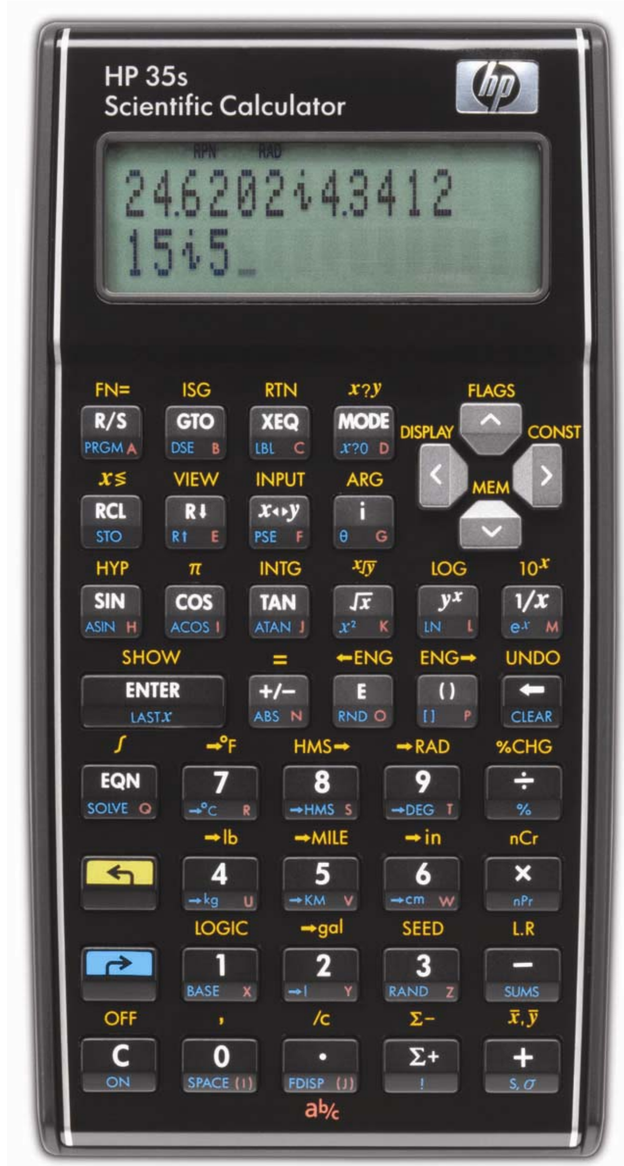
hp calculators



HP 35s Introduction to the training aids

Use of the training aids

Special symbols

Special key combinations

RPN and algebraic modes

Calculator settings and resetting the calculator

Use of the Training Aids

HP provides these training aids to help readers learn about the HP 35s, or to gain experience in its use. They do not replace the manuals but offer a hands-on way to try some of the many HP 35s features. Readers who do not have an HP 35s but wish to learn about it can benefit by studying these aids too. The training aids use no colors so they can be printed on a black and white printer with no loss of information. The examples are provided purely for practice and do not represent any real situations or people.

Special Symbols

The training aids use special symbols to show keys on the HP 35s and characters on the screen (also called the display). The four cursor keys, up, down, left and right, are shown as [∧][∨][<][>].

The yellow left shift key and the blue right shift key are shown as [↰] and [↱]. Any other key pressed after one of these two is called a "shifted key" and is shown as if the shifted function were an ordinary key. For example to get the inverse sine function, called ASIN, it is necessary to press the yellow left shift key [↰] and then the [SIN] key. This would be shown in the training aids as [↱][ASIN]. The special symbols at the top and the sides of the screen are called "annunciators" and are shown as they appear, for example the right shift symbol ↱ or the warning symbol ⚠ .

The HP 35s uses the letters A through Z as the names of variables. It uses the same letters as program labels. When a key is pressed that needs a letter after it, the symbol **A..Z** is shown at the top of the screen. When this symbol is shown, keys with letters to their lower right return those letters when pressed. The keys are then shown in these training aids as the letters [A] through [Z]. Two other keys have extra labels, two labeled (**I**) and **(J)** are used for the special "index" registers.

Some examples will show the way the screen looks while the example is worked through, as in Figure 1.

Figure 1

Special Key Combinations

There are a few special key combinations where two keys need to be held down at the same time. For example, if the display is too dark or too light, it is possible to change the contrast. This is done by pressing and holding down the [C] key (this is the key at the lower left of the keyboard, also called the [ON] key), then pressing [+] repeatedly for a darker screen or [−] for a lighter screen, with the [C] key still held down. Once the contrast is suitable, both keys can be released.

Other combinations of holding down the [C] key while other keys are pressed also have special effects. The key should not be held down while another key is pressed unless a training aid says this needs to be done.

RPN and algebraic modes

The HP 35s has two calculation modes. RPN is the traditional HP calculation mode preferred by many experienced and professional users. Algebraic mode is used on some newer HP calculators and on most other calculators. The HP 35s allows users to choose either one, or to use both. Most of the training aids include examples in both modes.

Calculator Settings and Resetting the Calculator

The training aids assume that the HP 35s modes and settings are as they would be when a new HP 35s is turned on the first time. Changes to these settings needed for examples are described in the training aids. After some examples have been worked through, the HP 35s settings might be very different from the original ones. A quick way to return to the standard settings is to perform a MEMORY CLEAR, but note that this will clear all of the calculator memory.

Press and hold down the [C] key, then press and hold down the [R/S] key as well, and press the [i] key. Now release all three keys, and the display will show MEMORY CLEAR to say that everything has been cleared from the calculator memory, and all settings have returned to their original values. DO NOT DO THIS IF YOU WANT TO KEEP ANY PROGRAMS, EQUATIONS OR DATA THAT ARE IN YOUR CALCULATOR. If you want to keep what is in memory but return the settings to their original values, you will have to change the settings one by one.

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HP 35s Using RPN Mode

Calculation modes

A simple example in RPN

Functions of a single number in RPN

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RPN mode in detail

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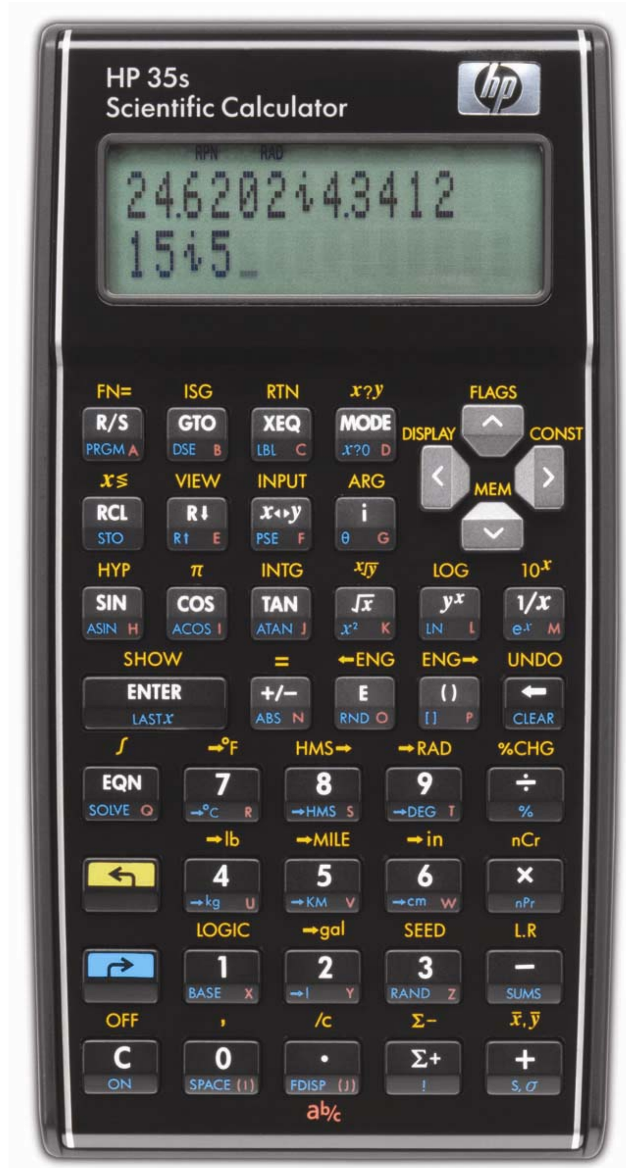
Example – which stepladder?



Calculation modes

The HP 35s allows calculations to be made in “RPN” mode, in “algebraic” mode, or in “Equation” mode. Algebraic and Equation modes and programs are described in other training aids.

RPN mode is the traditional way most HP calculators work. To add 1 and 2, keys are pressed in the order 1 ENTER 2 +. This mode is very suitable for calculations where the user is working towards a solution, without having a particular formula to work on.

Note: When doing the examples press MODE 5 to set RPN mode, or MODE 4 to clear RPN mode and set algebraic mode. The selected mode is shown at the top of the calculator screen.

Functions of a single number in RPN

In RPN mode, to square a number, the number is typed, then the ↱ x^2 key is pressed. If a second number is to be squared, the steps are repeated.

A simple example in RPN

Example 1: A gardener wants to plant a triangular piece of ground and to put protective edges around the plot. The plot will have a right angle and the two shorter edges will be 1.2m long and 0.5m long. How long will the third edge be?

Solution: The length can be calculated using Pythagoras’ formula. From $a^2 + b^2 = c^2$ the third side is:

$$c = \sqrt{(a^2 + b^2)}$$

To calculate this, it is first necessary to square the numbers 1.2 and 0.5. On a calculator, the square of a number is a function of a single number. It does not involve adding or multiplying two numbers.

To square 1.2 and 0.5, it is enough to type:

1 . 2 ↱ x^2 . 5 ↱ x^2

Figure 1

Answer: The second result, 0.25, is on the lower line of the calculator screen, called the X register. The previous result, 1.2 squared, is on the upper line, called the Y register. Registers are places where numbers are held in the calculator; X and Y are the first two registers in the **RPN stack**. The stack is the most important tool in RPN calculations. Its use is shown later in this example.

Other functions of one number, for example sine, log or square root, work the same way. The number is typed and shows up in the lower line, in the X register. Then the function key, for example SIN or $\sqrt{x}$ is pressed to give the answer. The square and square root keys are labeled with an “x” as a reminder that they work on the number in the X register.

Arithmetic calculations with two numbers

Now that the lengths of the two sides have been squared, it is necessary to add the two squares.

Figure 2

To add the two numbers, it is enough to press the add key.

+

Figure 3

In RPN mode addition takes the number from the X register, uses it, and puts the result in the X register, so the result is seen on the lower line. This is like a function of one number, but because addition uses **two** numbers, it takes the second number from the Y register. The number in the Y register is removed. There is a third stack register above Y, called the Z register, and the number in the Z register moves down to the Y register.

Subtraction, multiplication and division work the same way. The number in X is subtracted from, multiplied by, or divided into the number in Y. If the two numbers are in the wrong order, $x \leftrightarrow y$ can be used to exchange them.

To get the final answer, since this is a function of a single number, it is enough to press the $\sqrt{x}$ function key.

$\sqrt{x}$

Answer: The length of the third edge of the garden plot is 1.3m.

Another example - the area of a piece of carpet

Here is another example to show how arithmetical calculations involving addition and multiplication are carried out using the stack in RPN mode.

RPN mode is best for users going through calculations a step at a time, and sometimes even changing their minds during the calculation.

Press DISPLAY 1 then 2 to set FIX 2 mode, in which two digits will appear after the decimal point, as below. This is especially useful when calculations are made with prices in dollars and cents.

RPN mode in detail

Now press the keys.

6	ENTER	This puts the 6 in the calculator, ENTER separates it from the next number The number 6 is in X and in Y after ENTER is pressed

Figure 4

[8] This puts 8 in X, a new number replaces the previous one after ENTER is pressed

Figure 5

[+] This adds the 8 to the 6

Figure 6

[5] This puts 5 in X. After a calculation, a new number pushes the old one into Y.

Figure 7

[×] This multiplies the 14 by the 5 and leaves the result in X

Figure 8

There is a clear pattern here. A number is typed, then something is done with that number. Then another number is typed, and something is done again. In this example, a new number is added to a number that was typed before, or multiplied by it, but RPN works the same way for other actions too.

The RPN stack: At each step, RPN takes one or more numbers it needs from the stack of numbers, for example 6 and 8 above to add them. Then it puts the answer on the stack, ready for use at the next step. The stack holds 4 numbers, in registers called X, Y, Z and T. X is the number most recently typed or calculated and is shown on the lower line of the screen. Y is the number typed or calculated before X, and is shown on the upper line. Numbers in Z and T are not shown but are ready to be used if necessary. When a calculation uses the numbers in both the X and the Y registers, and puts the result in X, then the number in Z is copied into Y. The number in T is copied to Z, but also stays in T. The [↱] [LAST x] key fetches a copy of the last number that was in X before the most recent calculation, so it can be used again or to correct mistakes. Two other keys are used with the RPN stack. [R↓] is called "roll down" and moves the number in Y down into X, Z to Y, T to Z and X to T. [↱] [R↑] is called "roll up" and moves the stack in the opposite direction, X up to Y and so on.

The ENTER key has a special task in RPN. It copies into register Y the number typed or calculated in register X. This is useful if two numbers are being put on the stack, for example to add 1 and 2 1 ENTER 2 + is typed, and ENTER separates the 1 from the 2 so they are treated as two separate numbers, not as the one number 12. The number in Y is pushed into Z, the number in Z is pushed into T, and the number previously in T is lost. After ENTER is typed, another number immediately typed into the X register or recalled into it with the RCL function (described in a separate training aid) replaces the number in X. This allows ENTER to separate two numbers, and the second number goes in the X register.

As ENTER copies the number from X to Y, it can also be used to make a copy for other purposes, such as doubling a number by means of ENTER +. Pressing ENTER repeatedly pushes the number in X into the Z and then the T registers.

Why "RPN?" You might have noticed that calculating the carpet area in RPN did not use brackets, and RPN is actually designed to work without brackets. This often makes it a little quicker to use than algebraic mode. Mathematical notation without brackets was introduced by the Polish mathematician Jan Lukasiewicz in the 1920s. Since the operations such as +, − or × are done *after* the number is entered, this method of calculation is called Reverse Polish Notation, or RPN. The numbers it uses are on the stack, not inside brackets, so it is also called "Stack notation".

Making corrections

In RPN mode, digits in a number that is being typed can be deleted with the ← key. If a number has been completed or calculated, this key deletes it completely.

In RPN mode, ↱ LASTx brings back the number that was in X before the most recent calculation. This can be used to correct a calculation. For example if a wrong number was added, then ↱ LASTx − corrects the error. If the number was to be used for multiplication instead, pressing ↱ LASTx again, and then × will give the correct answer.

If two numbers are entered in the wrong order, x◂▸y can be used to change the order in RPN mode. For example, if 2 ÷ 7 is required, but 7 ENTER 2 has been typed by mistake, it is enough to press x◂▸y before ÷ and the correct answer will be obtained.

If a calculation has gone completely wrong in RPN, it is enough to start over again. Any numbers left on the stack from previous calculations can be ignored.

Functions of two numbers

Unlike functions of a single number, the arithmetical operations +, −, × and ÷ use two numbers, but there are also some mathematical functions that use two numbers.

An often-used two-number function is the exponentiation or "power" function, and this works in the same way as +, −, × and ÷ in RPN mode.

Example 4: What is 2 to the power 10?

Solution: The calculation is 2^{10} using the y^x key.

In RPN mode, put 2 in the Y register, put 10 in the X register, then press y^x

[2] [ENTER] [1] [0] [y^x]

Answer: Two to the power 10 is 1,024, often called 1k in computing.

[y^x] works exactly like the arithmetical operators and is often considered to be one of them. Most other two-number functions work this way too. These are the root (or involution) function [↰] [$\sqrt[x]{y}$], quotient [↰] [INTG] [2] ([INT÷]) and remainder [↰] [INTG] [3] ([Rmdr]), combinations [↰] [nCr] and permutations [↱] [nPr].

Working with complex numbers, with pairs of numbers representing rectangular or polar coordinates and with pairs of numbers in statistical operations are described in training aids on these subjects.

Example – which stepladder?

Some people will wonder why RPN is worth using if algebraic mode and Equation mode work the way expressions are printed. Here is an example to show how RPN mode is useful and fast in solving step-by-step problems where there is no formula, and where the next calculation depends on the result of the previous one.

Example 7: You need to fix a tile that has fallen off your roof. The roof is 28 feet up, and you have a stepladder that is 29 feet long. You could also borrow your neighbor's 38 foot ladder. Is either ladder good for the job? You could try leaning each one in turn against the roof and seeing which is better, but it's raining, so why not work it out first on your HP 35s by seeing what angle each ladder will make with the vertical when you lean it against the roof?

Solution: First try it for your own ladder. Switch to RPN mode if it is not set. Enter the ladder length:

[2] [9] [ENTER]

Then enter the height and divide so you can get the angle, [2] [8] [÷]. You get 1.04. That can not be right; sines and cosines should be smaller than 1. Use [↱] [LASTx] [×] [↱] [LASTx] to get the numbers back, then [$x \leftrightarrow y$] to swap them. Now press [÷] to divide them again, in the right order, and see 0.97.

Actually, pressing [$1/x$] would get the same result, making the correction more quickly. Anyway, this is the sine of the angle between the ladder and the vertical. Or is it the cosine? Press [↱] [ASIN] and see the answer, 74.91 degrees. No, that is not right, it must be the arc cosine that you need. You could press [←] [↱] [LASTx] again to undo the arc sine, but it is as quick to press [SIN], then [↱] [ACOS].

Figure 9

Your ladder would be only 15 degrees away from the vertical. That is uncomfortably steep. So try the same calculation for your neighbor's 38 foot ladder.

Type [2] [8] [ENTER] [3] [8] [÷] then [↱] [ACOS]. This time the answer is 42.54 degrees. The ladder would be at a rather shallow angle and might slip away as you stand on it.

Answer: Neither ladder is really suitable. Maybe you should ask some other neighbors if they would lend you a ladder with a better length. What would be a good length? 30 degrees would probably still be too much, about 20 degrees would be about right. So type the height again and divide by the cosine of 20 degrees. Type 2 8 ENTER 2 0 COS ÷. That gives 29.80. A 30 foot long ladder would be almost ideal if a neighbor has one.

The same calculations could be done in algebraic mode with no difficulty. Nevertheless, many users find that algebraic mode is less well suited to such step-by-step calculations, especially because ↱ LASTx must be used repeatedly to bring back the results of previous calculations.

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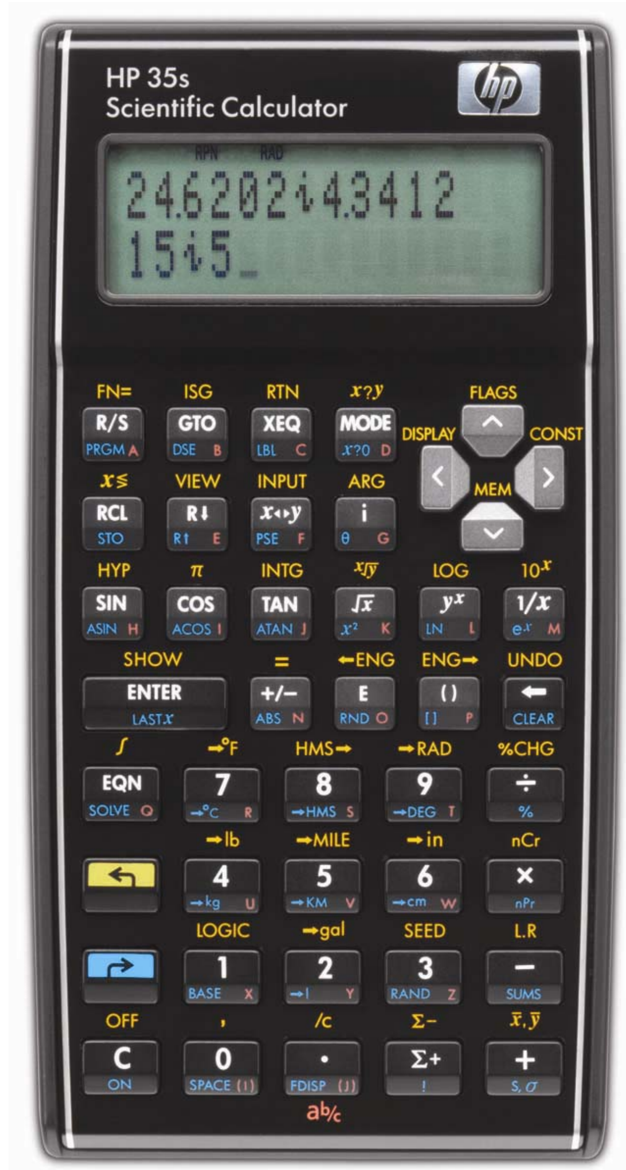
HP 35s Using Algebraic Mode



Calculation modes

The HP 35s allows calculations to be made in “RPN” mode, in “algebraic” mode, or in “Equation” mode.

RPN mode is the traditional way most HP calculators work. To add 1 and 2, keys are pressed in the order [1] [ENTER] [2] [+]. This mode is very suitable for calculations where the user is working towards a solution, without having a particular formula to work on.

Algebraic mode is the way many newer HP calculators work. It is also the way most other calculators work. To add 1 and 2, keys are pressed in the order [1] [+] [2] [ENTER] as shown in Figure 1. This way of working is most suitable when the user just needs to type a formula and get an answer.

Figure 1

In Equation mode, the user types a formula or an expression the way it looks in a textbook and saves it in a list of equations. Then the equation can be use once or repeatedly, for different values of variables. Equations can also be used with the integration command and the solver command.

For complicated tasks that need to be repeated, writing a program is the best solution. Programs can be written in RPN mode or in algebraic mode, and can include equations.

Equation mode, RPN mode, and programs are described in other training aids.

Note: When doing the examples press [MODE] [4] to set algebraic mode. The selected mode is shown at the top of the calculator screen, as in Figure 1.

Functions of a single number in algebraic

As an example, in algebraic mode, to square a number, the [↱] [x^2] key is pressed, the number is typed, and [ENTER] is pressed. This is the way all functions except factorial ([↱] [!]) work. Factorial is pressed after the number.

A simple example in algebraic

Example 1: A gardener wants to plant a triangular piece of ground and to put protective edges around the plot. The plot will have a right angle and the two shorter edges will be 1.2m long and 0.5m long. How long will the third edge be?

Solution: The length can be calculated using Pythagoras’ formula. From $a^2 + b^2 = c^2$ the third side is:

$$c = \sqrt{(a^2 + b^2)}$$

To try this, first set algebraic mode, pressing [MODE] [4]. Now to square 1.2 and 0.5, type:

[↱] [x^2] [1] [·] [2] [ENTER]
[↱] [x^2] [·] [5] [ENTER]

Figure 2

Answer: The second result, 0.25, is on the lower line of the calculator screen. In algebraic mode, the formula or expression used to calculate this result is shown on the upper line. The previous result, 1.2 squared, has vanished, though it can still be used, as will be shown.

Note: When functions are printed, some come before the number, for example √2 or sin(30). Others are printed with the function after the number, examples are 6! or 5^2. Calculators rarely work like this; on many algebraic calculators, all functions of one number are calculated by typing the function first, followed by the number, usually in parentheses (brackets). This is how algebraic mode on the HP 35s works, with the exception of factorial as noted above.

Arithmetic calculations with two numbers

To add two numbers in algebraic mode, it is necessary to type or calculate the first number, press [+], to type or calculate the second number and press [ENTER] to finish the calculation.

Note: On some Algebraic calculators, a key marked [=] finishes a calculation, but on the HP 35s, [ENTER] is used. The [=] key is used only when an equation is being typed in Equation mode.

