





Solve: An introduction to the HP Solve system

Background

The Solve application appears in the form outlined here on the HP 48GX, HP 48G, HP48G+, HP49G, HP48Gii and HP49G+ graphical calculators but many other HP calculators offer a similar facility in some form or other. The Solve applet finds solutions to equations using successive numerical approximations. Answers are given as decimal approximations rather than as exact values, and only one variable can be solved for at a time (an other application, the multiple equation solver is capable of solving system of multiple equations).

In this text buttons which appear on the keyboard are represented as far as possible using images of the button:  or . Screen menu buttons such as the one in the image below right are shown as .





Use

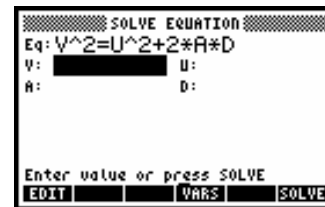
The Solve application allows the user to enter and solve for the current equation. The application is started by pressing  and selecting SOLVE EQUATION. The screen on the right will be displayed.




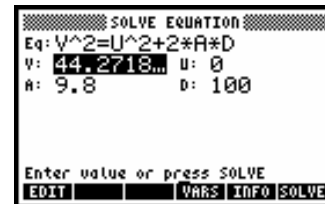
Enter an equation such as $V^2=U^2+2*A*D$ by typing


           

    and the screen will now display all the unknown variable of the equation.



An equation is solved by entering known values in all variables except one, the 'unknown variable', and then solving for the unknown value by pressing . Only one value can be solved for at a time.



The Solve applet begins its search for the solution from the value in the highlighted field, known as the 'initial guess', when  is pressed. Equations with multiple solutions can be solved by supplying different initial guesses. The user can also select a range as a guess by entering 2 number in a list such as $\{ 2 \ 4 \}$. Note that these number will be used as initial guess, and that if a solution exists within this interval, the solver is likely to find it, however depending on the complexity of the function, there is no guaranty.

Some introductory examples

The examples which follow are designed to illustrate the functioning of the Solve application. Other models operate in a similar fashion¹.

Example 1: Exponential growth

The population P , in thousands, of a species of frog at time t years after the study began is given by the equation $P = 5.3e^{0.073t} + 2.74$. Find the population after 10 years and the number of years taken to reach populations of 12,000 and 1500.

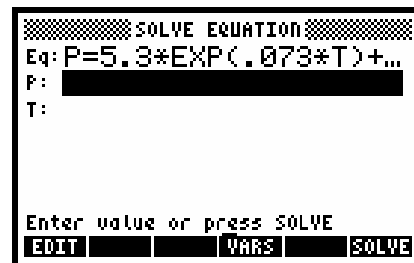
- The equation is entered into the Solve application.

Press \leftarrow NUM.SLV and select SOLVE EQUATION \leftarrow ENTER. If there are any existing equations then they can be deleted using \leftarrow DEL and selecting Delete Value \leftarrow ENTER.

Now press

\leftarrow ALPHA P \leftarrow = 5 . 3 \times \leftarrow e^x \leftarrow) . 0 7 3 \times ALPHA T \leftarrow + \leftarrow 2 . 7 4 \leftarrow ENTER

At this point the screen should appear as shown right.

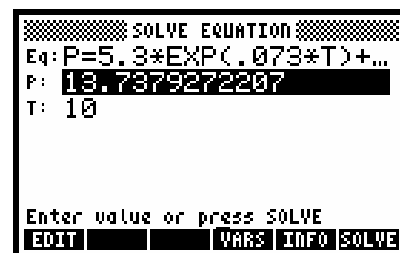


- Enter the known value of $t = 10$.

\leftarrow 1 0 \leftarrow ENTER

Highlight P by pressing \leftarrow and solve for its value by pressing SOLVE.

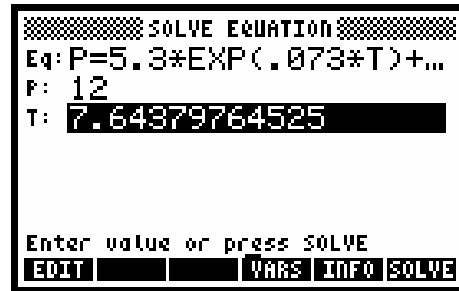
The answer of $P = 13.7379$ is shown right and translates to a population of 13,738 frogs.



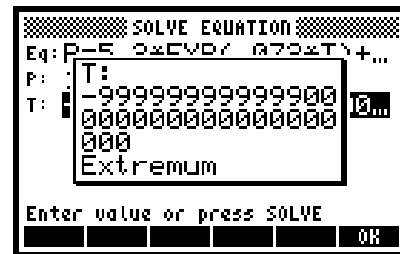
- With the highlight still on P, enter the target population of 12 (ie 12,000). The highlight will then be on the T field, allowing us to solve for its value.

