a program to find all the roots of polynomials of degree 3 or less). To do so, we'll use the Display Result command (◢, i.e. ALPHA +◢). Although its mainly used for interrupting a program to see the contents of a variable (pressing 2nd RCL), it can be placed in the entry line and behaves as stated in the manual: "When execution reaches the display result command symbol, execution stops and the result up to that point appears on the display. You can resume execution by pressing ENTER".

The calculator will prompt you for the variables as it finds them, so if we want them to be displayed in a particular order (e.g., A first, then B, and then C) we should rewrite the expression accordingly. Remember that you can always add something like A – A + …

Before keying in the formula, we'll store a non-zero value in A, to avoid the DIVIDE BY 0 error!

1 X SAVE A SAVE A ENTER

We can now key in the formula and store it in, say, Prog 0:

1 / 2A (-B + √ (B^2 – 4AC)) ◢ (-B – √ (B^2 – 4AC)) / 2A → PROG 0

1 X ÷ S 2 Y ALPHA SAVE A ( ) N (–) M ALPHA G↔T B + ◢ √ K ALPHA G↔T B x^2 L –SPC 4 T ALPHA SAVE A ALPHA RangeC ▸ ▸ ALPHA + ◢ ( ) N (–) M ALPHA G↔T B –SPC √ K ALPHA G↔T B x^2 L –SPC 4 T ALPHA SAVE A ALPHA RangeC ▸ ▸ ÷ S 2 Y ALPHA SAVE A SAVE A PROG 0 , ENTER

Will it work? Let's try to solve $x^2 - 11x + 30 = 0$. Run Prog 0 (PROG 0 , ENTER ENTER) and enter the coefficients in the order they are written: CL/ESC 1 X ENTER , CL/ESC (–) M 1 X 1 X ENTER and CL/ESC 3 Z 0 , ENTER

The first root (6) appears in the result line, to view the second root (5) press ENTER . To find the roots of another polynomial, you'll have to press PROG 0 , ENTER ENTER again. The history stack is cleared by the Display Result command!