In this example, the two numbers have been calculated already (assuming you have just completed the previous example). One is shown on the lower line, so it is enough to press [+] begin the addition. The HP 35s will the show the display in Figure 3.

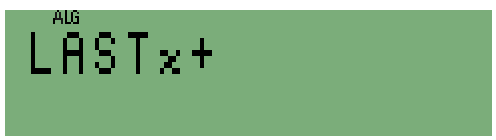


Figure 3

LASTx is the terminology the HP 35s uses to refer to the last number calculated, which in this case will be the 1.44. The HP 35s is ready for the second number for the addition. It can be found in the second level of the HP 35s operational stack, referred to as register Y. (The other two levels above register Y are called register Z and T). To use the number in the second level of the stack at this point, press [R↓]. The HP 35s will then show the display in Figure 4.

Figure 4

Pressing the [R↓] (roll down) key in algebraic mode allows for the selection of previous results from the four level stack. The [<] and [>] keys are used to move the cursor under the stack register desired and [ENTER] is used to select that value. When the [R↓] key is pressed, the cursor is always initially positioned under the Y register.

In this instance, the value in the Y register is exactly what we want. Press [ENTER] and the HP 35s will show the display as in Figure 5.

Figure 5

[ENTER] must be pressed to finish the addition. The result is shown in Figure 6.

Figure 6

To find the square root of this result, is press [$\sqrt{x}$] [↱] [LASTx] [ENTER].

Figure 7

Alternatively, if you know at the beginning the values to be used and what you wish to do with them, you could key in this calculation in one step by pressing:

[$\sqrt{x}$] [↱] [x^2] [1] [·] [2] [>] [+] [↱] [x^2] [·] [5] [ENTER]

Figure 8

Answer: The length of the third edge of the garden plot is 1.3m. One purpose of this example is to illustrate the way algebraic mode can be used “interactively” rather than merely keying in a problem that is already written out. However you need to solve your problem, the HP 35s can handle it.

Another example - the area of a piece of carpet

Here is another example to show how arithmetical calculations involving addition and multiplication are carried out using parentheses in algebraic mode.

Example 2: A new carpet is needed for two rooms, one 6 yards long, one 8 yards long, both 5 yards wide. What is the total area of carpet to be bought?

Solution: The area is calculated using the expression $(6 + 8) \times 5$.

In algebraic mode the total length can be calculated first, 6 yards + 8 yards. Then the length is multiplied by the width, 5 yards.

So these keys would be typed:

[( )]			This enters the open and close the parentheses to put around (6+8)
[6]	[+]	[8]	This gives the 6+8
[>]			This places the cursor outside the parentheses to continue
[×]	[5]		This multiplies by 5
[ENTER]			This tells the calculator that the formula is finished so it can now get the answer

and the formula and answer would be shown

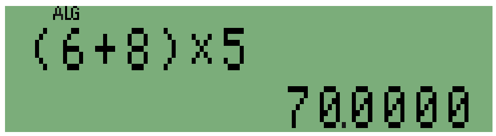


Figure 9

Answer: The total area of carpet is 70 square yards.

To continue a calculation after pressing the [ENTER] it is enough to press another calculation key. For example if the carpet costs $17.32 per square yard, it is easy to continue the calculation and get the total price of the carpet. First press [×]. Then finish the calculation by pressing [1] [7] [·] [3] [2] [ENTER], as below.

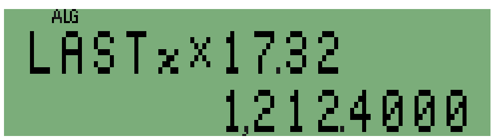


Figure 10

The total price is $1,212.40.

To begin a new calculation, the first number in that calculation is typed. The [↱] [LASTx] key brings the answer from the last calculation into the new calculation.

For example another way to calculate the price of the carpet would be to type [1] [7] [·] [3] [2] [×] [↱] [LASTx] [ENTER].

Figure 11

Why "Algebraic"? You can see that the formula to calculate was typed and is displayed in the way it looks when it is written down on paper in algebraic notation. That is why this calculation mode is called Algebraic Mode. Algebraic notation was developed over centuries as a shorthand way of writing things such as "add the number eight to the number six and multiply the result by the number five".

Making corrections

In algebraic mode, digits in a number that is being typed can be deleted with the [←] key. If a number has been completed or calculated, this key deletes it completely.

In algebraic mode, addition, subtraction, multiplication and division are not carried out immediately. If a wrong key was pressed, [+] and [−] should be followed by a [0] and [×] or [÷] should be followed by a [1].

Functions of two numbers

Unlike functions of a single number, the arithmetical operations [+], [−], [×] and [÷] use two numbers, but there are also some mathematical functions that use two numbers.

An often-used two-number function is the exponentiation or "power" function, and this works in the same way as [+], [−], [×] and [÷] in algebraic mode.

Example 3: What is 2 to the power 10?

Solution: The calculation is 2^{10} using the [y^x] key.

In algebraic mode, type 2, press [y^x], type 10, and press [ENTER] to complete the calculation.

[2] [y^x] [1] [0] [ENTER]

Figure 12

Answer: Two to the power 10 is 1,024, often called 1k in computing.

[y^x] works exactly like the arithmetical operators and is often considered to be one of them. Other two-number functions work as shown in the next example.

Example 4: What is the permutation of 69 items taken 2 at a time?

Solution: This involves the permutation function, or the [↱] [nPr] key.

In algebraic mode, type [↱] [nPr]

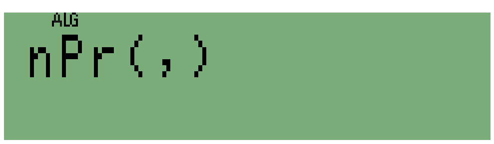


Figure 13

The permutation function is presented in the display with the required open and close parentheses as well as a comma inside them to separate the two required arguments. The cursor is blinking to indicate the insertion point – where the next key pressed will be entered. This insertion point is exactly where it should be to enter the first argument.

Now type [6] [9]. This is the first argument. To move past the comma, press [>]. Now press [2] [ENTER].

Figure 14

<u>Answer:</u> The permutation of 69 items taken 2 at a time is 4,692. Note that it was not necessary to move beyond the closing parenthesis before pressing [ENTER].

Percentage functions are used in algebraic mode and are explained in the business training guide on Percentages.

Working with complex numbers, with pairs of numbers representing rectangular or polar coordinates and with pairs of numbers in statistical operations are described in training aids on these subjects.

Algebraic operator precedence

In algebraic mode the HP 35s calculates using "operator precedence". This means that a combination of several [+] and [−] operations (or several [×] and [÷] operations) is calculated from left to right, but [×] and [÷] have a higher "precedence" and are carried out before [+] and [−].

<u>Example 5:</u> What is the result of calculating 1 ÷ 2 ÷ 3 in algebraic mode?

<u>Solution:</u> Type the keys [1][÷][2][÷][3][ENTER].

Figure 15

<u>Answer:</u> The result is equal to 1 ÷ 6, in other words the calculation goes from left to right, 1 ÷ 2, and the result divided by 3. If the calculation went the other way, it would be 1 ÷ (2 ÷ 3), or 3 ÷ 2, giving 1.5 as the result.

The rules of precedence are that algebraic calculations are carried out in the following order.

1. Expressions in parentheses.
2. All single number functions, also complex number functions, percentages, and co-ordinate transformations.
3. The two-number functions [$\sqrt[x]{y}$] and [y^x].
4. The other two-number functions, [nPr], [nCr] and [%CHG].
5. Multiplication, division and integer quotient and remainder, [×], [÷], [INT÷] and [Rmdr].
6. Addition and subtraction.

Operations with the same level of precedence are carried out from left to right, as this example showed.

<u>Example 6:</u> In what order is the calculation 1 + (0.5 + 1.5) × $3^{4!}$ carried out?

<u>Solution:</u> Type the keys [1][+][()][0][.][5][+][1][.][5][>][×][3][y^x][4][↱][!][ENTER].

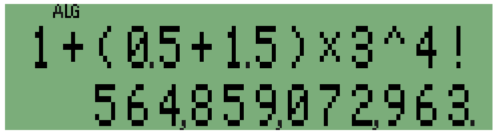


Figure 16

<u>Answer:</u> The calculation in brackets is carried out first, giving the result 2. The rest of the calculation proceeds from right to left, as the factorial function has highest precedence, followed by the power function, followed by multiplication, with addition coming last. The answer 564,859,072,963 can be confirmed if 1 is subtracted first, then the result is divided by 2. That result is equal to 3^{24}, which is 3 to the power 4 factorial.

Example – reusing a previous calculation

A useful feature in algebraic mode is the ability to reuse a previous calculation while changing some of the values in it. The next example illustrates how this would be helpful.

<u>Example 7:</u> You wish to perform a calculation involving the gravitational constant, g. You want to add 1 to g divided by three.

<u>Solution:</u> Suppose you key in the following.

[1] [+] [↰] [CONST] [ENTER] [÷] [3] [ENTER]

The HP 35s display would show:

Figure 17

Something tells you there is something wrong. Then you notice that you accidentally used the speed of light, c, rather than the gravitational constant, g. Rather than starting over, you can edit the previous expression and correct your mistake as follows. Press:

[<] [<] [<]

The first press of the left cursor key begins the edit of the previously entered expression. Pressing the left cursor key two additional times places the cursor just to the right of “c” in the expression. At this point, we wish to delete c and replace it with g. Press:

[←] [↰] [CONST] [>] [ENTER] [ENTER]

Figure 18

<u>Answer:</u> This example shows how to edit an expression in algebraic mode. While somewhat trivial, it would certainly be easier to edit a much larger expression to correct a mistake than retyping the entire expression all over again.

hp calculators

HP 35s Unit Conversions

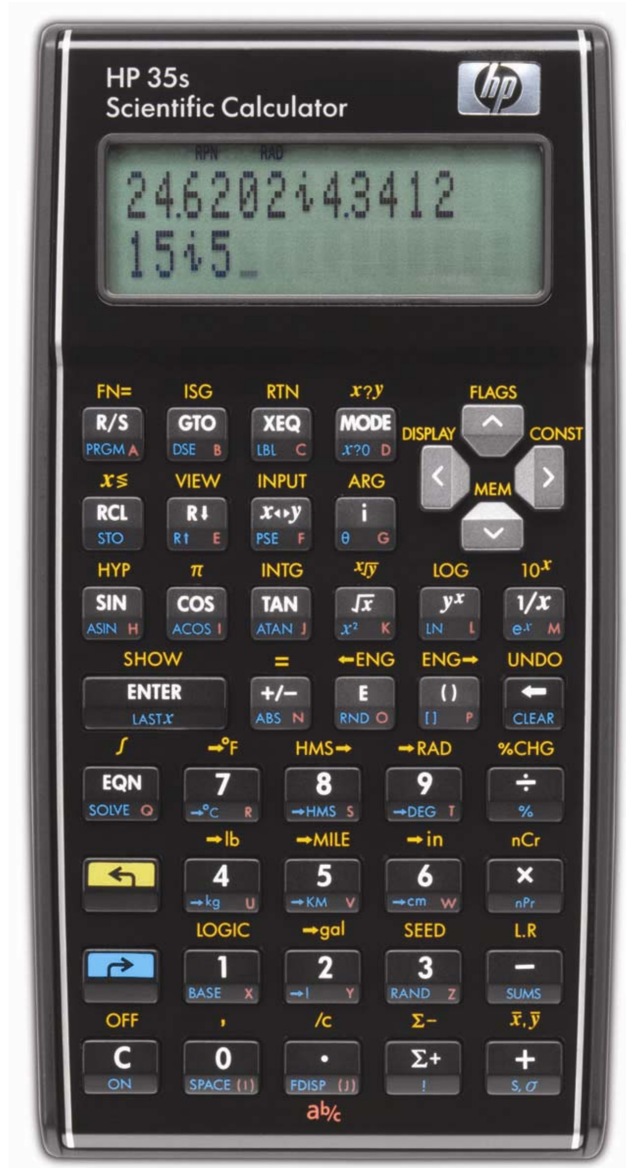
Metric units and Imperial units

Conversion keys

Practice working problems involving conversions

Performing conversions that are not built in

Special considerations for temperature conversions



Metric units and Imperial units

Measurements of quantities such as length, mass or temperature use units. Metric units include centimeters and meters, grams and kilograms, or Celsius and Kelvin degrees. Imperial units include feet and yards, ounces and pounds, or Fahrenheit and Rankine degrees. The HP 35s provides eight functions for converting to and from Metric units. These conversions are useful for many problems in engineering, mathematics, and physical and biological sciences. They can also be used to create additional conversions, through HP 35s equations and programs.

Two training aids describe unit conversions on the HP 35s. This aid describes mass, length and volume conversions. Temperature conversions are more complicated; a simple example is given in this training aid and a second training aid describes conversion of temperature units in detail. For coordinate, angle and time conversions see the separate training aids, for example angle conversions are covered in the training aid on angle conversions and angle arithmetic.

Conversion keys

The unit conversion functions are on the right and left shifted [2] [4] [5] [6] and [7] keys. The available conversions are as follows:

[↱] [→kg] for pounds to kilograms
[↰] [→lb] for kilograms to pounds
[↱] [→KM] for miles to kilometers
[↰] [→MILE] for kilometers to miles
[↱] [→°C] for Fahrenheit to Centigrade
[↰] [→°F] for Centigrade to Fahrenheit
[↱] [→cm] for inches to centimeters
[↰] [→in] for centimeters to inches
[↱] [→l] for gallons to liters, and
[↰] [→gal] for liters to gallons.

The right and left shifted functions on each key are the inverse of each other. Ways to build up other conversions from them are shown below.

Note that conversions *to* Metric units are always on the right-shifted leys, and conversions *from* Metric units are on the corresponding left-shifted keys.

Conversions of lb/kg, of in/cm, mile/km and of gal/l involve only multiplication by a conversion factor. Conversions of °F/°C require addition or subtraction of an offset constant as well as multiplication; they are described in more detail in the separate training aid on temperature conversions.

Practice working problems involving conversions

Example 1: Convert 10 inches to centimeters

Solution: In RPN mode, type the number 10 and then press the right-shifted [5] key.

[1] [0] [↱] [→cm]

In algebraic mode, do the same. Pressing [ENTER] completes the calculation, but this is not necessary unless the conversion is part of a longer calculation.

[↱] [→cm] [1] [0] [ENTER]

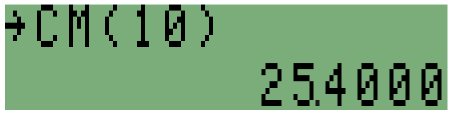


Figure 1

Answer: 25.4 centimeters.

Example 2: How many gallons is 25 liters?

Solution: In RPN mode, type the number 25 and then press the left-shifted [2] key.

[2] [5] [↰] [→gal]

In algebraic mode, do the same. Again, pressing [ENTER] completes the calculation, but is not necessary unless the conversion is part of a longer calculation.

[↰] [→gal] [2] [5] [ENTER]

Figure 2

Answer: 6.6043 gallons.

Example 3: Convert 16 square inches to square centimeters

Solution: A square inch is an inch times an inch. After one [↱] [→cm] conversion, the units become centimeters times inches. After a second [↱] [→cm] conversion, the units become centimeters times centimeters, or square centimeters. So, in this case, conversion to centimeters is carried out twice, to give square centimeters.

In RPN mode, type the number 16 and then press the right-shifted [6] key twice.

[1] [6] [↱] [→cm] [↱] [→cm]

In algebraic mode, do the same. Again, pressing [ENTER] completes the calculation, but is not necessary unless the conversion is part of a longer calculation.

[↱] [→cm] [↱] [→cm] [1] [6] [ENTER]

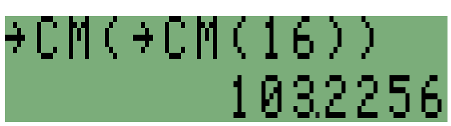


Figure 3

Another way to do this is to take the square root of 16 cm², giving 4 cm, then convert this to inches, then take the square. Figure 4 shows the result and confirms that the method used above is correct.

[↱] [x^2] [↱] [→cm] [$\sqrt{x}$] [1] [6] [ENTER]

Figure 4

Answer: 103.2256 square centimeters.

Example 4: Convert 5 yards to meters

Solution: The conversion keys use inches and centimeters, so it is necessary to go from yards to inches, then convert inches to centimeters, and finally go from centimeters to meters.

In RPN mode, type the number 5, multiply by 3 to go to feet, and multiply by 12 to go to inches. Now press the right-shifted [6] key to convert inches to centimeters. Finally divide by 100 to convert centimeters to meters.

[5] [ENTER] [3] [×] [1] [2] [×] [↱] [→cm] [1] [0] [0] [÷]

In algebraic mode, the order is different, and [ENTER] must be used at the end to complete the whole calculation

[↱] [→cm] [5] [×] [3] [×] [1] [2] [>] [÷] [1] [0] [0] [ENTER]

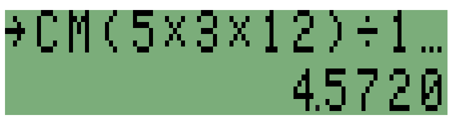


Figure 5

Answer: 4.572 meters.

Performing conversions that are not built in

Example 5: As the density of water is 1 gm/cm³, what is it in lb/ft³ ?

Solution: This conversion is not built into the calculator. As in examples 3 and 4, it is therefore necessary to separate the calculation into the basic units, and then convert each unit. In this example, the steps required are:

- Convert gm to kg, by dividing by 1,000
- Convert kg to lb with [↰] [→lb]
- Convert 1/cm to 1/in three times, as the cm are cubed. A short cut for converting inverse units is to notice that this is the same as doing the opposite transformation. So, converting 1/cm to 1/in can be done with [↱] [→cm].
- Convert 1/in³ to 1/ft³ by multiplying by 12 cubed.

In RPN mode, the above should be done with these keys:

[1] [ENTER] [1] [0] [0] [0] [÷] [↰] [→lb] [↱] [→cm] [↱] [→cm] [↱] [→cm] [1] [2] [ENTER] [3] [y^x] [×]

In algebraic mode, the following keys are used instead; note that [ENTER] is needed to complete the calculation.

[↱] [→cm] [↱] [→cm] [↱] [→cm] [↰] [→lb] [1] [÷] [1] [0] [0] [0] [>] [×] [1] [2] [y^x] [3] [ENTER]

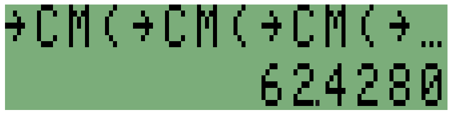


Figure 6

Answer: The density of water is close to 62.4 pounds per cubic foot.

Special considerations for temperature conversions

Special care must be taken with temperature conversions. The two commands [↱] [→°C] and [↰] [→°F] convert **temperatures** but not temperature differences. The following example shows a simple temperature conversion, for more details see the separate training aid on temperature conversions.

Example 8: What is 20 degrees Celsius in Fahrenheit?

Solution: In RPN mode, type the number 20 and then press the left-shifted [7] key.

[2] [0] [↰] [→°F]

In algebraic mode, do the same. As usual, pressing [ENTER] completes the calculation, but is not necessary unless the conversion is part of a longer calculation.

[↰] [→°F] [2] [0] [ENTER]

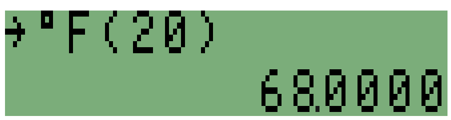


Figure 7

Answer: 68 degrees Fahrenheit.

hp calculators

HP 35s Temperature Conversions

Metric units and Imperial units

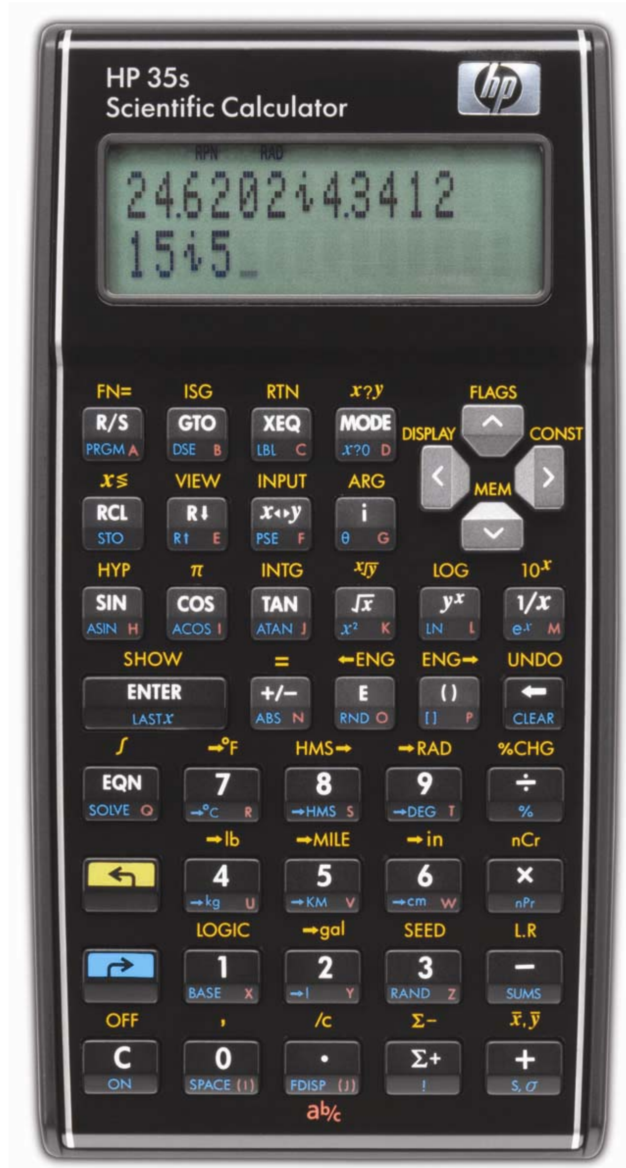
Conversion keys

Practice working problems involving temperature conversions

Conversion of temperatures and conversion of temperature differences

Other temperature scales

Using equations and programs for complicated conversions



Metric units and Imperial units

Measurements of quantities such as length, mass or temperature use units. Metric units include centimeters and meters, grams and kilograms, or Celsius and Kelvin degrees. Imperial units include feet and yards, ounces and pounds, or Fahrenheit and Rankine degrees. The HP 35s provides ten functions for converting to and from Metric units. These conversions are useful for many problems in engineering, mathematics, and physical and biological sciences. They can also be used to create additional conversions, through HP 35s equations and programs.

Two training aids describe unit conversions on the HP 35s. A separate training aid describes mass, length and volume conversions. Temperature conversions are more complicated; this training aid covers temperature units in detail. For coordinate, angle and time conversions see the separate training aid on angle conversions and angle arithmetic.

Conversion keys

The unit conversion functions are on the right and left shifted [2] [4] [5] [6] and [7] keys. The available conversions are as follows:

[↱] [→kg] for pounds to kilograms
[↰] [→lb] for kilograms to pounds
[↱] [→KM] for miles to kilometers
[↰] [→MILE] for kilometers to miles
[↱] [→°C] for Fahrenheit to Centigrade
[↰] [→°F] for Centigrade to Fahrenheit
[↱] [→cm] for inches to centimeters
[↰] [→in] for centimeters to inches
[↱] [→l] for gallons to liters, and
[↰] [→gal] for liters to gallons.

The right and left shifted functions on each key are the inverse of each other. Ways to build up other conversions from them are shown below.

Note that conversions *to* Metric units are always on the right-shifted leys, and conversions *from* Metric units are on the corresponding left-shifted keys.