1 2 ENTER

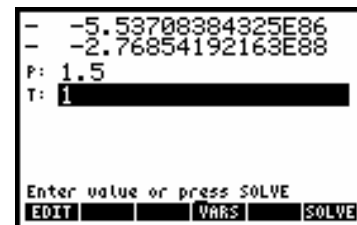
This gives an answer of $t = 7.64$, which translates to 8 years if whole years are required.



- There is, of course, no solution to the final question which you can verify by entering 1.5 for P and solving for T. The calculator will need around 30s to return a result of $-9.999999EXP-499$, the machine equivalent of $-\infty$. Pressing on \square will cause the calculator to display the extremum message specifying that the calculator found an extremum, but not a solution to the question.



Note: pressing a key while the calculator is trying to solve an equation will make the calculator show the current values tried by the equation solver as on the screen on the right. The 2 values are the 2 values currently used by the solver, the $-$ (or $+$, or $?$) sign in front of the number shows that the equation is negative, positive or undefined at that point.



Example 2: Probability distribution functions

In this task we will enter the general formula for a cumulative binomial probability and use it to solve the question below:

A normal pack of cards is shuffled and a card is drawn at random, recorded and returned to the pack. The process is then repeated to give a total of 20 draws. What is the probability that you will be successful in drawing a Heart at least ten but at most 13 times?

- Press NUM.SLV and select SOLVE EQUATION ENTER . If there are any existing equations then they can be deleted using DEL and selecting Delete Value ENTER .

- The equation we will use is: $P(a \leq X \leq b) = \sum_{i=a}^b \frac{n!}{(n-i)!i!} p^i (1-p)^{n-i}$.

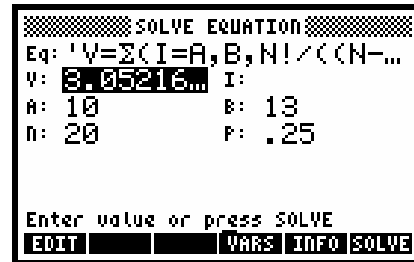
Use the sequence of keystrokes below to enter the equation, using V for the value of the resulting probability.

$\text{ALPHA } \text{V} \text{ } \text{R} \text{ } = \text{ } \text{R} \text{ } \Sigma \text{ } \text{ALPHA } \text{I} \text{ } \text{R} \text{ } = \text{ } \text{ALPHA } \text{A} \text{ } \text{R} \text{ } , \text{ } \text{ALPHA } \text{B} \text{ } \text{R} \text{ } , \text{ } \text{ALPHA}$
 $\text{N} \text{ } \text{ALPHA} \text{ } \text{R} \text{ } 2 \text{ } \div \text{ } \text{R} \text{ } \text{ALPHA} \text{ } \text{N} \text{ } -$
 $\text{ALPHA} \text{ } \text{R} \text{ } \text{ALPHA} \text{ } \text{R} \text{ } 2 \text{ } \times \text{ } \text{ALPHA} \text{ } \text{R} \text{ } \text{ALPHA} \text{ } \text{R} \text{ } 2 \text{ } \times \text{ } \text{ALPHA} \text{ } \text{P} \text{ } \text{Y}^{\text{X}} \text{ } \text{ALPHA} \text{ } \text{R} \text{ } \text{ALPHA}$
 $\text{R} \text{ } \text{ALPHA} \text{ } \text{P} \text{ } \text{Y}^{\text{X}} \text{ } \text{R} \text{ } \text{ALPHA} \text{ } \text{N} \text{ } - \text{ALPHA} \text{ } \text{R} \text{ } \text{ENTER}$

Enter the known values of $A=10$, $B=13$, $N=20$ and $P=0.25$ using:

$\text{R} \text{ } 1 \text{ } 0 \text{ } \text{ENTER} \text{ } 1 \text{ } 3 \text{ } \text{ENTER} \text{ } 2 \text{ } 0 \text{ } \text{ENTER}$
 $0 \text{ } . \text{ } 2 \text{ } 5 \text{ } \text{ENTER}$

With the highlight on V, press SOLVE . After a pause, the result will be as shown. This probability may seem incorrect but pressing MODES will reveal the true result of $1.38349051976\text{E}-2$ or 0.0138 . Changing numeric format in the MODES view to a display using fixed decimal places may give a better result.



¹ Other models of HP calculators differ to a greater or lesser degree in their implementation of Solve. You should consult the manual for your particular calculator for instructions.