Conversions of lb/kg, of in/cm, mile/km and of gal/l involve only multiplication by a conversion factor. Conversions of °F/°C require addition or subtraction of offset constants as well as multiplication, and are therefore described in this training aid, in more detail.

Practice working problems involving temperature conversions

Special care must be taken with temperature conversions. The two commands [↱] [→°C] and [↰] [→°F] convert *temperatures*, as the first two examples below show, but they do not convert temperature differences.

Example 1: Many photographic film developers are designed to work best at 20 degrees Celsius. What is 20 degrees Celsius in Fahrenheit?

Solution: In RPN mode, type the number 20 and then press the left-shifted [7] key.

[2] [0] [↰] [→°F]

In Algebraic mode, do the same. Pressing [ENTER] completes the calculation, but is not necessary unless the conversion comes at the end of a longer calculation.

[↰] [→°F] [2] [0] [ENTER]

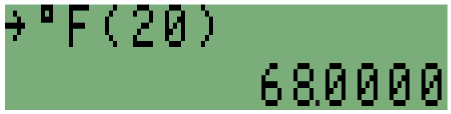


Figure 1

Answer: 20 degrees Celsius is 68 degrees Fahrenheit.

Example 2: What is –40 degrees Fahrenheit when measured in degrees Celsius?

Solution: In RPN mode, type the number 40, change the sign, and then press the right-shifted [7] key.

[4] [0] [+/–] [↱] [→°C]

In Algebraic mode, do the same. Again, pressing [ENTER] completes the calculation, but is not necessary unless the conversion is part of a longer calculation.

[↱] [→°C] [4] [0] [+/–] [ENTER]

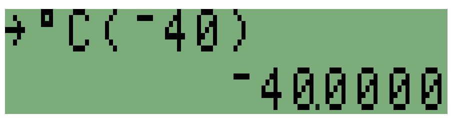


Figure 2

Answer: The result is –40. That is not an error – this example shows that at –40 degrees the Celsius and Fahrenheit scales coincide.

Conversion of temperatures and conversion of temperature differences

With most measurements, zero is an absolute minimum. A length of zero inches or zero centimeters is the smallest possible length, and zero is zero in either of these units. Temperatures are different. Zero degrees Celsius is the freezing point of water at Standard Pressure, but the lowest possible temperature is Absolute Zero, –273.15 degrees Celsius. In degrees Fahrenheit, the freezing point of water is 32 degrees, and Absolute Zero is –459.67 degrees Fahrenheit.

This means that a conversion from a measurement of 20°C to Fahrenheit requires multiplication by 9/5 because 5 degrees Celsius are the same size as 9 degrees Fahrenheit, but then addition of 32 because 0°C is 32°F. As Figure 3 shows, this gives the correct answer of 68 degrees Fahrenheit, obtained in Example 1. The opposite is needed for conversion from Fahrenheit to Celsius, first subtraction of 32, then multiplication by 5/9. The [↱] [→°C] and [↰] [→°F] functions automatically carry out these calculations.

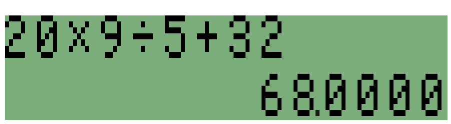


Figure 3

As opposed to a temperature measurement, a temperature difference of zero really is zero, and does not need the addition or subtraction of 32. Adding 5 Celsius degrees to 20°C is the same as adding 9 Fahrenheit degrees to 68°F and does not require addition or subtraction of 32.

Note: To make clear the distinction between temperature measurement and temperature difference, temperature measurements are usually called “degrees Celsius” or “degrees Fahrenheit”, and temperature differences are called “Celsius degrees” or “Fahrenheit degrees”.

Because the [↱] [→°C] and [↰] [→°F] functions convert temperature measurements, not temperature differences, conversion of differences must be dealt with either by a manual conversion, using the factor 5/9,or by the addition of a temperature difference to a temperature only on the same scale.

<u>Example 3:</u> An experimental new heater is designed to raise the temperature of its surroundings by exactly 20 Celsius degrees and then to turn itself off. If the heater is working correctly, what should the temperature be, in degrees Fahrenheit, after the heater is used in a room initially at a temperature of 50 degrees Fahrenheit?

<u>Solution:</u> A temperature *difference* of 20 Celsius degrees is not the same as a temperature of 20 degrees Celsius. A temperature of 20 degrees Celsius is 68 degrees Fahrenheit, as Example 1 showed. The temperature difference can be calculated as 20 times 9 divided by 5, giving 36 Fahrenheit degrees. Adding this to 50 will give 86 degrees Fahrenheit. Figure 4 shows this calculation in Algebraic mode.

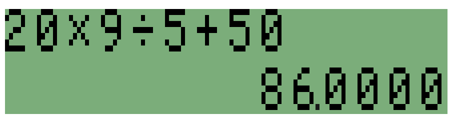


Figure 4

Alternatively, the conversion functions can be used to calculate this as follows.

In RPN mode, type the number 50, and press the right-shifted [7] key to convert it to Celsius. Then add 20 Celsius degrees. Finally convert back to Fahrenheit.

[5] [0] [↱] [→°C] [2] [0] [+] [↰] [→°F]

In Algebraic mode, set up the conversion to Fahrenheit, then do the conversion of 50 to Celsius, and then add 20. In this case, pressing [ENTER] is again not required to complete the calculation.

[↰] [→°F] [↱] [→°C] [5] [0] [>] [+] [2] [0] [ENTER]

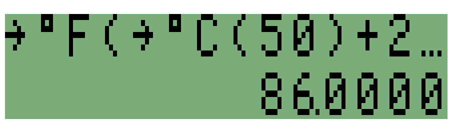


Figure 5

<u>Answer:</u> As figures 4 and 5 show, the correct answer is 86 degrees Fahrenheit.

Other temperature scales

A temperature scale with 100 degrees between two points is called a centigrade scale ("centigrade" means one hundred degrees), and is an obvious scale for use in the metric system where measurements are based on powers of 10. A scale with 0 at the freezing point of water and 100 at the boiling point was suggested by Celsius, and is now called the Celsius scale. The Fahrenheit scale is the best known alternative, but some old textbooks (especially French ones) use the Reaumur scale, with the freezing point of water at 0 degrees and the boiling point at 80 degrees.

The Kelvin and Rankine temperature scales avoid the complication of Absolute Zero not being called 0. Kelvin degrees are the same size as Celsius degrees, but Absolute Zero is 0 degrees Kelvin. Rankine degrees are the same size as Fahrenheit degrees but again Absolute Zero is 0 degrees Rankine.

Temperatures can therefore be converted using these expressions:

$T°K \equiv T°C + 273.15°C$

$T°R \equiv T°F + 459.67°F$

$T°K \equiv T°R \times 5/9$

The symbol ≡ means "is equivalent to", so the first expression means that a temperature of T°C can be converted to an equivalent temperature in degrees Kelvin by the addition of 273.15.

Using equations and programs for complicated conversions

For complicated conversions, it can be useful to write an equation or a program to do the conversion automatically.

Example 4: Write an equation to convert degrees Fahrenheit to degrees Kelvin.

Solution: Assume that the temperature in Fahrenheit will be in the variable F. To enter the equation, equation mode is first entered by pressing EQN, and the expression is typed as follows:

(RCL F + 4 5 9 · 6 7 > × 5 ÷ 9

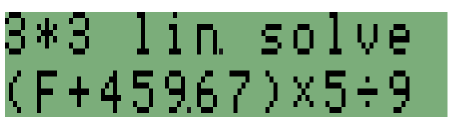


Figure 6

Answer: Figure 6 shows the required equation entered on the HP35s.

Example 5: Use the equation from example 4 to convert 90 degrees Fahrenheit to degrees Kelvin.

Solution: If equation mode is not already set following Example 4 then set equation mode by pressing EQN. If other equations are stored in the calculator, it might be necessary to use the up or down cursor keys to select the equation that was typed above. Then press ENTER to use the equation. A prompt for F will be displayed.

Figure 7

[9] [0] [R/S] should be typed, and the equation will run for a moment, then the answer will be displayed.

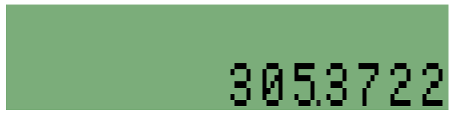


Figure 8

<u>Answer:</u> The answer, 305.372 degrees Kelvin, is displayed.

The equation can now be used again to convert a different temperature from degrees Fahrenheit to degrees Kelvin. Press [EQN], to enter equation mode again, press [ENTER] to start the equation again, type the temperature in degrees Fahrenheit, and press [R/S] to carry out the calculation.

Programs can be used instead of equations if the user prefers to use programs or if the additional power of program commands such as test and loops is needed. How to write programs is described in a separate training aid.

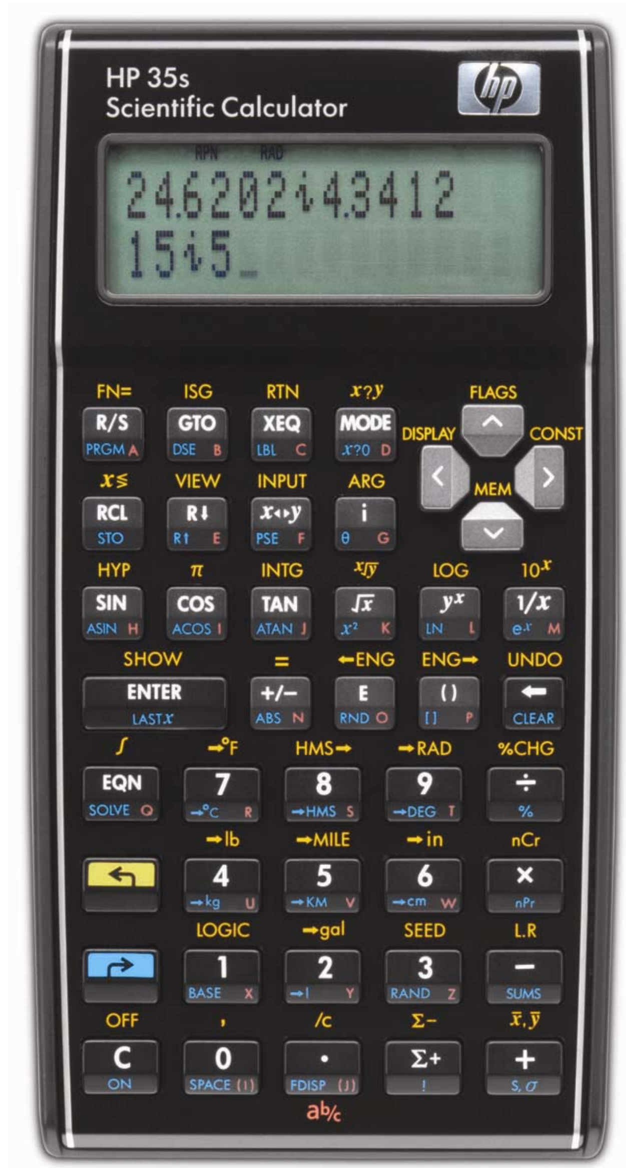
hp calculators

HP 35s Angular conversions and arithmetic

Angular measurements

Time measurements

Practice solving problems involving angles and times



Angular measurements

There are two primary ways of measuring angles, radians and degrees (there is a third way, Grads, which is not used as often). Radians measures the span of an angle in terms of the unit circle, where a full revolution involves an angle of 2π. Degrees measures the span of an angle where a full revolution involves an angle of 360 degrees. The HP 35s calculator can work with angles in either measurement system and provides the ↰ →RAD and ↱ →DEG functions to convert between them.

Angles are also sometimes measured in degrees using two different formats: decimal degrees and degrees, minutes, and seconds. In decimal degrees, an angle might simply be 33.5 degrees. In the degrees, minutes, seconds (or DMS) format, an angle might be 30 degrees, 15 minutes, 10 seconds. An angle in the DMS format has a degree broken down into 60 minutes and each minute broken down into 60 seconds. The HP 35s calculator can convert between these two formats of angles in degrees using the ↱ →HMS and ↰ HMS→ functions. Note that these functions are actually Hours Minutes Seconds and Hours conversions, but work for angle conversions between decimal degrees and DMS.

Time measurements

A useful application of the conversion between decimal degrees and DMS angles is that the exact same conversion can also work for time. A measurement of 10.5 hours can be converted into 10 hours and 30 minutes by the same process an angle of 10.5 degrees can be converted into 10 degrees, 30 minutes.

Practice solving problems involving angles and times

Example 1: Convert an angle of 100 degrees into radians.

Solution: In RPN mode: 1 0 0 ↰ →RAD
In algebraic mode: ↰ →RAD 1 0 0 ENTER

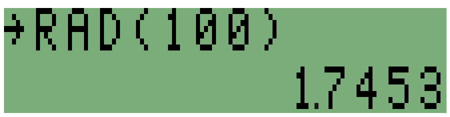


Figure 1

Answer: 1.7453 radians. Figure 1 shows the display assuming algebraic mode.

Example 2: Convert an angle of 1.5 radians into decimal degrees.

Solution: In RPN mode: 1 · 5 ↱ →DEG
In algebraic mode: ↱ →DEG 1 · 5 ENTER

Figure 2

Answer: 85.94 degrees. Figure 2 shows the display assuming algebraic mode.

Example 3: Add an angle of 30.5 degrees to an angle of π/4 radians and express the answer in radians.

Solution: In RPN mode: 3 0 · 5 ↰ →RAD ↰ π 4 ÷ +
In algebraic mode: ↰ →RAD 3 0 · 5 > + ↰ π ÷ 4 ENTER

Figure 3

Answer: 1.3177 radians. Figure 3 shows the display assuming algebraic mode.

Example 4: Convert an angle of 20.67 decimal decrees to an angle format of DMS.

Solution: In RPN or algebraic mode: [2] [0] [·] [6] [7] [↱] [→HMS]
In algebraic mode: [↱] [→HMS] [2] [0] [·] [6] [7] [ENTER]

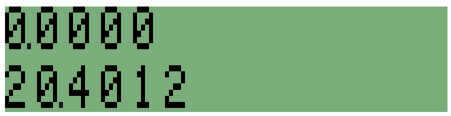


Figure 4

Answer: The equivalent measurement in DMS is 20 degrees, 40 minutes and 12 seconds. Figure 4 shows the display assuming RPN mode.

Example 5: Add 5 hours 33 minutes to 3 hours 58 minutes.

Solution: Each measurement of time will need to be converted from the Hours Minutes Seconds format into an equivalent "decimal hours" format and then added together.

In RPN mode: [5] [·] [3] [3] [↰] [HMS→] [3] [·] [5] [8] [↰] [HMS→] [+] [↱] [→HMS]
In algebraic mode: [↱] [→HMS] [↰] [HMS→] [5] [·] [3] [3] [>] [+] [↰] [HMS→] [3] [·] [5] [8] [ENTER]

Figure 5

Answer: The answer is 9 hours, 31 minutes.

Example 6: What is the size of the angle formed by joining an angle of π/5 radians and an angle of 40.62 degrees. Express the answer in DMS format.

Solution: In RPN mode: [↰] [π] [5] [÷] [↱] [→DEG] [4] [0] [·] [6] [2] [+] [↱] [→HMS]

In algebraic mode: [↱] [→HMS] [↱] [→DEG] [↰] [π] [÷] [5] [>] [+] [4] [0] [·] [6] [2] [ENTER]

Figure 6

Answer: The resulting angle is 76 degrees, 37 minutes and 12 seconds. Figure 6 shows the display assuming algebraic mode.

hp calculators

HP 35s Using Calculator Memories to Help Solve Problems

Variables and Memory Registers

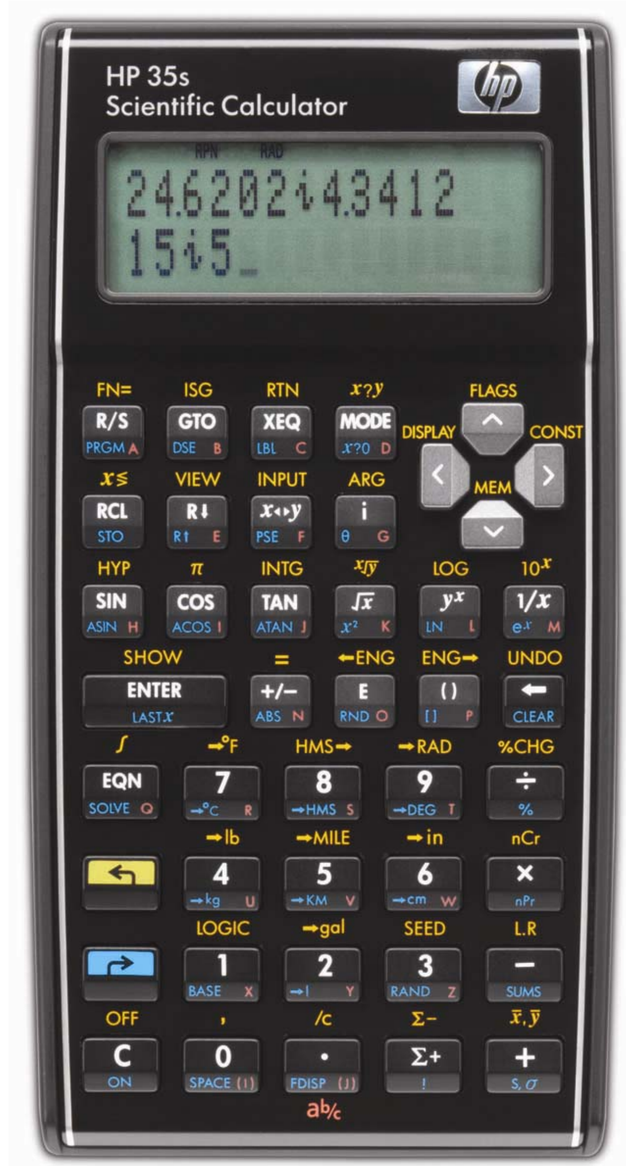
Practice Examples:

Storing and Using a Constant

Storing a Temporary Result

Exchanging and Viewing Registers

Other Operations with Memory Registers



Variables and Memory Registers

When an equation is typed on the HP 35s, it can use **variables** with names from A through Z. For example an equation

$$3X^2 - 5X = A$$

has the variables X and A in it.

Variables can also be used in programs and in calculations from the keyboard.

Each variable consists of a number and of a place in the calculator memory where the number is stored.

The number is called the **value** of the variable. If no value has been give to a variable then its value is 0.

The place in memory where this number is stored is called a **data register**, or a **memory register**, or just a **memory**.

Each memory register can be referred to by a numeral as well as by its name. Register A is -1 and register Z is -26. Six more registers can be referred to by numerals and hold values from statistics calculations. Two of the lettered variables are special "index" registers, which are explained in another training aid. The names "data register" or "memory register" or "memory" refer to all of these, not just the variables, so these names are often used in this training aid, rather than the name "variables."

In many cases it is helpful to use variable names as mnemonics, for example D for density or P for pressure, but when registers are used to store a table then names are meaningless and the numeral for each register is what counts.

This training aid shows ways in which memory registers can be used. A separate training aid covers the special topic of how arithmetic can be carried out directly in memory registers and using the memory registers.

Practice Example: Storing and Using a Constant

The HP 35s provides a set of physical constants, such as the speed of light. The conversion functions also provide constants to convert between metric and imperial measurements. Users who need to store other constants can put them into the memory registers so they can be easily used in calculations.

Example 1: An engineer is working with a type of concrete that has a density of 149.8 lb/ft³ (Different types of concrete have different densities, so the density of concrete is not a physical constant provided by the HP 35s!) Store the density of this concrete in a data register and use it to calculate the mass of a concrete beam 2 ft by 1.5 ft by 20ft.

Solution: Type the density, then press [↱] [STO] and a variable name to store the density in that variable's memory register. To store a density of 149.8 in variable D, press these keys.

[1] [4] [9] [·] [8] [↱] [STO] [D] [ENTER]

When [↱] [STO] is pressed, the symbol "A..Z" appears at the top of the screen. This tells the user that the next key pressed should be one of the keys with letters A to Z at their lower right, and that the corresponding letter will be used. For the letter "D", press the [MODE] key.

To calculate the mass, multiply the length by the width by the height. Then recall the number from D and multiply by that. In RPN mode, press the keys:

[2] [ENTER] [1] [·] [5] [×] [2] [0] [×] [RCL] [D] [×]

In algebraic mode, press:

[2] [×] [1] [·] [5] [×] [2] [0] [×] [RCL] [D] [ENTER]

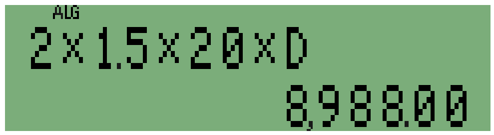


Figure 1

Answer: The beam has a mass of 8,988 pounds. This value of the variable D can be used for further calculations. If a different type of concrete is selected, the density of this new type can be stored in D and the calculations can be repeated. The value in D is not lost when the calculator is turned off.

Note: The recall and the multiplication can be combined into one command RCL×D. A separate training aid describes using arithmetic with the memory registers.

Practice Example: Storing a Temporary Result

The memory registers are available separately from the memory in which ordinary calculations are carried out. In algebraic mode, up to thirteen levels of brackets can be used, together with numbers saved with the brackets. RPN mode has four stack registers, X, Y, Z and T, and also the LastX register, often called L. The memory registers are separate from these. Note that the variables named L, T, X, Y and Z are not the same as the stack registers with these names, and that the Exponent key [E] and the Cancel key [C] do not access the variables with these names.

If a calculation is more complicated than the algebraic or RPN rules allow, temporary results can be stored in memory registers, and can then be used later.

Temporary results can also be stored in memory registers just to make a calculation easier, as in this example.

Example 2: The formula below uses the expression (0.2 + sin(35°)) three times. In algebraic mode, it would be difficult to re-use this expression without typing it in each time. In RPN mode the expression could be calculated once, then kept on the stack and re-used as needed, but this would require keeping track of which number is where on the stack.

$$\frac{5 \cdot \mathrm{ASIN}(.2+\mathrm{SIN}(35))}{\mathrm{ACOS}(.2+\mathrm{SIN}(35))} \cdot \sqrt{3 \cdot (.2+\mathrm{SIN}(35))}$$

Figure 2

Solution: The expression uses degrees, so set Degrees mode if it is not already set. (To do this press [MODE] [1].) First calculate the expression that is used several times and store its value in a memory register. In this example, use register V for the value of the expression. Then calculate the whole formula, recalling the value each time it is needed.

In algebraic mode, type the expression like this:

[·] [2] [+] [SIN] [3] [5] [ENTER]

Figure 3

Then store it in register V by typing:

[↱] [STO] [V] [ENTER]

Figure 3

Now the main formula can be calculated. First calculate the top line at the left-hand of the formula. The value of the expression is still available, so there is no need to recall it, but to see how it all works, recall V, calculate its arc sine and multiply by 5:

[↱] [ASIN] [RCL] [V] [>] [×] [5]

Next, divide by the arc cosine of the expression, recalling it again from V:

[÷] [↱] [ACOS] [RCL] [V]

Figure 4

Now multiply by the square root of three times the expression.

[>] [×] [√x] [3] [×] [RCL] [V]

Figure 5

Finish the calculation by pressing [ENTER]:

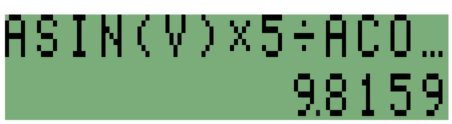


Figure 6

Answer: To four decimal places the complete formula evaluates to 9.8159. Calculation was considerably easier, and the expression displayed on the upper line is simpler, because the temporary value was stored in a memory register.

In RPN mode the calculation would be carried out using the following keys:

Calculate the value and store it in V:

[3] [5] [SIN] [.] [2] [+] [↱] [STO] [V]

As the value is already on the stack, just calculate its arc sine, then multiply by 5:

[↱] [ASIN] [5] [×]

Next, divide by the arc cosine of the expression, which is recalled from V:

[RCL] [V] [↱] [ACOS] [÷]

Now multiply by the square root of three times the expression. In RPN there is no need for brackets:

[3] [RCL] [V] [×] [√x] [×]

Figure 7

Answer: In RPN mode the answer is the same, and carrying out the calculation in a suitable order reduces the number of keystrokes needed.

Practice Example: Exchanging and Viewing Registers

Two more commands that work with memory registers are “exchange” and “view”. Pressing [↰] [x⇄] displays the A..Z symbol, and any letter from A through Z can be entered. The value in the chosen register is exchanged with the value shown on the lower line of the calculator screen.

One use for this is to see what value is stored in a register. For example, the engineer from Example 1 might forget whether the density of concrete is in register C for Concrete or in register D for Density. Pressing [↰] [x⇄] [C] will bring the value from register C to the lower line of the screen so it can be seen, and pressing [↰] [x⇄] [C] again will put the values back as they were. The exchange command is rarely used for this, because the VIEW command, described below, does the job better. Another use for the exchange command is shown in the example below.

Example 3: In the middle of a calculation, the engineer from Example 1 decides that register D should be used to store the depth of the foundations of a building. Currently the Area, the height, and the depth of the building are in registers A, B and C. That means the density of concrete should be taken from D and placed in C, while the number in C must be placed in D, all without losing the value currently in use shown on the lower line of the display. How can this be done?

Solution: The engineer first exchanges D with the current value. The current value gets stored in D and the density is in the current value. Then the density, now in the current value, is exchanged with the depth, in register C. This puts the density of concrete into register C and the depth into the current value. Finally, exchanging the depth in the current value with the original value now in D completes the exchange. The keys pressed are:

[↰] [x⇆] [D] [↰] [x⇆] [C] [↰] [x⇆] [D]

Answer: The three exchanges swap values in two data registers without affecting an ongoing calculation. Note that this works in algebraic and in RPN mode.

Pressing [↰] [VIEW] displays the A..Z symbol, and any letter from A through Z can be pressed. The value in the chosen register is displayed in a message without changing the value on the lower line of the calculator screen. For example, pressing [↰] [VIEW] [C] after Examples 1 and 3 should now display the density of concrete stored in register C.

Figure 8

Pressing the cancel key [C] on the lower left of the keyboard, or the back-arrow [←] at the middle right, clears the message and brings back the display in the calculator screen.

Other Operations with Memory Registers

There is no special command to clear a register, it is enough to store a zero in it, but see also the description below of CLVARS and of the register catalog.

Variables are used in equations and in programs. When the Solver is used, it asks which variable is the unknown one and prompts for values for the other variables. The Integrate command must be told which is the variable to integrate for.

The INPUT command allows a program to request a value for a variable.

Variables can also be used with the program loop control commands ISG (Increment and Skip if Greater) and DSE (Decrement and Skip if Equal).

The CLVARS command is activated by pressing [↱] [CLEAR] [2] and clears all the variables A through Z to zero.

Registers 28 through 33 are the statistics registers, normally used for statistical calculations. Numbers can not be stored directly into them through statistical operations, but can be placed in them through the index register. This will lead to errors if incorrect values are stored into these registers. The statistics registers are cleared when [↱] [CLEAR] [4] is pressed.

Pressing [↰] [MEM] selects the Memory menu and then pressing [1] displays a catalog of the registers. The [↑] and [↓] cursor keys step through the registers. To see all the digits of a register, press [↱] [SHOW] when the register is displayed. To copy a register to a calculation, press [ENTER]. To clear the variable to zero, press [↰] [CLEAR]. To cancel the catalog, press the cancel key [C], or to go back to the Memory menu, press [←].

Arithmetic calculations using the registers directly are described in a separate training aid, as has been mentioned already.

As the above shows, the memory registers provide many ways to help in calculations on the HP 35s.

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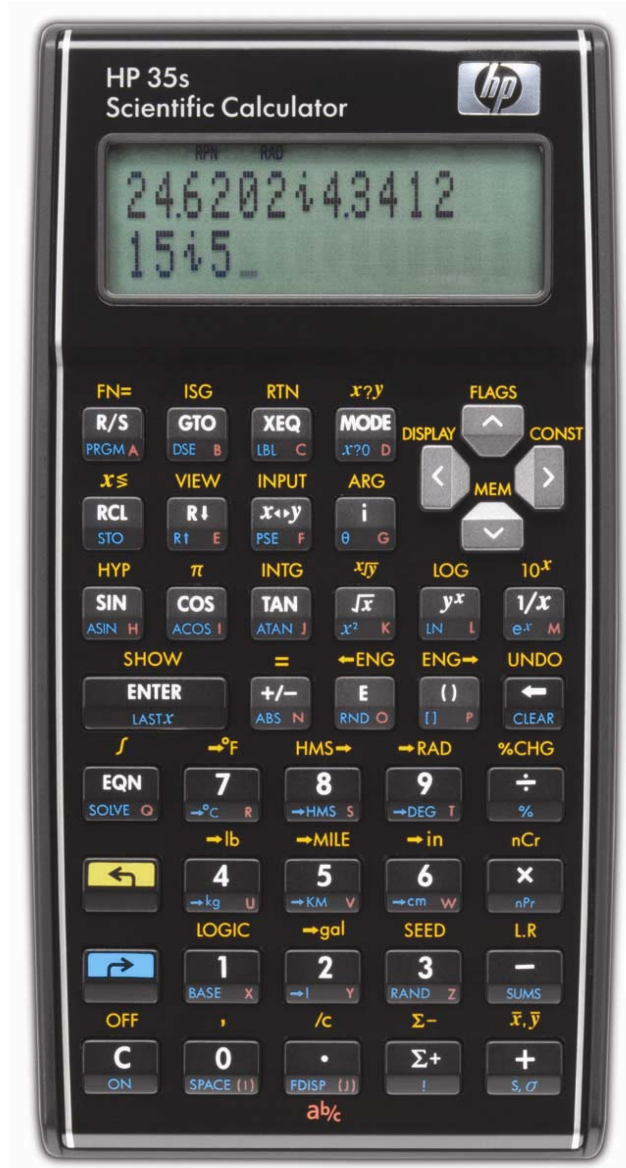
HP 35s Using the indirect registers



The HP 35s and indirect registers

Differences from the HP 33s

Examples using the indirect registers

The HP 35s and indirect registers

The HP35s contains registers or variables that can be referenced directly or indirectly. Variables A through Z can be directly addressed, as in a [↱] [STO] [A] instruction. Indirect addressing uses two of these direct variables as indices that hold the location or address where an operation is to be performed. The two variables that are used this way are [I] and [J]. The indirect registers begin at address 0 and can go up to 800, if the user allocates that many. That is 801 additional storage registers compared to the earlier HP 33s calculator. Figure 1 shows the HP 35s display when a non-zero value has been stored into indirect register 800 (which would allocate 801 indirect registers). NOTE: the indirect registers are allocated by the highest-numbered, non-zero indirect register in use. If the highest used register is cleared or has a zero stored into it, the allocation will shrink down to the next highest non-zero indirect register.

Figure 1

Each allocated indirect register uses 37 bytes of program memory. This is to allow room for storing a real number, a complex number, or a 2-D or 3-D vector containing 2 or 3 real numbers. It is possible to use a short program to place 3 real numbers into each indirect register, reducing the memory required by nearly 2/3. See the Indirect Registers Data Packing module for more information.

It is also possible to address the direct variables and the statistics variables indirectly using addresses of -1 through -32. Address -1 would refer to the direct variable [A], address -26 would refer to the direct variable [Z], and -27 trough -32 would refer to the statistical summation registers. This is shown in a table on page 14-22 of the HP 35s user's guide.

The way indirect addressing works is to store the number corresponding to the register you wish to use in either [I] or [J]. Then you perform a [↱] [STO] [(I)] or [↱] [STO] [(J)] (or any other allowed operation). For example, if you wish to recall a value stored in direct register [A], you can either press [RCL] [A] or store -1 into [I] by [↱] [STO] [(I)] and then perform a [RCL] [(I)]. Both will recall the value stored in A.

As an example, suppose register I contains the number 5. If you have a number in the display you wish to store and you press [↱] [STO] [(I)], then the number displayed would be stored into indirect register 5, since that is the number that was in the I register. The J register works the same way. The address to be used is stored into either I or J, and then the special [(I)] or [(J)] part of an instruction tell the HP 35s to perform the operation on the register pointed to by the value in I or J. If you attempt to recall or use a value in an indirect storage location that is not allocated, you will get an error message in the HP 35s display.

This becomes very useful is when you need to work with a lot of numbers, often within a program, or when you may not be able to know in advance where the number you wish to use is stored.

Differences from the HP 33s

On the HP 33s, a special register was used as the index for indirect operations, the register i. On the HP 35s, two registers can be used as two different indices, the variables I and J.

On the HP 33s, the variables A through Z were referenced indirectly by values placed in register i of 1 to 26 in order. On the HP 35s, the variables A through Z are referenced by values in either I or J of -1 down to -26, with -1 referencing A and -26 referencing Z. Similarly, the statistics registers were referenced indirectly on the HP 33s using values of 28 through 33. On the HP 35s, they are referenced using an index of -27 through -32. On the HP 33s the index register was itself referenced by a value of 27. Since the index registers on the HP 35s are the variables I and J, there is no specialized index register.

On the HP 35s, the indirect registers are cleared using the CLVARx function, found in the [↱] [CLEAR] menu. Press [↱] [CLEAR] [▽] and the display below will be shown. CLVARx is menu choice 6.

Figure 1

The CLVARx function prompts for a 3-digit value. The function will clear all indirect registers larger than this value – they will be set to zero. Because the HP 35s allocates indirect registers based on the highest numbered register containing a non-zero value, this will change the number of allocated indirect registers.

For example, if there are 100 indirect registers allocated, CLVARx 050 will clear and deallocate the indirect registers 50 and higher, leaving 0 through 49 available for use. CLVARx 000 would clear indirect registers 1 and higher. To clear indirect register 0, store 0 into it.

The HP 35s indirect registers provides the user with many capabilities beyond what was available with the HP 33s.

Examples using the indirect registers

Example 1: Write a short program to load indirect registers 1 through 10 with random numbers.

Solution: Press [GTO] [·] [·] and then enter the program below. Press [↱] [PRGM] and then these keystrokes:

[↱] [LBL] [A] [1] [·] [0] [1] [↱] [STO] [I] [↱] [RAND] [↱] [STO] [(I)] [↰] [ISG] [I] [GTO] [A] [0] [0] [4] [↰] [RTN]

The program will look like the one below and will have the length as shown in Figure 2. The program checksum is C289.

Figure 2

A001 LBL A
A002 1.01
A003 STO I
A004 RANDOM
A005 STO (I)
A006 ISG I
A007 GTO A004
A008 RTN

<u>Answer:</u> Run the program by pressing [XEQ] [A] [ENTER]. When the program completes, in RPN mode the last two random numbers generated will be shown while in algebraic mode, only the most recent random number will be shown in the display.

<u>Example 2:</u> Assuming that indirect registers 1 through 10 contain the random numbers generated in example 1, write a short program to sort indirect registers 1 through 10 with the smallest number found in register 1.

<u>Solution:</u> The program presented below will sort indirect registers 1 through 10 using the Bubble Sort. The program will run in either RPN mode only. Press [GTO] [.] [.] and then enter the program below. Press [↱] [PRGM] and then these keystrokes:

[↱] [LBL] [B] [1] [.] [0] [1] [↱] [STO] [I] [1] [+] [↱] [STO] [J] [↰] [FLAGS] [2] [0] [RCL] [(I)] [RCL] [(J)] [↰]
[x?y] [3] [GTO] [B] [0] [1] [8] [↰] [ISG] [I] [↰] [ISG] [J] [GTO] [B] [0] [0] [8] [↰] [FLAGS] [3] [0] [GTO]
[B] [0] [0] [2] [↰] [RTN] [↰] [FLAGS] [1] [0] [↱] [STO] [(I)] [x<>y] [↱] [STO] [(J)] [x<>y]
[GTO] [B] [0] [1] [2] [↰] [RTN]

The program will look like the one below and will have the length and checksum as shown in Figure 3. The program checksum is 5C10.

Figure 3

B001	LBL B	B013	ISG J
B002	1.01	B014	GTO B008
B003	STO I	B015	FS? 0
B004	1	B016	GTO B002
B005	+	B017	RTN
B006	STO J	B018	SF 0
B007	CF 0	B019	STO (I)
B008	RCL (I)	B020	X <> Y
B009	RCL (J)	B021	STO (J)
B010	X < Y?	B022	X <> Y
B011	GTO B018	B023	GTO B012
B012	ISG I		

<u>Answer:</u> Run the program by pressing [XEQ] [B] [ENTER]. As the program executes, the flag 0 annunciator will flash on and off as the program loops through the indirect registers making exchanges of adjacent registers when needed. When the program completes the smallest value will be in indirect register 1 and the largest value will be in indirect register 10.

<u>Example 3:</u> Jake wants a program that will loop through the numbered indirect registers to display the values stored within. Input is to be a number of the form bbb.eee, where bbb is the first indirect register to be viewed and eee is the highest to be viewed. If bbb.eee is positive, the program should PAUSE to display the contents. If bbb.eee is entered as a negative number, the program should STOP to display the value. Jake only wants a program that works in RPN mode. He also wants a program that displays the indirect register being displayed in Y and its contents shown in X.

Solution: Jake wrote the program presented below which will display the indirect registers. The program will run in RPN mode only. Press [GTO] [·] [·] and then enter the program below. Press [↱] [PRGM] and then these keystrokes:

[↱] [LBL] [C] [↱] [x?0] [3] [↰] [FLAGS] [1] [1] [↱] [ABS] [↱] [STO] [I] [RCL] [I] [↰] [INTG] [6] [RCL] [(I)]
[↰] [FLAGS] [3] [1] [R/S] [↰] [FLAGS] [3] [1] [GTO] [C] [0] [1] [4] [↱] [PSE] [↰] [ISG] [I] [GTO] [C] [0] [0]
[6] [↰] [FLAGS] [2] [1] [↰] [RTN]

The program will look like the one below and will have the length and checksum as shown in Figures 4 and 5 below.

Figure 4

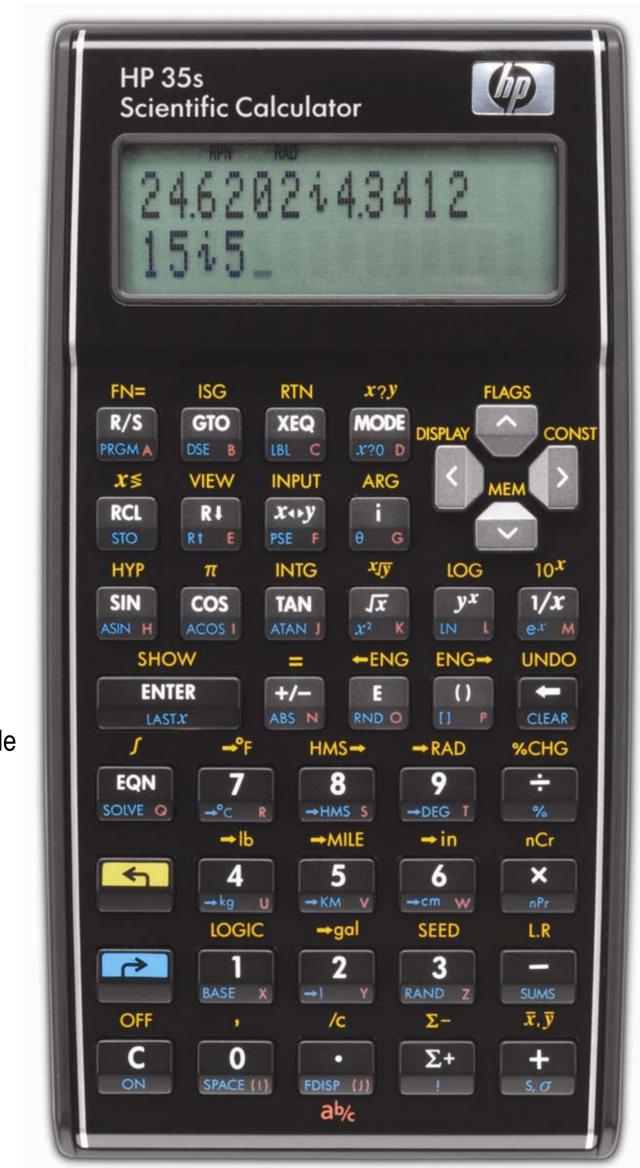
Figure 5

C001	LBL C	C010	STOP
C002	X < 0?	C011	FS? 1
C003	SF 1	C012	GTO C014
C004	ABS	C013	PSE
C005	STO I	C014	ISG I
C006	RCL I	C015	GTO C006
C007	IP	C016	CF 1
C008	RCL(I)	C017	RTN
C009	FS? 1		

Answer: Run the program by pressing [1] [·] [0] [1] [XEQ] [C] [ENTER]. Since the input was positive, the HP 35s will pause and display each value stored in indirect registers 1 through 10. To have the HP 35s stop and display the value, key in the input as a negative number. Jake now has the program he wanted. NOTE: If you specify a range of bbb.eee which goes beyond the presently allocated indirect registers, this program will produce an error message.

hp calculators

HP 35s Using Register Arithmetic



Variables and Memory Registers

Practice Examples:

Calculating Using STO Arithmetic

Calculating Using RCL Arithmetic in RPN mode

Storage Arithmetic in a Program

Variables and Memory Registers

The purpose of this training aid is to show how arithmetic can be carried out directly using HP 35s memory registers. First, the following is a short explanation of variables and registers; the same information is given in the practice aid on using calculator memories. That training aid then gives more information on the various other uses of memory registers.

When an equation is typed on the HP 35s, it can use **variables** with names from A through Z. For example an equation

$$3X^2 - 5X = A$$

has the variables X and A in it.

Variables can also be used in programs and in calculations from the keyboard.

Each variable consists of a number and of a place in the calculator memory where the number is stored.

The number is called the **value** of the variable. If no value has been give to a variable then its value is 0.

The place in memory where this number is stored is called a **data register**, or a **memory register**, or just a **register**.

Each memory register can be referred to by a numeral as well as by its name. Register A is -1 and register Z is -26. Six more registers can be referred to by numerals, holding values from statistics calculations. The names "data register" or "memory register" or "memory" refer to all of these, not just the variables, so these names are sometimes used in this training aid, rather than the name "variables."

The training aid on general uses of registers shows that numbers can be stored in registers by the STO command, and can be recalled from registers by the RCL command. This aid covers the special topic of how arithmetic can be carried out directly with memory registers using the commands STO+, STO-, STO×, STO÷, RCL+, RCL-, RCL× and RCL÷ in RPN mode and also shows alternatives that can be used in algebraic mode.

Practice Example: Calculating Using STO Arithmetic

The HP 35s provides a set of physical constants, such as the speed of light. Users who need to store other constants can put them into the memory registers so they can be used in calculations.

Example 1: A planetary scientist needs to perform several calculations using the masses of the Earth and the Moon. First the scientist wants to store the mass of the Earth in register E and of the Moon in M, in kilograms. The Earth-Moon system is sometimes called a "twin planet system" and the scientist wants to put the total mass of the Earth and the Moon in register T.

Solution: First type the Moon's mass, then press [↱] [STO] and the variable name to store the mass in that variable's memory register. Press the keys as shown below. The key labeled [E] is above the [9] on the keyboard. Typing [E] [2] [2] means "times 10 to the power 22".

[7] [.] [3] [4] [9] [E] [2] [2] [↱] [STO] [M]
(Note: In algebraic mode, press [ENTER] after the [M] above)

When [↱] [STO] is pressed, the symbol "A..Z" appears at the top of the screen. This tells the user that the next key pressed should be one of the keys with letters A to Z at their lower right, and that the corresponding letter will be used. For the letter "M", press the [1/x] key. The number is stored in M, but remains on the lower line of the screen, as shown in Figure 1 (which shows the display in algebraic mode).

Figure 1

Store the Moon's mass in register T as well, so that the Earth's mass can be added to it. The mass has already been stored in M but it is still available to be stored in T as well. Figure 2 shows the screen in algebraic mode.

[↱] [STO] [T] (Note: In algebraic mode, press [ENTER] after the [T])

Figure 2

Now type the mass of the Earth and store it in register E. To use register E, press [R↓] when the A..Z symbol is at the top of the screen. This is **not** the same as the key labeled [E] used for entering powers of 10.

[5] [.] [9] [7] [3] [6] [E] [2] [4] [↱] [STO] [E]

The mass of the Earth is now in register E and is still on the lower line of the screen. To add it to the mass of the Moon already in register T, use the STO+ command in RPN mode only.

[↱] [STO] [+] [T]

In RPN mode, this takes the number in the lower line of the display and adds it to register T. The number is still available for further use. It is still the "current number", i.e., the number is still in stack register X. Figure 3 assumes RPN mode.

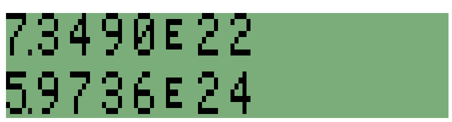


Figure 3

In algebraic mode, it is necessary to key the following to perform a STO+ equivalent. NOTE: The resulting value displayed is different in algebraic mode when compared to RPN mode. Figure 4 assumes algebraic mode.

[+] [RCL] [T] [↱] [STO] [T]

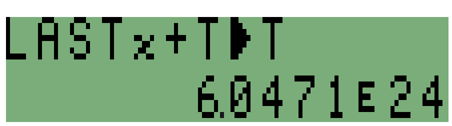


Figure 4

<u>Answer:</u> The mass of the Moon is now in register M, the mass of the Earth is in register E, and the mass of the Earth-Moon twin system is in register T. The mass of the Earth is also still in the current register, as shown in Figure 2. To confirm that the number in register T is the sum of the two masses, view register T by pressing:

[↰] [VIEW] [T]

Figure 5

In RPN mode, the STO+ command adds the current number to the register selected by its name, STO- subtracts the current number from the named register, STO× multiplies the named register by the current number and STO÷ divides the named register by the current number. In all these cases in RPN mode, the number itself is unchanged and continues to be the current number. As it has not changed, the value in the LastX register also remains unchanged.

Practice Example: Calculating Using RCL Arithmetic in RPN mode

<u>Example 2:</u> If the Earth-Moon system is called a twin system, the mass of the Moon should be fairly similar to the mass of the Earth. How do they compare?

<u>Solution:</u> The mass of the Earth is still in the current register. Recall the mass of the Moon from register M and divide it into the current register. Press these keys.

[RCL] [÷] [M]

The result of the division is now in the current register.

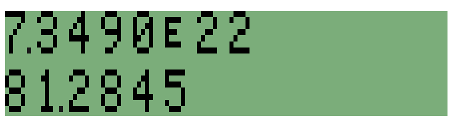


Figure 6

<u>Answer:</u> The ratio of the masses of the Earth and the Moon is about 1:81. The Moon's mass is only about 1.2% that of the Earth's, not really a twin. Nevertheless, the two are much closer in mass than any other major planet-satellite system. For example the mass of Ganymede is 0.0078% of the mass of Jupiter, and the mass of Deimos is 0.0000017% of the mass of Mars. Only Charon and Pluto are closer, with Charon having about 15% of the mass of Pluto – and not all planetary scientists are willing to consider Pluto to be a planet.

In RPN mode, when [RCL] is pressed, followed by an arithmetic operation and a letter, then the number in the chosen register is recalled and added to, subtracted from, multiplied by, or divided into, the current register. As opposed to STO arithmetic, RCL arithmetic changes the current number and leaves the stored number unchanged. Because the current number is changed, its previous value is stored in the LastX register for re-use in RPN mode.

Storage Arithmetic in a Program

As these examples show, STO and RCL arithmetic make some calculations easier to carry out. It is generally quicker to use a STO or RCL arithmetic operation rather than to RCL a number, calculate with it, and then STO the result. Quite apart from this, many users find that storage register arithmetic has important applications in programs. There are three reasons for this.

(1) Each STO or RCL instruction takes one less step in a program than STO or RCL followed by a separate arithmetic command. Saving a step in a program makes it shorter, faster and easier to read.

(2) STO arithmetic does not use the RPN stack and does not change the LastX register. This means that programs can be written to work in the same way as built-in HP 35s functions, to replace the original number with a calculated result, keep a copy of the original number in LastX, and leave the rest of the stack unchanged. Such programs can then be used like built-in functions, and can be called from other programs.

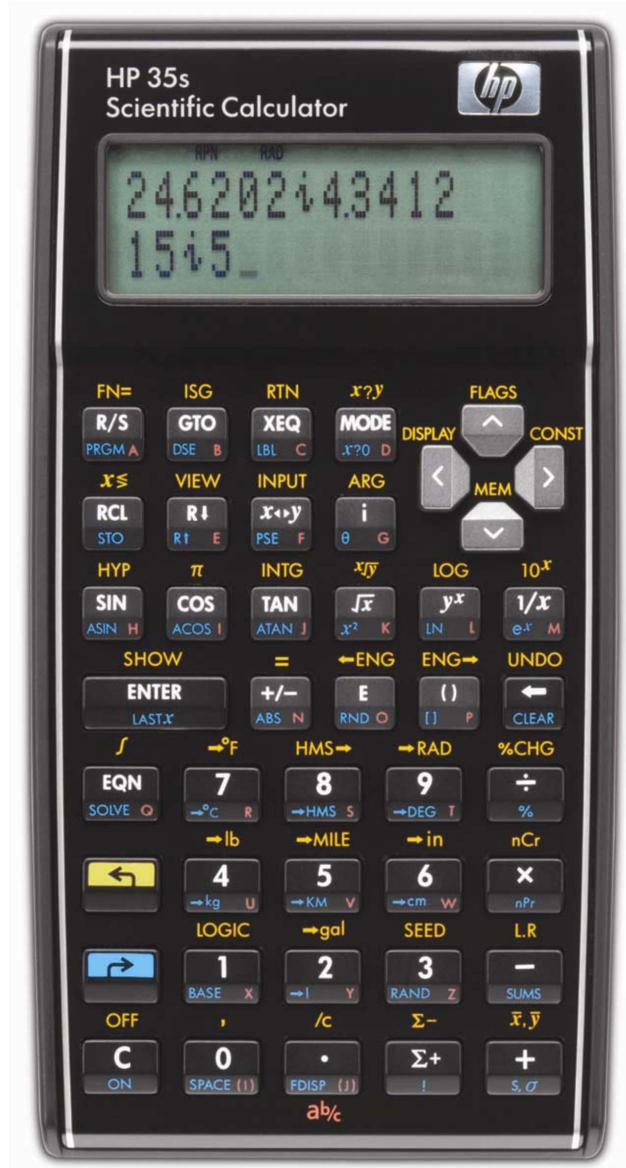
This training aid has shown how STO and RCL arithmetic can be useful in keyboard calculations and in programming. With experience, users can find many occasions where storage arithmetic on the HP 35s is a real help in their work.

hp calculators

HP 35s Using the built-in constants

The built-in constants

Practice using the built-in constants



The built-in constants

The HP 35s includes 41 physics constants built into the ↰ CONST menu. These constants remove the need to keep a table of frequently used constants handy or to look them up in a reference manual. These constants can be used when doing calculations in run mode, within a program, or within an equation. The 41 constants included are:

Speed of light in vacuum
Standard acceleration of gravity
Newtonian constant of gravitation
Molar volume of ideal gas
Avogadro constant
Rydberg constant
Elementary charge
Electron mass
Proton mass
Neutron mass
Muon mass
Boltzmann constant
Planck constant
Planck constant over 2 pi
Magnetic flux quantum
Bohr radius
Electric constant
Molar gas constant
Faraday constant
Atomic mass constant
Magnetic constant
Bohr magneton
Nuclear magneton
Proton magnetic moment
Electron magnetic moment
Neutron magnetic moment
Muon magnetic moment
Classical electron radius
Characteristic impendence of vacuum
Compton wavelength
Neutron Compton wavelength
Proton Compton wavelength
Fine structure constant
Stefan–Boltzmann constant
Celsius temperature
Standard atmosphere
Proton gyromagnetic ratio
First radiation constant
Second radiation constant
Conductance quantum
The base number e of natural logarithm

In algebraic mode, the constants are shown as the corresponding symbol. In RPN mode, when doing calculations manually, the constants are shown as their numeric values. In either mode, the constants are shown as their corresponding symbol when in equation mode or within a program.

The HP 35s displays between 4 to 6 constants on the screen, depending on which "page" of the constant menu is being viewed. The first two pages are shown in example 1 below. To move from one page to the next, you can press ∨ to move down a page or ∧ to move up a page. To move across a page, press > to move right and < to move left. Once you are on the page, you can select a constant by pressing the numeric key indicating its position on the page, with 1 selecting the first constant shown, 2 the second, etc.

Practice using the built-in constants

Example 1: What is the ratio of a proton's mass to an electron's mass?

Solution: These constants are on the second displayed page of constants. The first page looks like this:

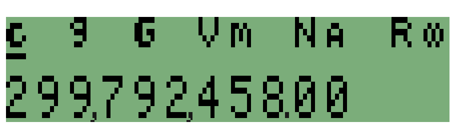


Figure 1

The second page looks like this. To move from one page to the next, you can press [⌄] to move down a page or [⌃] to move up a page.

Figure 2

In RPN mode, press: [↰] [CONST] [⌄] [>] [>] [ENTER] [↰] [CONST] [⌄] [>] [ENTER]

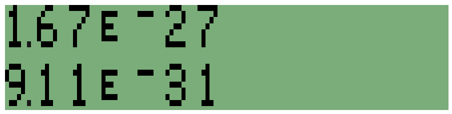


Figure 3

The display is now showing the two mass values. Press [÷] to compute the ratio.

Figure 4

In algebraic mode, press: [↰] [CONST] [⌄] [>] [>] [ENTER] [÷] [↰] [CONST] [⌄] [>] [ENTER] [ENTER]

Figure 5

<u>Answer</u>: The proton is approximately 1836 times more massive than an electron.

<u>Example 2:</u> A space probe is traveling at 50,000 miles per hour. How many times faster would it have to travel to reach 10% of the speed of light?

<u>Solution:</u> In RPN mode, press:

[↰] [CONST] [ENTER] [1] [0] [÷]

Now convert the space probe's speed to miles per second.

[5] [0] [0] [0] [0] [ENTER] [6] [0] [÷] [6] [0] [÷]

Now compute the number of times faster the probe would have to travel to reach 10% of the speed of light by dividing the two values.

[÷]

In algebraic mode, press:

[( )] [↰] [CONST] [ENTER] [÷] [1] [0] [>] [÷]

Now convert the space probe's speed to miles per second.

[( )] [5] [0] [0] [0] [0] [÷] [6] [0] [÷] [6] [0]

Now compute the number of times faster the probe would have to travel to reach 10% of the speed of light by pressing:

[ENTER]

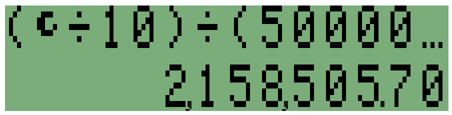
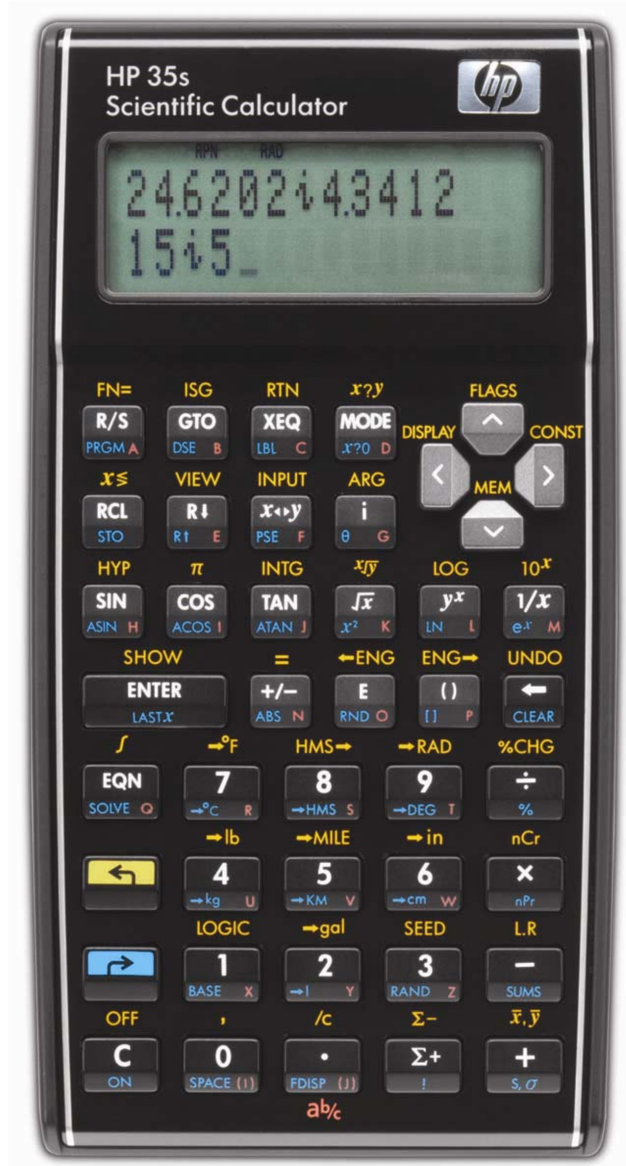


Figure 6

Answer: The space probe would have to travel over two million times faster than its present speed to reach 10% of the speed of light. Figure 6 shows the result in algebraic mode.

hp calculators

HP 35s Averages and standard deviations



Averages and standard deviations

Practice solving problems involving averages and standard deviations

Averages and standard deviations

The average is defined as the sum of all data points divided by the number of data points included. It is a measure of central tendency and is the most commonly used. A standard deviation is a measure of dispersion around a central value. To compute the standard deviation, the sum of the squared differences between each individual data point and the average of all the data points is taken and then divided by the number of data points included (or, in the case of sample data, the number of data points included minus one). The square root of this value is then taken to obtain the standard deviation. The property of the standard deviation is such that when the underlying data is normally distributed, approximately 68% of all values will lie within one standard deviation on either side of the mean and approximately 95% of all values will lie within two standard deviations on either side of the mean. This has application to many fields, particularly when trying to decide if an observed value is unusual by being significantly different from the mean.

On the HP 35s, values are entered into the statistical / summation registers by keying in the number (or pair of numbers) desired and pressing [Σ+]. This process is repeated for all numbers or pair of numbers. When entering a pair of numbers in RPN or algebraic mode, key the Y value, press [ENTER], then key the X value and press [Σ+].

To view the mean, press [↰] [x̄,ȳ]. To view the standard deviation, press [↱] [S,σ]. When either of these is pressed, the HP 35s displays a menu of possible values. Items on this menu are viewed by pressing the [<] or [>] parts of the cursor keys at the top of the HP 35s.

To use a value displayed on the menu, press the [ENTER] button and the value will be copied for further use. This is illustrated in the problems below.

Practice solving problems involving averages and standard deviations

Example 1: The sales price of the last 10 homes sold in the Parkdale community were: $198,000; $185,000; $205,200;$225,300; $206,700; $201,850; $200,000; $189,000; $192,100; $200,400. What is the average of these sales prices and what is the sample standard deviation? Would a sales price of $240,000 be considered unusual in the same community?

Solution: Be sure to clear the statistics / summation memories before starting the problem.

[↱] [CLEAR] [4]

The keystrokes are the same whether in RPN or algebraic mode:

[1] [9] [8] [0] [0] [0] [Σ+] [1] [8] [5] [0] [0] [0] [Σ+] [2] [0] [5] [2] [0] [0] [Σ+]
[2] [2] [5] [3] [0] [0] [Σ+] [2] [0] [6] [7] [0] [0] [Σ+] [2] [0] [1] [8] [5] [0] [Σ+]
[2] [0] [0] [0] [0] [0] [Σ+] [1] [8] [9] [0] [0] [0] [Σ+] [1] [9] [2] [1] [0] [0] [Σ+]
[2] [0] [0] [4] [0] [0] [Σ+]

To find the average, press: [↰] [x̄,ȳ]. Figure 1 displays the menu shown.

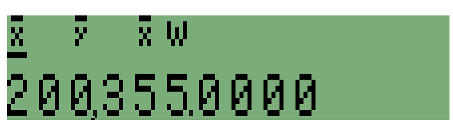


Figure 1

To find the sample standard deviation, press: [↱] [S,σ]. Figure 2 displays the menu shown.

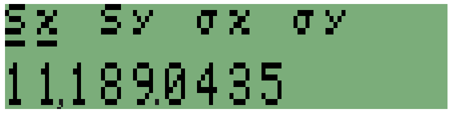


Figure 2

To find the value two standard deviations above and below the average, press the following:

In RPN mode:

[↱] [S,σ] [ENTER] [2] [×] [ENTER] [ENTER] [↰] [$\bar{x},\bar{y}$] [ENTER] [+] [x↔y] [↱] [LASTx] [x↔y] [−]

In algebraic mode:

[↱] [S,σ] [ENTER] [×] [2] [+] [↰] [$\bar{x},\bar{y}$] [ENTER] [ENTER] (computes the above value)
[↰] [$\bar{x},\bar{y}$] [ENTER] [−] [2] [×] [↱] [S,σ] [ENTER] [ENTER] (computes the below value)

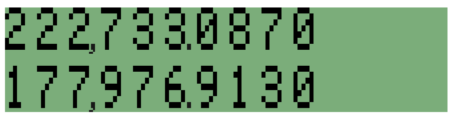


Figure 3

Answer: The average sales price is $200,355 and the sample standard deviation is $11,189. Within two standard deviations on either side of this average, in this case between $177,977 and $222,733, 95% of all home sales prices should fall. If a home were to sell for $240,000 in this area, it would be an unusual event. Figure 3 indicates the display in RPN mode.

Example 2: The table below indicates the high and low temperatures for a winter week in Fairbanks, Alaska. What are the average high and low temperatures for this week?

	Sun	Mon	Tues	Wed	Thurs	Fri	Sat
High	6	11	14	12	5	-2	-9
Low	-22	-17	-15	-9	-24	-29	-35

Solution: Be sure to clear the statistics / summation memories before starting the problem.

[↱] [CLEAR] [4]

In either RPN or algebraic mode:

[2] [2] [+/−] [ENTER] [6] [Σ+] [1] [7] [+/−] [ENTER] [1] [1] [Σ+] [1] [5] [+/−] [ENTER] [1] [4] [Σ+]
[9] [+/−] [ENTER] [1] [2] [Σ+] [2] [4] [+/−] [ENTER] [5] [Σ+] [2] [9] [+/−] [ENTER] [2] [+/−] [Σ+]
[3] [5] [+/−] [ENTER] [9] [+/−] [Σ+]

To find the average high temperature, press: [↰] [$\bar{x},\bar{y}$]. Figure 4 displays the menu shown.

Figure 4

To find the average low temperature, press: [▷]. Figure 5 displays the menu shown.

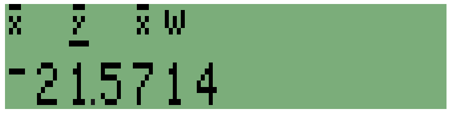


Figure 5

Answer: The average high temperature that week was 5.29 degrees and the average low temperature was –21.57 degrees.

Example 3: John has bought gas on his driving trip at four gasoline stations as follows: 15 gallons at $1.56 per gallon, 7 gallons at $1.64 per gallon, 10 gallons at $1.70 per gallon and 17 gallons at $1.58 per gallon. What is the average price of the gasoline purchased?

Solution: The HP 35s has a weighted average mean calculation built-in that will solve this problem easily. Be sure to clear the statistics / summation memories before starting the problem.

[right-shift] [CLEAR] [4]

In RPN or algebraic mode:

[1] [5] [ENTER] [1] [.] [5] [6] [Σ+] [7] [ENTER] [1] [.] [6] [4] [Σ+] [1] [0] [ENTER] [1] [.] [7] [Σ+] [1] [7] [ENTER] [1] [.] [5] [8] [Σ+]

To find the weighted average price of gasoline purchased, press: [left-shift] [x̄,ȳ] [>] [>]. Figure 6 displays the menu shown.

Figure 6

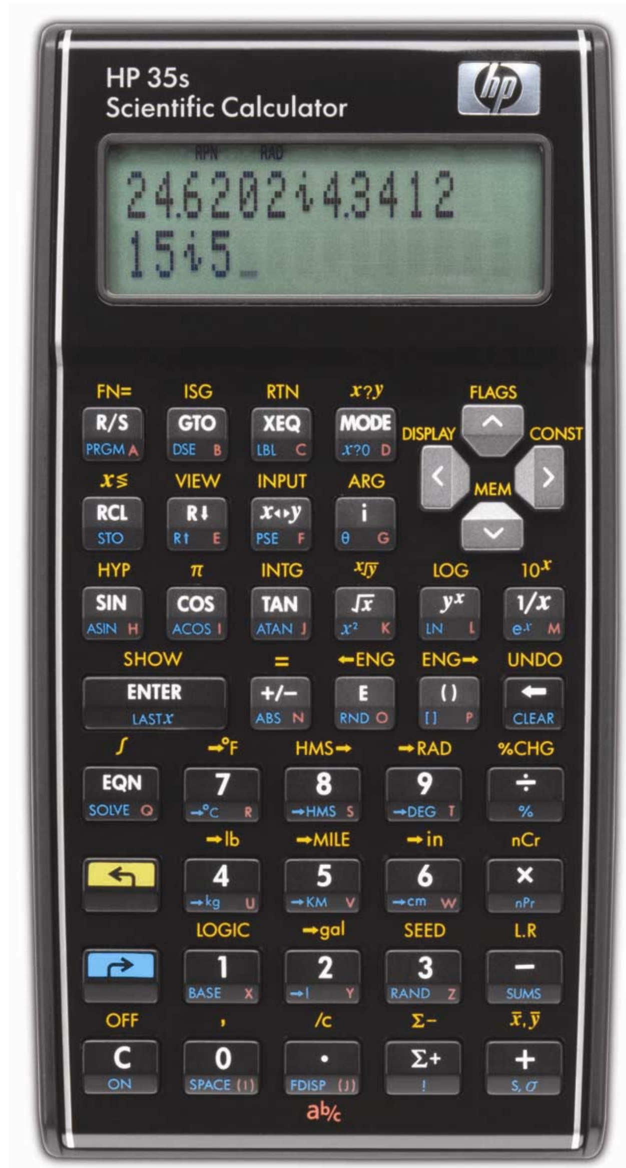
Answer: The average price per gallon John has paid on his trip is slightly less than $1.61.

hp calculators

HP 35s Probability – Rearranging items

Rearranging items

Practice solving problems involving factorials, permutations, and combinations



Rearranging items

There are a great number of applications that involve determining the number of ways a group of items can be rearranged. The factorial function, accessed by pressing [↱] [!] (which is the right-shifted function of the [Σ+] key) on the 35s, will determine the number of ways you can rearrange the total number of items in a group. Note that the 35s will interpret the factorial function as the gamma function if the argument for the function is a non-integer real number. The permutation function, accessed by pressing [↱] [nPr] (which is the right-shifted function of the [×] key), will return the number of ways you can select a subgroup of a specified number of items from a larger group, where the order of each of the items in the subgroup is important. The combination function, accessed by pressing [↰] [nCr] (which is the left-shifted function of the [×] key), will return the number of ways you can select a subgroup of a specified number of items from a larger group, where the order of each of the items in the subgroup is not important.

To see the difference between permutations and combinations, consider the set of three items A, B, and C. If we select a subgroup of 2 items, we could select AC and CA as two possible subgroups. These would be counted as different subgroups if computing the number of permutations, but only as one subgroup if computing the number of combinations. Note that the factorial function operates the same in algebraic mode as it does in RPN mode. The number is keyed in and then the factorial function is selected from the keyboard. For permutations and combinations in RPN mode, the two numbers must be entered into the first two levels of the stack and then the function is selected from the keyboard. In algebraic mode, permutations and combinations require the function to be selected, then the first number to be keyed in and then the second number keyed in followed separated from the first by a 35s supplied comma followed by pressing the [ENTER] key to evaluate the function.

Factorials show up throughout mathematics and statistics. Permutations and combinations show up in many discrete probability distribution calculations, such as the binomial and hypergeometric distributions.

Practice solving problems involving factorials, permutations, and combinations

Example 1: How many different ways could 4 people be seated at a table?

Solution: In RPN or algebraic mode: [4] [↱] [!]

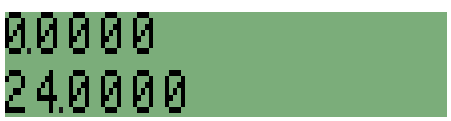


Figure 1

Answer: 24. Figure 1 shows the display assuming RPN mode.

Example 2: How many different hands of 5 cards could be dealt from a standard deck of 52 cards? Assume the order of the cards in the hand does not matter.

Solution: Since the order of the cards in the hand does not matter, the problem is solved as a Combination.

In RPN mode: [5] [2] [ENTER] [5] [↰] [nCr]

In algebraic mode: [↰] [nCr] [5] [2] [>] [5] [ENTER]

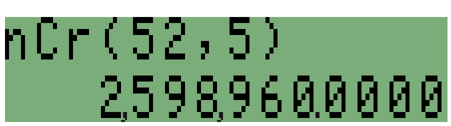


Figure 2

Answer: 2,598,960 different hands. Figure 2 shows the display assuming algebraic mode.

Example 3: John has had a difficult week at work and is standing in front of the doughnut display at the local grocery store. He is trying to determine the number of ways he can fill his bag with his 5 doughnuts from the 20 varieties in the display case. He considers the order in which the doughnuts are placed into the bag to be unimportant. How many different ways can he put them in his bag?

Solution: Since the order in which the doughnuts are placed in the bag does not matter, the problem is solved as a combination.

In RPN mode: [2] [0] [ENTER] [5] [↰] [nCr]

In algebraic mode: [↰] [nCr] [2] [0] [>] [5] [ENTER]

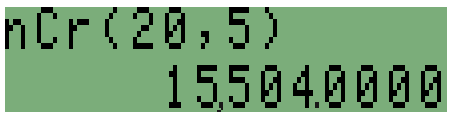


Figure 3

Answer: 15,504 different ways. Figure 3 shows the display assuming RPN mode.

Example 4: John has had a difficult week at work and is standing in front of the doughnut display at the local grocery store. He is trying to determine the number of ways he can fill his bag with his 5 doughnuts from the 20 varieties in the display case. He considers the order in which the doughnuts are placed into the bag to be quite important. How many different ways can he put them in his bag?

Solution: Since the order in which the doughnuts are placed in the bag matters, the problem is solved as a permutation.

In RPN mode: [2] [0] [ENTER] [5] [↱] [nPr]

In algebraic mode: [↱] [nPr] [2] [0] [>] [5] [ENTER]

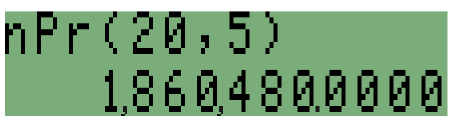


Figure 4

Answer: 1,860,480 different ways. John may be in front of the display case for some time. Figure 4 shows the display assuming algebraic mode.

Example 5: If you flip a coin 10 times, what is the probability that it comes up tails exactly 4 times?

Solution: This is an example of the binomial probability distribution. The formula to find the answer is given by:

$$P(X)=nCx\cdot p^{X}\cdot(1-p)^{(n-X)}$$

Figure 5

where P(X) is the probability of having X successes observed, nCx is the combination of n items taken x at a time, and p is the probability of a success on each trial.

In RPN mode: [1] [0] [ENTER] [4] [↰] [nCr] [0] [·] [5] [ENTER] [4] [y^x] [×] [1] [ENTER] [0] [·] [5] [−] [1] [0] [ENTER] [4] [−] [y^x] [×]

In algebraic mode: [↰] [nCr] [1] [0] [>] [4] [>] [×] [0] [·] [5] [y^x] [4] [×] [( )] [1] [−] [0] [·] [5] [>] [y^x] [( )] [1] [0] [−] [4] [ENTER]

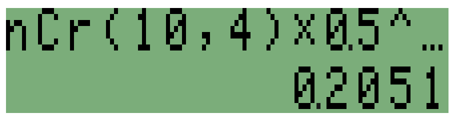


Figure 6

<u>Answer:</u> If you flip a coin 10 times, there is a 20.51% chance of seeing heads 4 times. Figure 6 indicates the display if solved in algebraic mode.

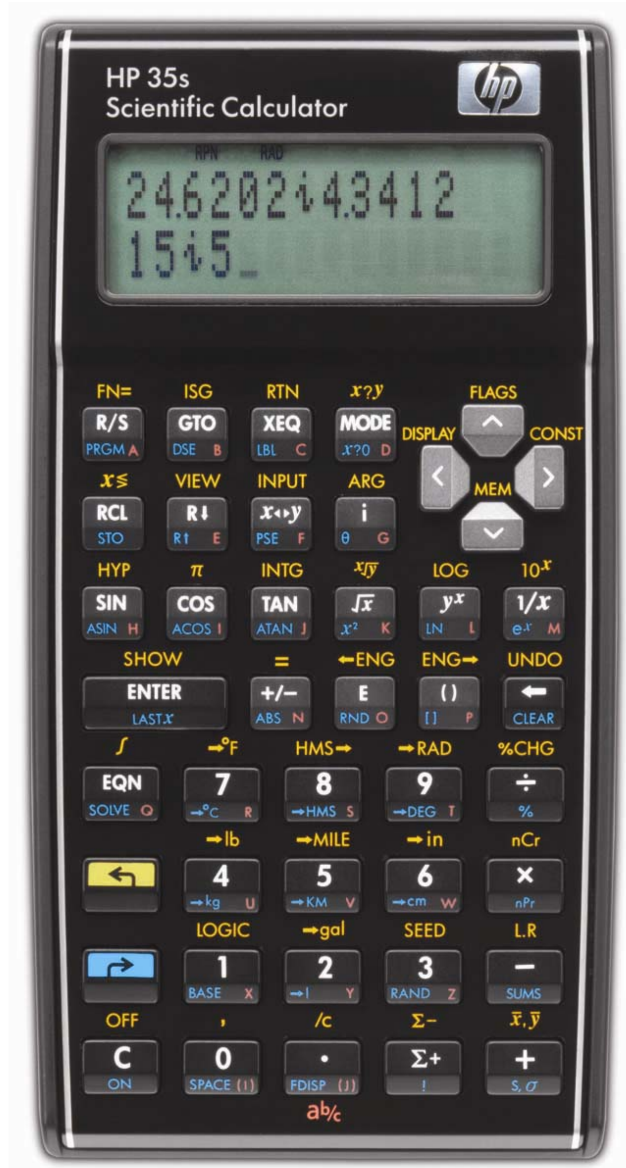
hp calculators

HP 35s Normal distribution applications

The normal distribution

Entering the normal distribution program

Practice solving problems involving the normal distribution



The normal distribution

The normal distribution is frequently used to model the behavior of random variation about a mean. This model assumes that the sample distribution is symmetric about the mean, M, with a standard deviation, S, and generates the shape of the familiar bell curve. A standardized normal distribution has a mean of 0 and a standard deviation of 1. This results in the familiar Z value used in normal distribution problems to signify the number of standard deviations above or below the mean a particular observation falls. It is computed using the formula shown below.

$$Z = \frac{X - \mu}{\sigma}$$

Figure 1

where X is the observation, μ is the mean and σ is the standard deviation. Z is often called a Z-score.

Entering the normal distribution program

Solving problems involving the normal distribution requires the entry of the program below into the HP 35s calculator. This program can be found in chapter 16 of the HP 35s RPN/ALG Scientific Calculator Owner's Manual.

Given a value x, this program calculates the probability that a random selection from the sample data will have a higher value. This is known as the upper tail area, Q(x). This program also provides the inverse: given a value Q(x), the program calculates the corresponding value x. This program uses the built–in integration feature of the HP 35s to integrate the equation of the normal frequency curve. The inverse is obtained using Newton's method to iteratively search for a value of x which yields the given probability Q(x). The program as listed will work in RPN mode only and that mode is assumed throughout this training aid.

After each label's section in the program listing below, the checksum and length are displayed in parentheses to the right of the page. These should match what you see on your HP 35s if you have entered the program correctly. To see each checksum once you have completely entered the program below, while still in program mode, press [↰] [MEM] [→] [ENTER] [↰] [SHOW]. Pressing [↓] will scroll down through each label in the program showing its length. To see each checksum, press [↰] [SHOW] when each label is displayed. For example, in the listing below, the (70BF – 26) indicates a checksum of 70BF and a length of 26 bytes.

In RPN mode, press the following keys to prepare for entry of the program (**WARNING:** Doing this will erase all of program memory):

[↱] [PRGM] [↱] [CLEAR] [3] [←] [ENTER]

Once this is done, key in the following program:

[↱] [LBL] [S] [0] [↱] [STO] [M] [↰] [INPUT] [M] [1] [↱] [STO] [S] [↰] [INPUT] [S] [↰] [RTN] (70BF – 26)
[↱] [LBL] [D] [↰] [INPUT] [X] [XEQ] [Q] [ENTER] [↱] [STO] [Q] [↰] [VIEW] [Q] [GTO] [D] [ENTER] (042A – 18)
[↱] [LBL] [I] [↰] [INPUT] [Q] [RCL] [M] [↱] [STO] [X] (A970 – 12)
[↱] [LBL] [T] [XEQ] [Q] [ENTER] [RCL] [−] [Q] [RCL] [X] [↱] [STO] [D] [R↓] [XEQ] [F] [ENTER] [RCL] [÷] [T]
[÷] [↱] [STO] [+] [X] [↱] [ABS] [0] [.] [0] [0] [0] [1] [↰] [$x?y$] [3] [GTO] [T] [ENTER] [RCL] [X]
[↰] [VIEW] [X] [GTO] [I] [ENTER] (EDF4 – 57)
[↱] [LBL] [Q] [RCL] [M] [RCL] [X] [↰] [FN=] [F] [↰] [∫] [D] [2] [↰] [π] [×] [$\sqrt{x}$] [RCL] [×] [S] [↱] [STO] [T]
[÷] [+/−] [0] [.] [5] [+] [↰] [RTN] (8387 – 52)
[↱] [LBL] [F] [RCL] [D] [RCL] [−] [M] [RCL] [÷] [S] [↱] [x^2] [2] [÷] [+/−] [↱] [e^x] [↰] [RTN] (B3EB – 31)

Press [↱] [PRGM] to exit program mode. You are now ready to work the following examples.

Practice solving problems involving the normal distribution

Example 1: Find Q(x) for a Z value of +1. Make sure the HP 35s is in RPN mode.

Solution: With the input value given as a Z-score, we're dealing with the standardized normal distribution having a mean of 0 and a standard deviation of 1. Press [MODE] [5] to enter RPN mode.

In RPN mode: [XEQ] [S] [ENTER]

Figure 2

Since we are dealing with a standardized normal distribution, the mean should stay equal to 0.

In RPN mode: [R/S]

Figure 3

Since we are dealing with a standardized normal distribution, the standard deviation is equal to 1.

In RPN mode: [R/S]

Now, calculate Q(x) for an x value of 1 by pressing:

In RPN mode: [XEQ] [D] [ENTER]

Figure 4

In RPN mode: [1] [R/S]

Figure 5

Answer: The upper tail probability for the standardized normal distribution with a value of x equal to +1 is 0.1587. This means that only 15.87% of all values would be larger than a Z-score of +1.

Example 2: Find Q(x) for a Z value of -1. Make sure the HP 35s is in RPN mode.

Solution: With the input value given as a Z-score, we're dealing with the standardized normal distribution having a mean of 0 and a standard deviation of 1. Press [MODE] [5] to enter RPN mode.

In RPN mode: [XEQ] [S] [ENTER]

Figure 6

Since we are dealing with a standardized normal distribution, the mean should stay equal to 0.

In RPN mode: [R/S]

Figure 7

Since we are dealing with a standardized normal distribution, the standard deviation is 1.

In RPN mode: [R/S]

Now, calculate Q(x) for an x value of –1 by pressing:

In RPN mode: [XEQ] [D] [ENTER] (Note: If example 2 is done right after example 1, then figure 4 will show a prompt of 1 rather than the zero shown)

Figure 8

In RPN mode: [1] [+/-] [R/S]

Figure 9

<u>Answer:</u> The upper tail probability for the standardized normal distribution with a value of x equal to -1 is 0.8413. This means that 84.13% of all values would be larger than a Z-score of –1. Conversely, 15.87% of all values would be smaller than a Z-score of –1.

<u>Example 3:</u> The average number of claims processed per hour by an insurance adjuster is 15 with a standard deviation of 4 and follows the normal distribution. If an adjuster processes 20 claims per hour, what percentage of adjusters is this person performing faster than?

<u>Solution:</u> This is a normal distribution problem where the input is not standardized. Press [MODE] [5] to enter RPN mode. Then execute label S and enter the mean and standard deviation.

In RPN mode: [XEQ] [S] [ENTER] [1] [5] [R/S] [4] [R/S]

Now execute label D and enter the value of x for which we wish to compute the value of Q(x).

In RPN mode: [XEQ] [D] [ENTER] [2] [0] [R/S]

Figure 10

Answer: The upper tail probability with a value of x equal to 20 is 0.1056. This means that 10.56% of all insurance adjusters would be performing faster than the individual under consideration. The person being considered is nearly in the top 10%.

Example 4: Find x given a Q(x) of 0.65. Assume a standardized normal distribution. Make sure the HP 35s is in RPN mode.

Solution: With the input value given as a Q(x) probability, we'll need to execute label I which will determine the appropriate value for x. Since this is a standardized normal distribution, execute label S first and enter values of 0 for the mean and 1 for the standard deviation. Press [MODE] [5] to enter RPN mode.

In RPN mode: [XEQ] [S] [ENTER] [0] [R/S] [1] [R/S]

Now execute label I and enter the value for Q(x). Note that the previous value computed for Q(x) is displayed at the prompt.

In RPN mode: [XEQ] [I] [ENTER] [0] [.] [6] [5] [R/S]

Figure 11

Answer: The value of x for which the upper tail probability is equal to 0.65 is –0.3853. Since the normal distribution is symmetrical around the mean, 50% of the area / probability will be above the mean and 50% will be below the mean. In this example, since we were looking for a value of x for which upper tail probability would be 65%, the value of x would be have to be less than 0.

Example 5: The average number of claims processed per hour by an insurance adjuster is 15 with a standard deviation of 4 and follows the normal distribution. Within what range, evenly distributed on either side of the average, would you expect to find 50% of the adjusters performing?

Solution: With the input value given as a Q(x) probability, we'll need to execute label I which will determine the appropriate value for x. Since this is a not a standardized normal distribution, execute label S first and enter values of 15 for the mean and 4 for the standard deviation. Press [MODE] [5] to enter RPN mode.
In RPN mode: [XEQ] [S] [ENTER] [1] [5] [R/S] [4] [R/S]

Now execute label I and enter the value for Q(x). Note that the previous value computed for Q(x) is displayed at the prompt.

In RPN mode: [XEQ] [I] [ENTER]

We're looking for a range within which 50% of the probability falls that is evenly spread around the average. Since the normal distribution is symmetrical, this means that 25% would be below the mean and 25% would be above the mean. The input values for Q(x), however, are upper tail probabilities. This means the values of Q(x) that need to be input will be 0.75 and 0.25.

In RPN mode: [0] [.] [2] [5] [R/S]

Figure 14

In RPN mode: [XEQ] [I] [ENTER] [0] [.] [7] [5] [R/S]

Figure 15

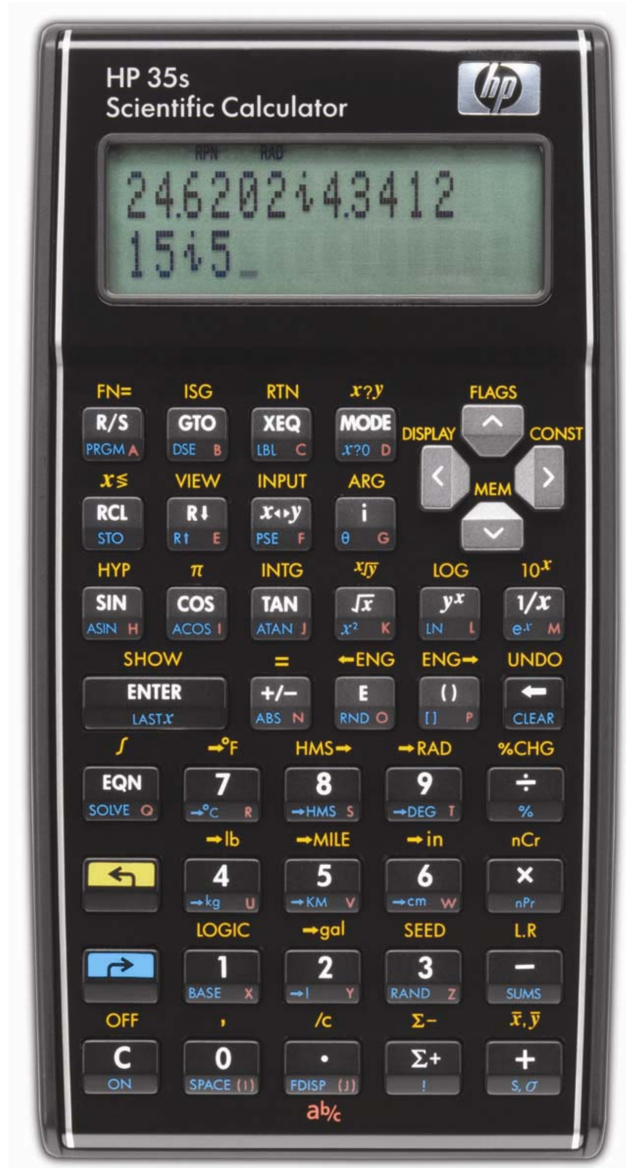
Answer: The middle 50% of the adjusters would average processing between 12.3020 and 17.6980 claims per hour.

hp calculators

HP 35s Linear Regression

Linear Regression

Practice solving linear regression problems



Linear Regression

Linear regression calculates the equation for a line that "best fits" a set of ordered pairs by minimizing the sum of the squared residuals between the actual data points and the predicted data points using the estimated line's slope and intercept. The equation of the line produced by linear regression is in the form Y = mX + b, where m is the slope of the line and b is the Y-intercept. Once the slope and intercept have been calculated, it is fairly easy to substitute other values for X and predict a corresponding value for Y, or to substitute a value for Y and predict a value for X. When the X value is a measure of time (months or years, for example), the equation is specifically referred to as a trend line.

On the HP 35s, values are entered into the statistical / summation registers by keying in the number (or pair of numbers) desired and pressing [Σ+]. This process is repeated for all numbers or pair of numbers. When entering a pair of numbers in RPN or algebraic mode, key the Y value, press [ENTER], then key the X value and press [Σ+].

To view the linear regression results, press [↰] [L.R.]. The HP 35s displays a menu of relevant values. Items on this menu are viewed by pressing the [<] or [>] cursor keys of the HP 35s.

This menu allows you to predict a value for X given a Y value, or predict a value for Y given an X value. It also displays the linear regression line's correlation, slope, and y-intercept. The correlation will always be between –1 and +1, where values closer to –1 and +1 indicating a good "fit" of the line to the data. Values nearer to zero indicate little to no "fit." Little reliance should be placed upon predictions made where the correlation is not near –1 or +1. Exactly how far away from these values the correlation can be and the equation still be considered a good predictor is a matter of debate. To use a value displayed on the menu, press the [ENTER] button and the value will be copied for further use. This is illustrated in the problems below.

Practice solving linear regression problems

Example 1: What is the slope and y-intercept of the line that best fits the points (0,4), (2,5) and (3,6)?

Solution: Be sure to clear the statistics / summation memories before starting the problem.

[↱] [CLEAR] [4]

In RPN or algebraic mode:

[4] [ENTER] [1] [Σ+] [5] [ENTER] [2] [Σ+] [6] [ENTER] [3] [Σ+]

To view the linear regression results, press [↰] [L.R.]. Figure 1 displays the menu shown.

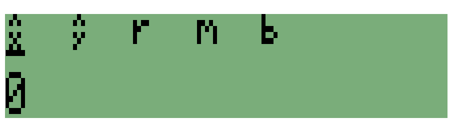


Figure 1

In either RPN or algebraic mode, press: [>] [>] [>] to view the slope.

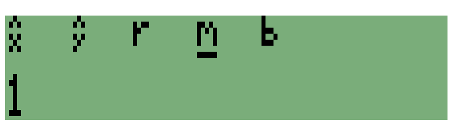


Figure 2

In either RPN or algebraic mode, press: [>] to view the y-intercept.

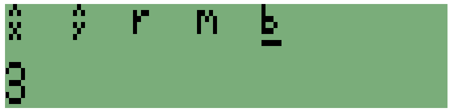


Figure 3

Answer: The slope of the line is 1 and the y-intercept is 3. The linear regression equation is Y = 1 X + 3.

Example 2: What is the slope and y-intercept of the line that best fits the points (2,5), (4,10), (6,20), and (9,25)? What is the correlation? Is the linear regression line a good fit to the data points?

Solution: Be sure to clear the statistics / summation memories before starting the problem.

[↱] [CLEAR] [4]

In RPN or algebraic mode:

[5] [ENTER] [2] [Σ+] [1] [0] [ENTER] [4] [Σ+] [2] [0] [ENTER] [6] [Σ+] [2] [5] [ENTER] [9] [Σ+]

To view the linear regression results, press [↰] [L.R.]. Figure 4 displays the menu shown.

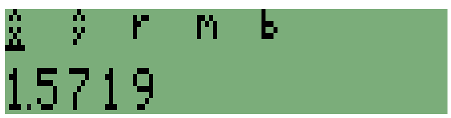


Figure 4

In either RPN or algebraic mode, press: [>] [>] [>] to view the slope.

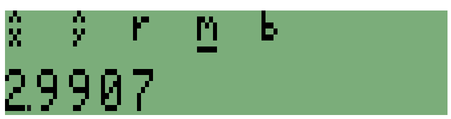


Figure 5

In either RPN or algebraic mode, press: [>] to view the y-intercept.

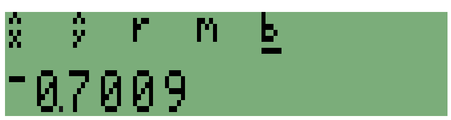


Figure 6

In either RPN or algebraic mode, press: [<] [<] to view the correlation.

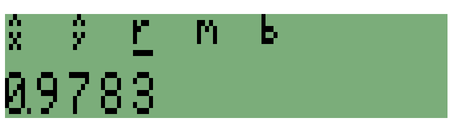
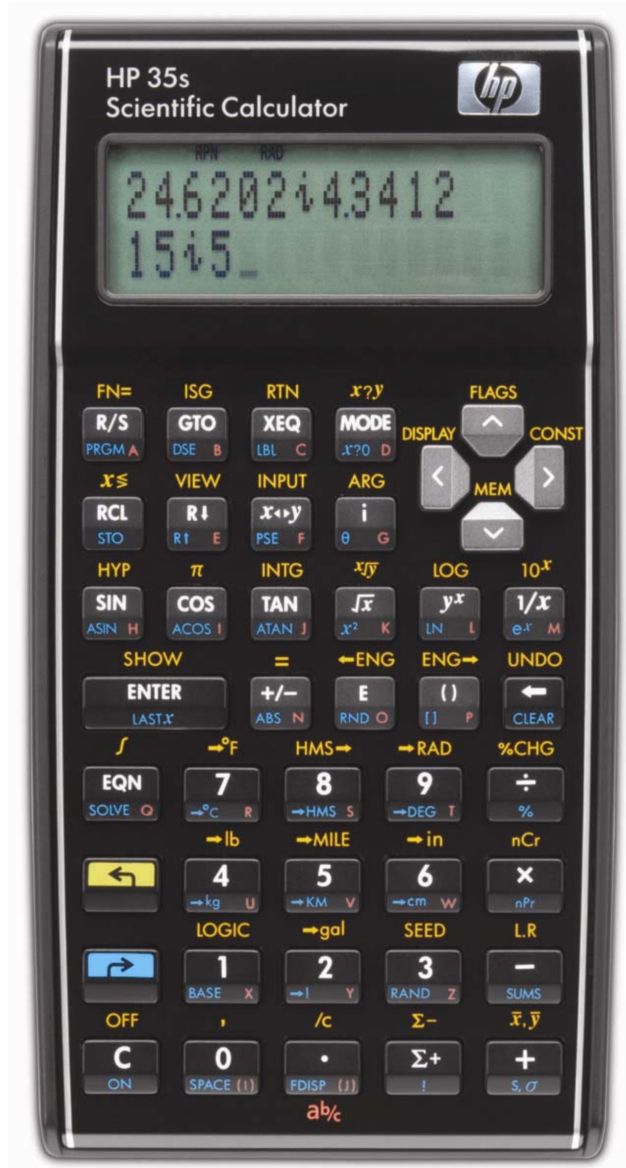


Figure 7

Answer: The slope of the line is 2.991 and the y-intercept is –0.701. The linear regression equation is Y = 2.991 X – 0.701. The correlation value of 0.9783 indicates a very good fit of the linear regression line to the data points. It is a "good fit".

hp calculators

HP 35s Working with Fractions



Simple Examples Using Fractions

Fractions in Programs and Equations

Exact Control of Fraction Display

Simple Examples Using Fractions

The HP 35s allows the user to enter numbers as fractions of the form "a b/c", to view results as fractions, and to control the way fractions are displayed. The symbol "a b/c" is written below the decimal point on the keyboard as a reminder that this key is used for most operations with fractions. Four simple examples will show the basics.

<u>Example 1:</u> Add 1 ¾ to 2 ⅝

<u>Solution:</u> The decimal point is used for fraction entry as follows.

In RPN mode, type the number 1 and press the decimal point key to separate the fractional part from the integer part. Then type 3, and the calculator will display 1.3. Press the decimal point key again and the calculator will recognize that a fraction is being entered. Press the number 4 and the calculator will display the fraction, as in Figure 1.

Figure 1

Now press then press the [ENTER] key, then type the number 2 ⅝ in the same way. Finally add the two. The keystrokes for the whole calculation are as below.

[1] [.] [3] [.] [4] [ENTER] [2] [.] [5] [.] [8] [+]

Figure 2

In algebraic mode, enter the numbers in the same way, but press the plus key between the two numbers.

[1] [.] [3] [.] [4] [+] [2] [.] [5] [.] [8] [ENTER]

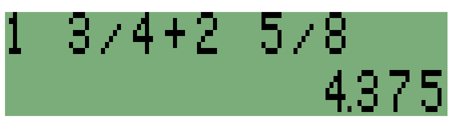


Figure 3

<u>Answer</u>: The result is 4 ⅜ and is displayed as a decimal number; the HP 35s recognizes numbers that are entered as fractions, but displays numbers as decimals unless told to display them as fractions.

<u>Example 2:</u> Display the result of the above calculation as a fraction.

<u>Solution:</u> Both in RPN mode and in algebraic mode, press [FDISP] for fractional display of numbers.

[FDISP]

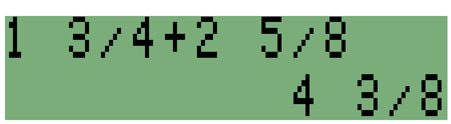


Figure 4

Answer: The result, 4 ⅜ is now displayed as a fraction; the display of Figure 3 will change to that in Figure 4. [FDISP] is on the front of the decimal point key, which is also used for entering fractions.

Example 3: Display the result using only halves, thirds or quarters.

Solution: The [/c] key allows the user to select the largest value allowable for the "/c" part of a fraction "a b/c". If the number 4 is stored in [/c] then only fractions with 2, 3 or 4 on the lower part (the denominator) will be displayed.

In RPN mode, type 4 and then press [↰] [/c] to see the previous result displayed as a fraction using only halves, thirds, or quarters.

[4] [↰] [/c]

Figure 5

The number 4 3/8 is displayed, rounded to 4 1/3.

Answer: If the fraction ⅜ must be approximated as the nearest fraction with 2, 3 or 4 in the denominator, then the closest value is 1/3. A small up-arrow symbol is shown at the right of the display, informing the user that the real answer is slightly larger than the answer displayed. The number 4 1/3 is 4.33333333333 to the accuracy of the HP 35s, but the true number is 4 3/8, or 4.375 exactly. To show the exact value, [↰] [SHOW] must be pressed. Like [FDISP], [/c] is above the decimal point key, which is also used for entering fractions.

Example 4: Round the actual result to be the result displayed.

Solution: As the example above showed, the value is not altered when the fraction display is changed. [FDISP] is a display mode, much like FIX or ENG, which also change the way a number is displayed, but not its true value. To change the true value to be as close as possible to that displayed, the RND (number round) command must be used.

Type [↱] [RND] to round the result to the decimal representation of the fraction being displayed. Do not confuse [RND] with the [RAND] (random number) command.

[↱] [RND]

Figure 6

Answer: Pressing [↰] [SHOW] shows that the decimal value has been rounded to 4.33333333333, which is the closest possible value to 4 1/3.

The small arrow now points down, to show that the exact decimal value is smaller than the fraction displayed. This is because 4.33333333333 is just smaller than 4 1/3.

To restore [/c] to its largest possible value, press [0] [↰] [/c]. The largest possible value is 4095.

To stop showing numbers as fractions, press [↱] [FDISP] a second time.

Fractions in Programs and Equations

When an equation is typed in, numbers cannot be typed as fractions. Instead, they should be typed using the division symbol. For example, 1 1/3 can be typed as (1 + 1 ÷ 3). Better still is to type it as 4 ÷ 3.

<u>Example 6:</u> Enter the equation D + 1 1/3

<u>Solution:</u> As explained, 1 1/3 is best typed into an equation as 4/3.

[EQN] [RCL] [D] [+] [4] [÷] [3] [ENTER]

Figure 7

<u>Answer:</u> The expression D + 1 1/3 is entered as the equation D + 4 ÷ 3.

Note: the command [FDISP] cannot be stored in a program. Instead of this, flag 7 should be set to display fractions, and cleared to return to normal display of numbers. See below for information about flags.

Exact Control of Fraction Display

Example 4 showed that [/c] can be used to control how fractions are displayed, through control of the denominator.

Normally, in [FDISP] mode, fractions are displayed to be as close as possible to the true value. The only limitation is that the denominator "c" can be no larger than 4095.

If a number smaller than 4095 is stored in [/c] then the largest possible value of "c" is that number, but any possible value of "c" can be used.

If flag 8 is set, then the numerator must be exactly "c", but the fraction can be simplified. If flag 8 is set and flag 9 is set too, then the numerator must be exactly "c", and there is no simplification.

<u>Example 7:</u> Display the fraction 179/3000 using the different flag settings combined with [/c].

<u>Solution:</u> This example will be shown in RPN mode. The same steps work in algebraic mode, but that [↱] [LAST x] is needed after each step when a flag is changed, as in example 3 above. First enter the fraction, and make sure [/c] is set to 4095, which is its usual value.

[0] [.] [1] [7] [9] [.] [3] [0] [0] [0] [ENTER] [0] [↰] [/c]

Figure 8

179/3000 is displayed.

Now store 99 in [/c]. This means that all fractions must be displayed with only one or two digits in the denominator.

[9] [9] [⬅] [/c]

Figure 9

The fraction is displayed with only two digits in the denominator, and it is rounded to the nearest possible fraction to 179/3000.

Now display the number with 99 as the denominator. To do this, set flag 8. First, select the flag menu:

[⬅] [FLAGS]

Figure 10

This brings up the flags menu. Press [1] to select the SF (Set Flag) command. Then press [8] to select flag 8.

[1] [8]

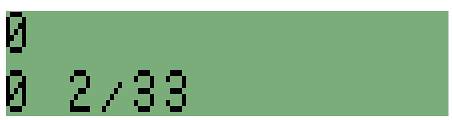


Figure 11

The result is now shown as 6/99 *but* this has been simplified to 2/33.

To display the fraction with the denominator exactly equal to 99, and no simplification, set flag 9 as well.

[⬅] [FLAGS] [1] [9]

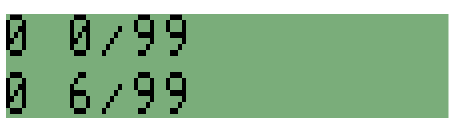


Figure 12

The result is now shown as 6/99 with no simplification.

Note: with flags 8 and 9 set to force all numbers to be displayed as multiples of 1/c, even zero is now displayed that way, so in Figure 12 the number 0 is shown as the fraction 0 0/99.

With flags 8 and 9 set, fractions will always be displayed as multiples of the denominator in [/c]. This can be very useful in some cases. For example, if a design is being drawn with a ruler marked in 1/16 of an inch, it is helpful to put 16 in [/c], then set flags 8 and 9, and see the results of all calculations as multiples of one-sixteenth.

Finally, to return to the normal display, store 0 in [/c], and clear flags 8 and 9. Clear flag 7 as well, to see that clearing flag 7 does the same as pressing [FDISP] to cancel fraction display mode.

[0] [↰] [/c] [↰] [FLAGS] [2] [7] [↰] [FLAGS] [2] [8] [↰] [FLAGS] [2] [9]

Figure 13

Answer: When all the fraction settings are reset to normal, and flag 7 is cleared to cancel fraction display, the fraction 179/3000 is displayed as the decimal number 0.060 to three decimal places.

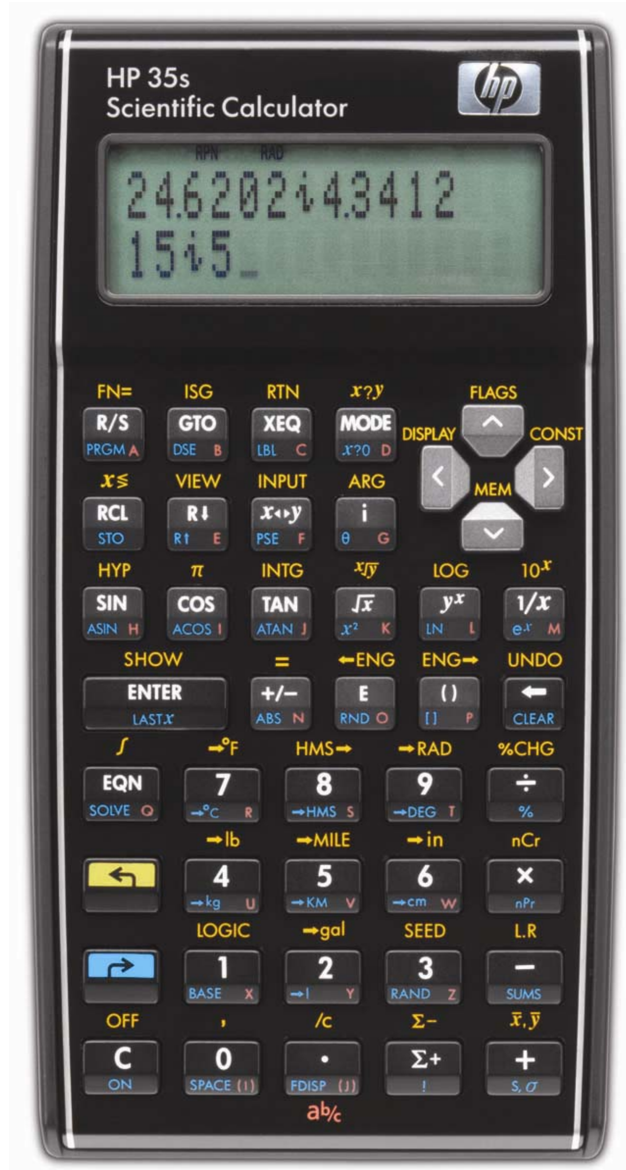
Note: for more information about flags, see the training aid on flags.

hp calculators

HP 35s Working with complex numbers –part 1

Complex numbers

Practice working problems involving complex numbers



Complex numbers

Complex numbers occur in problems facing several disciplines, from quantum mechanics to working with magnetic fields. They are also useful in modeling the flow of a fluid around a pipe. They even show up in the solution of a differential equation that models the up and down movement of a car's shock absorber. They are also used to describe the inductance and capacitance of electrical circuits, for example, using the formula E = I x Z, where E is voltage, I is current, and Z is impedance. In many electricity and electronics areas, the "i" of an imaginary number is usually represented as "j" to avoid any confusion with the variable "I" which represents current in electronics formulas.

To distinguish complex numbers from real numbers, the HP 35s has a dedicated [i] key, which is pressed between the real and imaginary part of a complex number. Because the HP 35s holds an entire complex number in one stack register, the entire 4-level stack can hold 4 complex numbers at once.

In RPN mode, the HP 35s has two "complex number" modes available. The first is the standard xiy mode, where the real portion is input, the key pressed, and then the complex number portion is input. The second is by entering the complex number in "polar" format or a magnitude r, then the theta symbol, followed by an angle, or simply rΘa. These are selected using the [↰] [DISPLAY] menu choices 9 and 10 as shown in figure 1. To choose option 9 once [↰] [DISPLAY] has been pressed, press 9. To choose option 10, press the decimal point followed by a zero.

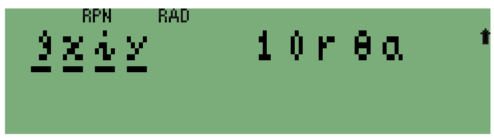


Figure 1

In algebraic mode, the HP 35s has **three** "complex number" modes available. The first two modes are the same as for RPN and are described in the preceding paragraph. The third mode which is only available in algebraic is the x+yi mode. It is selected using the [↰] [DISPLAY] menu choice 11, as shown in figure 2. To choose option 11 if you have already pressed [↰] [DISPLAY], press the decimal point followed by a one.

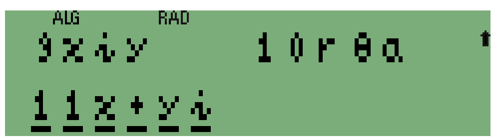


Figure 2

Note that changing the display mode changes any previously entered complex numbers to the new format. This means that to convert from polar to rectangular coordinates, for example, all that is needed is to change how a polar form complex number is displayed.

The HP 35s provides a new level of ease of use when dealing with complex numbers.

Practice working problems involving complex numbers

Example 1: Compute (2+3i) * [(7-6i) + (4+5i)]. Use the XiY display mode.

Solution: Press [↰] [DISPLAY] [9]

In RPN mode, perform the addition of the two complex numbers and then the multiplication:

[7] [i] [6] [+/-] [ENTER] [4] [i] [5] [+] [2] [i] [3] [×]

In algebraic mode:

[2] [i] [3] [×] [( )] [7] [i] [6] [+/-] [+] [4] [i] [5] [ENTER]

Figure 3

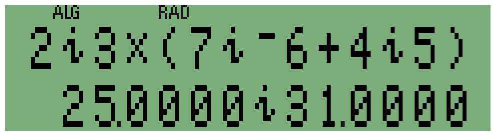


Figure 4

<u>Answer:</u> 25 + 31i. Figure 3 shows the display in RPN mode. Figure 4 shows the display in algebraic mode.

<u>Example 2:</u> In Radians mode, compute sin(2+3i) + cos(1-4i) + $e^{(2+2i)}$

<u>Solution:</u> In RPN mode:

[MODE] [2] (Sets Radians mode)
[2] [i] [3] [SIN] [1] [i] [4] [+/-] [COS] [+] [2] [i] [2] [↱] [e^x] [+]

In algebraic mode:

[MODE] [2] (Sets Radians mode)
[SIN] [2] [i] [3] [>] [+] [COS] [1] [i] [4] [+/-] [>] [↱] [e^x] [2] [i] [2] [ENTER]

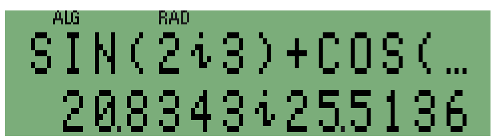


Figure 5

<u>Answer:</u> The approximate answer is 20.83 + 25.51i. Figure 5 shows the display in algebraic mode.

<u>Example 3:</u> Find 3+2i divided by 4-4i.

<u>Solution:</u> In RPN mode:

[3] [i] [2] [ENTER] [4] [i] [4] [+/-] [÷]

In algebraic mode:

[3] [i] [2] [÷] [4] [i] [4] [+/-] [ENTER]

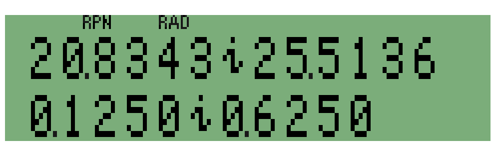


Figure 6

Answer: The answer is 0.125 + 0.625i. Figure 6 shows the answer in RPN mode

Example 4: For the complex number 5+6i, find the magnitude of the vector represented.

Solution: In RPN or algebraic mode:

[3] [i] [2] [ENTER] [↰] [DISPLAY] [·] [0]

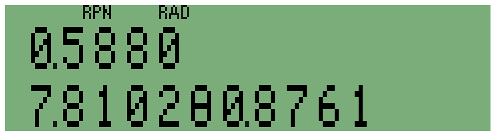


Figure 7

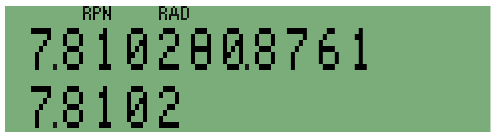


Figure 8

Answer: The answer of 7.8102 is shown in the display. Figure 7 shows the answer in RPN mode. Note that if the magnitude is needed separated from the number shown, the [↱] [ABS] function will provide it (this is shown in Figure 8). If the angle is desired separated from the number shown, the [↰] [ARG] function will provide it.

Example 5: The voltage in a circuit is 45 + 5j volts and the impedance is 3 + 4j ohms. Find the total current.

Solution: Using the equation E = I x Z, the current I is equal to E / Z.

In RPN mode:

[4] [5] [i] [5] [ENTER] [3] [i] [4] [÷]

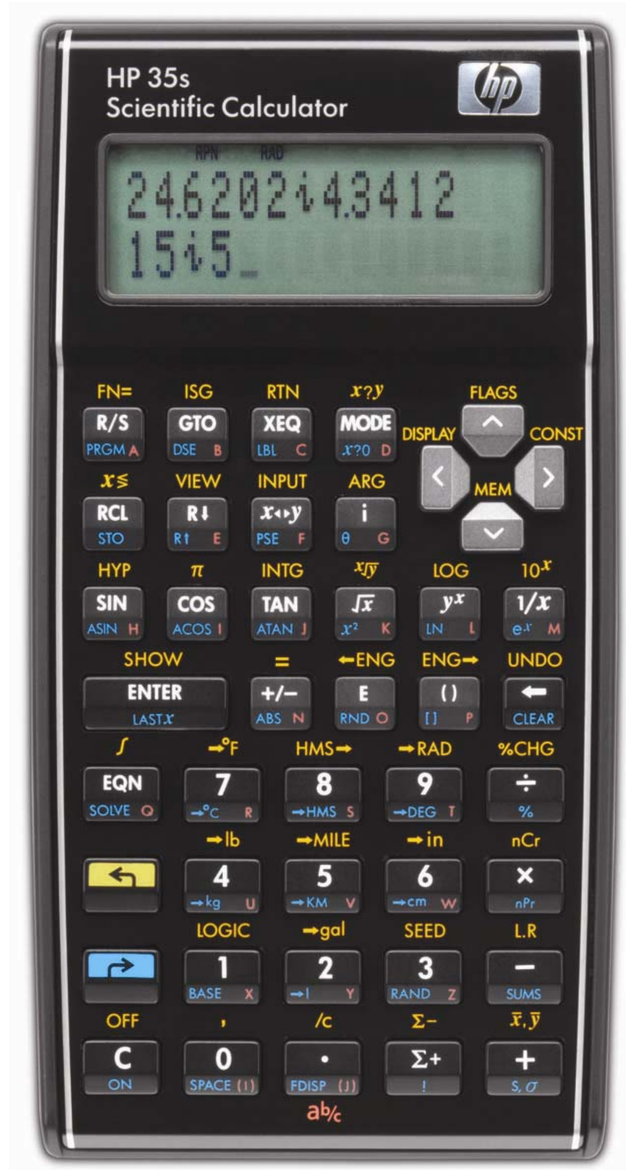
In algebraic mode:

[4] [5] [i] [5] [÷] [3] [i] [4] [ENTER]

Figure 9

Answer: The answer is 6.2 – 6.6i. This is equivalent to 6.2 - 6.6j amps. Figure 9 shows the answer in RPN mode.

hp calculators



HP 35s Working with complex numbers – Part 2

Complex numbers

Practice working problems involving complex numbers

Complex numbers

Complex numbers occur in problems facing several disciplines, from quantum mechanics to working with magnetic fields. They are also useful in modeling the flow of a fluid around a pipe. They even show up in the solution of a differential equation that models the up and down movement of a car's shock absorber. They are also used to describe the inductance and capacitance of electrical circuits, for example, using the formula E = I x Z, where E is voltage, I is current, and Z is impedance. In many electricity and electronics areas, the "i" of an imaginary number is usually represented as "j" to avoid any confusion with the variable "I" which represents current in electronics formulas.

To distinguish complex numbers from real numbers, the HP 35s has a dedicated [i] key, which is pressed between the real and imaginary part of a complex number. Because the HP 35s holds an entire complex number in one stack register, the entire 4-level stack can hold 4 complex numbers at once.

In RPN mode, the HP 35s has two "complex number" modes available. The first is the standard xiy mode, where the real portion is input, the key pressed, and then the complex number portion is input. The second is by entering the complex number in "polar" format or a magnitude r, then the theta symbol, followed by an angle, or simply rΘa. These are selected using the [↰] [DISPLAY] menu choices 9 and 10 as shown in figure 1. To choose option 9 once [↰] [DISPLAY] has been pressed, press 9. To choose option 10, press the decimal point followed by a zero.

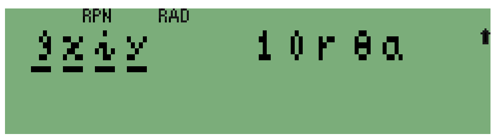


Figure 1

In algebraic mode, the HP 35s has **three** "complex number" modes available. The first two modes are the same as for RPN and are described in the preceding paragraph. The third mode which is only available in algebraic is the x+yi mode. It is selected using the [↰] [DISPLAY] menu choice 11, as shown in figure 2. To choose option 11 if you have already pressed [↰] [DISPLAY], press the decimal point followed by a one.

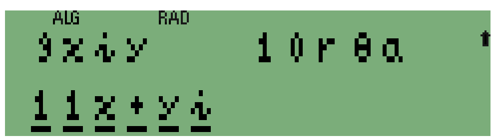


Figure 2

Note that changing the display mode changes any previously entered complex numbers to the new format. This means that to convert from polar to rectangular coordinates, for example, all that is needed is to change how a polar form complex number is displayed.

The HP 35s provides a new level of ease of use when dealing with complex numbers.

Practice working problems involving complex numbers

<u>Example 1:</u> Compute (2+3i) * [(7-6i) + (4+5i)]. Use the x+yi display mode in algebraic mode

<u>Solution:</u> Put the HP 35s into algebraic by pressing [MODE] [4]. Then press [↰] [DISPLAY] [.] [1]

[( )] [2] [+] [3] [i] [>] [×] [( )] [( )] [7] [+] [6] [+/-] [i] [>] [+] [( )] [4] [+] [5] [i] [ENTER]

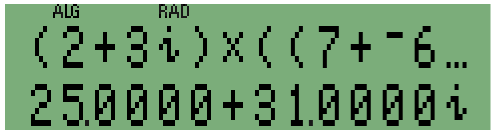


Figure 3

Answer: 25 + 31i. Figure 3 shows the display in algebraic mode.

Example 2: Extract the X and Y coordinates of the complex number 5θ30. Use degrees mode.

Solution: Changing the display mode to [↰] [DISPLAY] [9] will convert the complex number to an X and Y form. However, to extract the X and Y values, it is necessary to leave the display in polar form using the [↱] [ABS] function to extract the magnitude and the [↰] [ARG] function to extract the angle. Once extracted, the X and Y coordinates can be computed for further use as follows:

X = r COS Θ
Y = r SIN Θ

In either RPN or algebraic mode:

[MODE] [1] (Sets degrees mode)
[↰] [DISPLAY] [·] [0]
[5] [↱] [θ] [3] [0] [ENTER]

In algebraic mode:

[↱] [ABS] [↱] [LAST*x*] [>] [×] [COS] [↰] [ARG] [↱] [LAST*x*] [ENTER]

Figure 4

[5] [↱] [θ] [3] [0] [ENTER] [↱] [ABS] [↱] [LAST*x*] [>] [×] [SIN] [↰] [ARG] [↱] [LAST*x*] [ENTER]

Figure 5

In RPN mode:

[↱] [ABS] [↱] [LAST*x*] [↰] [ARG] [COS] [×]

Figure 6

x↔y ↱ ABS ↱ LAST x ↰ ARG SIN ×

Figure 7

Answer: The X coordinate is approximately 4.33 and the Y coordinate is 2.5. Figures 4 and 5 show the display in algebraic mode. Figures 6 and 7 show the display in RPN mode.

Example 3: Use the HP 35s to verify the triangle inequality for two complex numbers, which states that if z and w are any two complex numbers, then |z + w| ≤ |z| + |w|.

Use the complex numbers z = 3 + 1i and w = -1+2i

Solution: MODE 1 (Sets degrees mode)
↰ DISPLAY · 0

In RPN mode, compute |z + w| first.

3 i 1 ENTER 1 +/- i 2 +

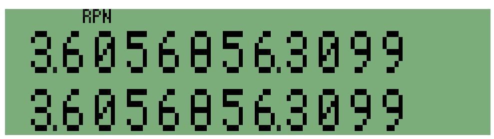


Figure 8

The magnitude of the resulting complex number will be approximately 3.6. It is computed by pressing:
↱ ABS

Figure 9

In RPN mode, now compute |z| + |w|.

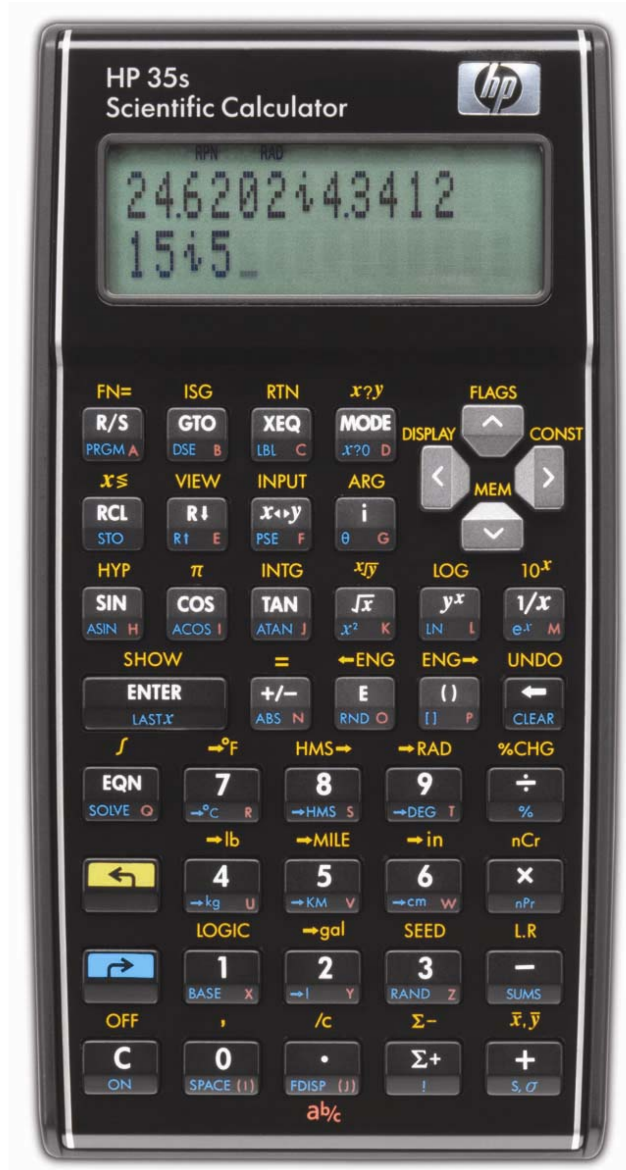
3 i 1 ↱ ABS
1 +/- i 2 ↱ ABS
+

Figure 10

Answer: The results verify the triangle inequality. The individual magnitudes of the two complex numbers added together is larger than the magnitude of the result from adding the complex numbers together.

hp calculators

HP 35s Solving Simple Trigonometry Problems



The trigonometric functions

Degrees, radians and gradians

Practice working problems involving trig functions

The trigonometric functions

The trigonometric functions, sine, cosine, tangent, and related functions, are used in geometry, surveying, and design. They also occur in the solutions to orbital mechanics, integration, and other advanced applications.

The HP 35s provides the three basic functions, and their inverse, or “arc” functions. These work in degrees, radians and gradians modes. In addition, π is provided as a function on the right-shifted “cos” key.

The secant, cosecant and cotangent functions are easily calculated using the COS, SIN, and TAN keys respectively, followed by $1/x$. To help remember whether the secant function corresponds to the inverse sine or cosine, it can be helpful to note that the first letters of “secant” and “cosecant” are inverted in relation to those of “sine” and “cosine”, just as the secant and cosecant are the inverted cosine and sine functions.

Trigonometric modes

The HP 35s can calculate trigonometric functions in any of these three modes: Degrees, Radians or Gradians.

Practice working problems involving trig functions

Example 1: Select the appropriate angle mode.

Solution: Press the MODE key below the screen.

Figure 1

Press 1, 2 or 3 to select DEGrees, RADians or GRADians mode, or use the arrow keys <, >, ^ and v to select the required mode and then press ENTER. For example, to select RAD, press 2.

Answer: The selected trigonometric mode is displayed at the top of the screen if it is RAD or GRAD. If no angle mode is shown, then the mode is degrees. The MODE command works the same way in algebraic and in RPN modes.

There are 360 degrees, or 2 π radians in a circle. Gradians mode divides each quarter of a circle into 100 parts, in a sort of decimal system, making 400 gradians in a circle.

It is very easy to forget that one angle mode is set but angles are being entered in a different mode. Making it a habit to check the angle mode is a good policy. The commands DEG, RAD and GRAD can be entered into programs, and it is worth using them to be sure that a program will work as required.

Example 2: What is the sine of π/2 radians?

Solution: In RPN mode, press: ↰ π 2 ÷ SIN.
In algebraic mode, SIN ↰ π ÷ 2 ENTER

Figure 3

Answer: The sine of π/2 radians is calculated as exactly 1. Answers will not always be exact as in this case. The HP 35s works with 12 decimal digits, so trigonometric calculations can be expected to be accurate to 12 decimal places. For example the sine of π radians is calculated as 2×10^{-13}, displayed as 2E-13, which is correctly equal to zero to 12 decimal places.

Example 3: Show that the rule $\sin^2(x) + \cos^2(x) = 1$ applies correctly when x is 45°.

Solution: First, remember to set the required angle mode. Press [MODE] [1].

In algebraic mode, work through the problem by calculating the sine, squaring it, then adding the square of the cosine:

[↱] [x^2] [SIN] [4] [5] [>] [>] [+] [↱] [x^2] [COS] [4] [5] [ENTER]

Figure 4

The same can be done in RPN mode. First, calculate the sine and cosine of 45°. Then add:

[4] [5] [ENTER] [SIN] [↱] [x^2] [$x\leftrightarrow y$] [COS] [↱] [x^2] [+]

Figure 5

Answer: Both the algebraic and the RPN calculations confirm that the rule $\sin^2(x) + \cos^2(x) = 1$ applies correctly when x is 45°.

Example 4: A ladder is leaning against a vertical wall. The ladder is 6 meters long and the foot of the ladder is 3 meters from the base of the wall. What is the angle between the top of the ladder and the wall?

Solution: In RPN mode, divide the side opposite the angle by the long side and get the arc sine:
[3] [ENTER] [6] [÷] [↱] [ASIN]

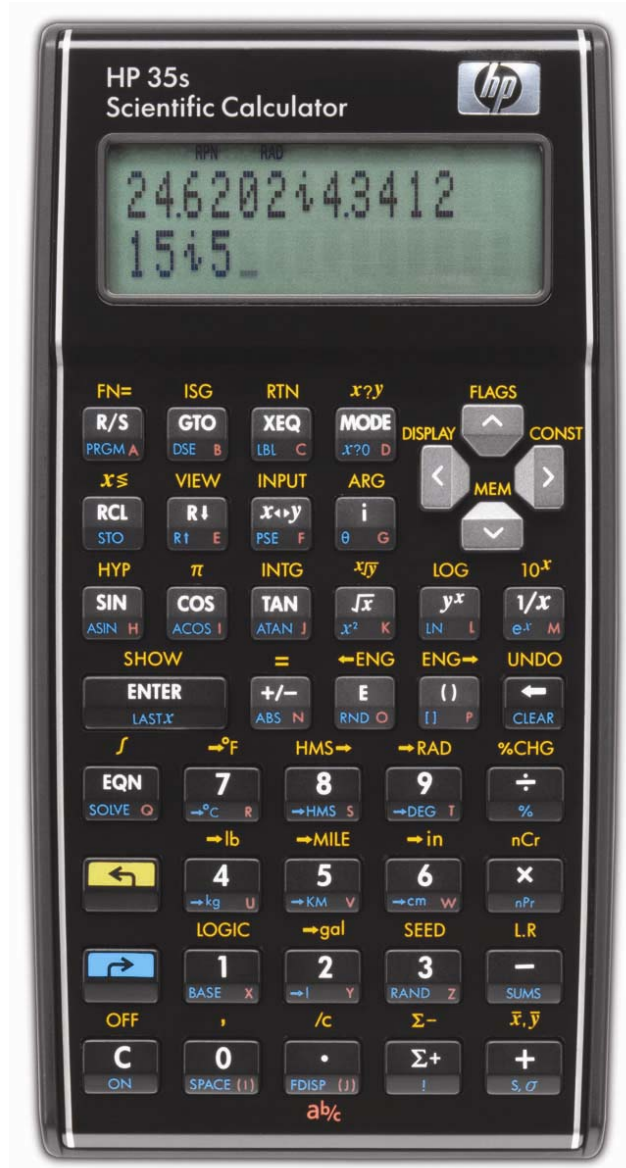
In algebraic mode, [↱] [ASIN] [3] [÷] [6] [ENTER]

Figure 6

Answer: The ladder is at an angle of 30 degrees from the wall.

hp calculators

HP 35s Logarithmic functions



Log and antilog functions

Practice working problems involving logarithms

Log and antilog functions

Before calculators like the HP 35s became easily available, logarithms were often used to simply multiplication. They are still used in many subjects, to represent large numbers, as the result of integration, and even in number theory.

The HP 35s has four functions for calculations with logarithms. These are the “common” logarithm of “x”, [LOG], its inverse, [10^x], the “natural” logarithm of “x”, [LN] and its inverse, [e^x].

Common logarithms are also called “log to base 10” and the common logarithm of a number “x” is written

$$\mathbf{LOG_{10}\,x} \quad \text{or just} \quad \mathbf{LOG\,x}$$

Natural logarithms are also called “log to base *e*” and the natural logarithm of a number “x” is written

$$\mathbf{LOG_{e}\,x} \quad \text{or} \quad \mathbf{LN\,x}$$

[10^x], and [e^x] are also called “antilogarithms” or “antilogs”. [e^x] is also called the “exponential” function or “exp”. Apart from being the inverses of the log functions, they have their own uses. [10^x] is useful for entering powers of 10. [e^x] is used in calculations where exponential growth is involved.

Practice working problems involving logarithms

Example 1: Find the common logarithm of 2.

Solution: In RPN mode: [2] [↰] [LOG]

Figure 1

In algebraic mode: [↰] [LOG] [2] [ENTER]

Figure 2

Answer: The common logarithm of 2 is very nearly 0.3010.

Example 2: What is the numeric value of the base of natural logarithms, *e*?

Solution: This is a quick way to type the value of *e*.

In RPN mode: [1] [↱] [e^x]

In algebraic mode: [↱] [e^x] [1] [ENTER]

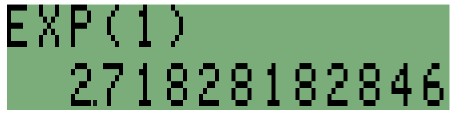


Figure 3

Answer: *e* is equal to 2.71828182846. The pattern 18 – 28 – 18 – 28 is easy to remember.

Example 3: What is the value of X, in the equation: $2^X = 8$?

Solution: To solve this example, we'll apply one of the properties of logarithms which states that the logarithm of an base taken to a power is equal to the power multiplied by the log of the base. This involves taking the logarithm of both sides of the equation. The original equation would then look like this:

$$X\ LOG(2) = LOG(8)$$

Figure 4

X is therefore equal to:

$$X = \frac{LOG(8)}{LOG(2)}$$

Figure 5

In RPN mode: [8] [⬑] [LOG] [2] [⬑] [LOG] [÷]

In algebraic mode: [⬑] [LOG] [8] [>] [÷] [⬑] [LOG] [2] [ENTER]

Figure 6

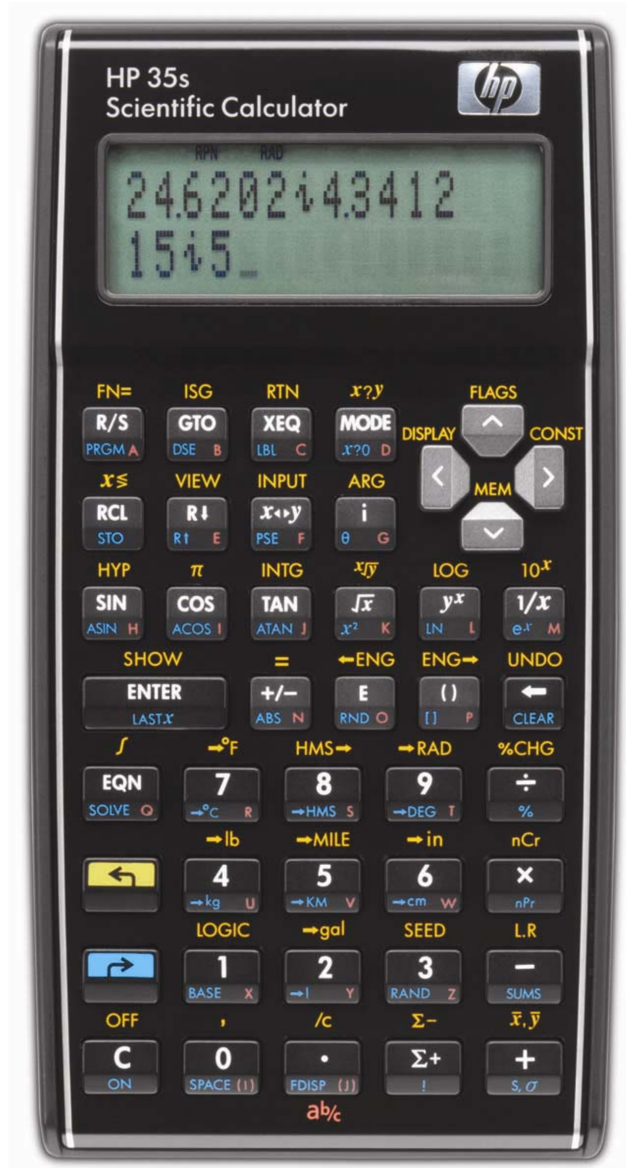
Answer: The value of X is 3. Figure 6 shows the result in algebraic mode. Note that the same answer will be found using natural logarithms or common logarithms.

hp calculators

HP 35s Hyperbolic functions

Hyperbolic trigonometric functions

Practice using hyperbolic trigonometric functions



Hyperbolic trigonometric functions

Trigonometric functions are often called “circular” functions, because the value for the cosine and sine of an angle lie on the unit circle defined by $X^2 + Y^2 = 1$ (points on the unit circle will have the X and Y coordinate of (Cosine(theta), Sine(theta))). Hyperbolic trigonometric functions have a similar relationship, but with the hyperbola defined by the equation $X^2 – Y^2 = 1$.

Given a value for Z, the hyperbolic sine is calculated by evaluating the following:

$$\frac{e^{Z}-e^{-Z}}{2}$$

Figure 1

The hyperbolic cosine is calculated by evaluating the following:

$$\frac{e^{Z}+e^{-Z}}{2}$$

Figure 2

Assume that Z is 3. The position on the unit hyperbola $X^2 – Y^2 = 1$ is defined by the point (COSH(Z),SINH(Z)), where COSH is the hyperbolic cosine and SINH is the hyperbolic sine. The value for the SINH(3) is equal to 10.0179 and the value of COSH(3) is 10.0677. When 10.0677 x 10.0677 – 10.0179 x 10.0179 is evaluated, the value is 1, so the point falls on the unit hyperbola. The hyperbolic tangent is defined as the hyperbolic sine divided by the hyperbolic cosine.

Hyperbolic functions have applications in many areas of engineering. For example, the shape formed by a wire freely hanging between two points (known as a catenary curve) is described by the hyperbolic cosine (COSH). Hyperbolic functions are also used in electrical engineering applications.

On the HP 35s, hyperbolic functions are access by pressing the [↰] [HYP] keys and then the appropriate trigonometric key or inverse trigonometric key.

Practice using hyperbolic trigonometric functions

<u>Example 1:</u> Find the Hyperbolic Sine of 2.

<u>Solution:</u> In RPN mode, [2] [↰] [HYP] [SIN]
In algebraic mode, [↰] [HYP] [SIN] [2] [ENTER]

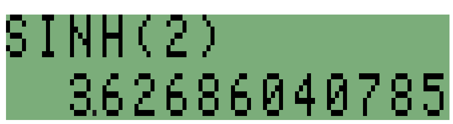


Figure 3

<u>Answer:</u> 3.62686. Figure 3 shows the display in algebraic mode.

<u>Example 2:</u> A tram carries tourists between two peaks that are the same height and 437 meters apart. Before the tram latches onto the cable, the angle from the horizontal to the cable at its point of attachment is 63 degrees. How long does it take the tram to travel from one peak to the other, if the tram moves at 135 meters per minute?

Solution: The travel time is given by the following formula:

$$t = \frac{437 \times \tan(63\ \text{degrees})}{135 \times \mathrm{ASINH}(\tan(63\ \text{degrees}))}$$

Assuming the 35s is in Radians mode, change it to Degrees mode to calculate the tangent value.

Assuming RPN mode: MODE 1 (Sets Degrees mode)
4 3 7 ENTER 6 3 TAN × LASTx HYP ASIN 1 3 5 × ÷

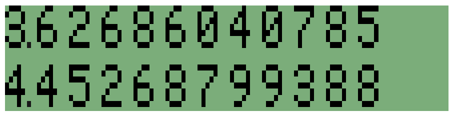


Figure 4

Assume algebraic mode: MODE 1 (Sets Degrees mode)
4 3 7 × TAN 6 3 > ÷ ( ) 1 3 5 × HYP ASIN TAN 6 3 ENTER

Figure 5

Answer: The travel time between the peaks is just under four and one half minutes. Figure 4 shows the display in RPN mode, while Figure 5 shows the display in algebraic mode.

Example 3: A cable is strung between two poles that are 40 feet apart, with the cable attached to each pole at a height of 30.436 feet above the level ground. At the midpoint between the poles, the cable is 18.63 feet above the level ground. What is the length of the cable required between the two poles?

Solution: The length of the cable is described by the formula below, where a is the lowest height of the cable and D is the distance between the two poles:

L = 2 a SINH ((D/2) / a)

Assuming RPN mode
4 0 ENTER 2 ÷ 1 8 . 6 3 ÷ LASTx x↔y HYP SIN x↔y 2 × ×

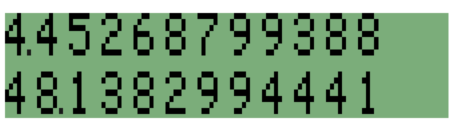


Figure 6

Assuming algebraic mode
HYP SIN 4 0 ÷ 2 ÷ 1 8 . 6 3 > × 2 × 1 8 . 6 3 ENTER

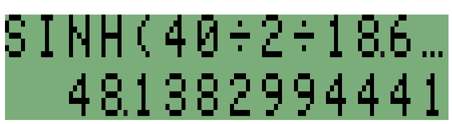


Figure 7

Answer: The length of the cable will be 48.14 feet.

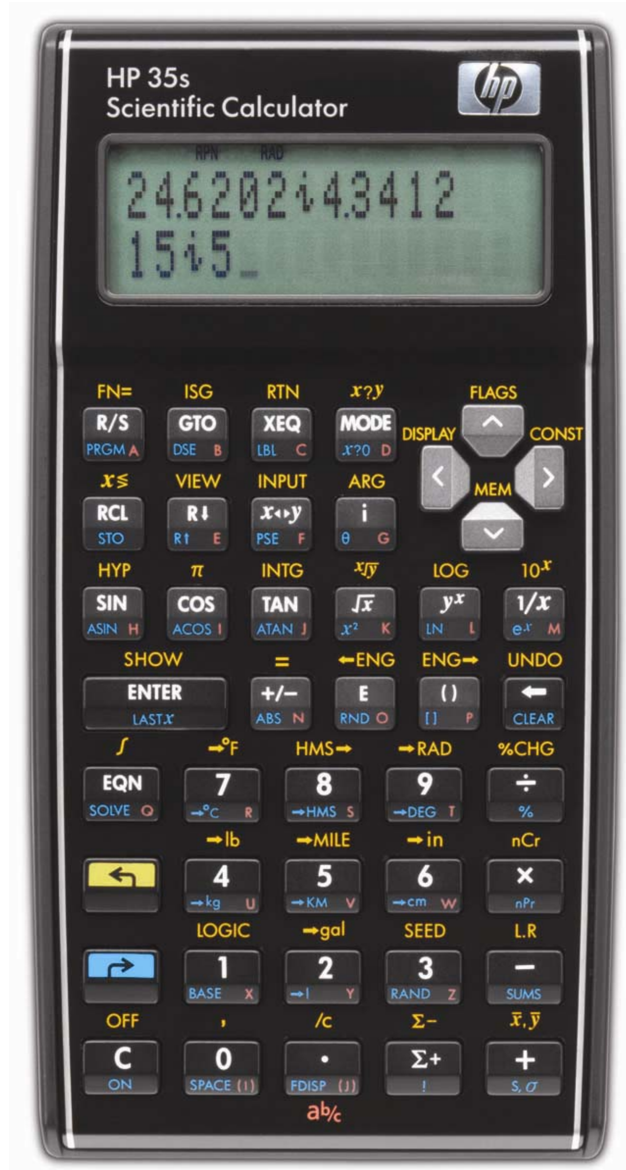
hp calculators

HP 35s Solving for roots

Roots of an equation

Using the SOLVE function

Practice solving problems involving roots



Roots of an equation

The roots of an equation are values of X where the value of Y is equal to zero. For example, the equation Y = X – 2 has a real root at the value +2. The equation Y = X^2 – 9 has real roots at the values of + 3 and – 3. Not every equation has roots that are real numbers. For example, the equation Y = X^2 + 4 has no real roots, meaning there are no real values for X that will cause X^2 + 4 to equal zero.

Using the SOLVE function

The HP 35s has a very powerful root finding capability built into its SOLVE function. As applied in this training aid, the SOLVE function, accessed by pressing the [SOLVE] key, will be used to find roots from user-written programs computing the value of a function. This will involve entering a small program, keying in a small equation into the program using a variable, indicating to the HP 35s which variable is being considered as the current function, and then solving for the value of that variable when the function is equal to zero. The HP 35s knows which variable to solve for by setting the value of the function under consideration using the [↰] [FN=] function. To indicate to the HP 35s that the variable X is to be used, press [↰] [FN=] [X].

This training aid cannot begin to illustrate the wide range of applications available using the built-in solver, but it can illustrate some of the more common uses.

Practice solving problems involving roots

Example 1: Solve for the roots of Y = X^2 – 4

Solution: We're looking for values of X such that X^2 – 4 = 0. First, we'll enter a program that computes the value of the function. If a program already exists in program memory with the name of X, then it will need to be cleared. This can be done by pressing [↰] [MEM] [>] [ENTER] to have the HP 35s display the list of programs in the calculator and then press [∨] to step through the program labels. When the label of the program to be deleted is shown in the display, pressing [↱] [CLEAR] will delete that program from the calculator's memory. Pressing [C] will then clear the display and allow you to proceed.

In RPN or algebraic mode: [↱] [PRGM] [↱] [LBL] [X] [EQN] [RCL] [X] [y^x] [2] [−] [4] [ENTER] [↰] [RTN]

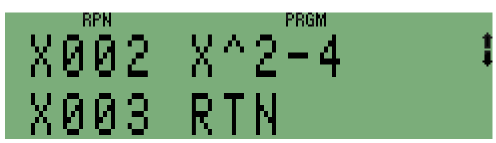


Figure 1

To show the checksum and length of this program, press the following in RPN or algebraic mode. Note that the symbol [>] means to press the right arrow cursor key.

In RPN or algebraic mode: [↰] [MEM] [>] [ENTER] [↰] [SHOW]

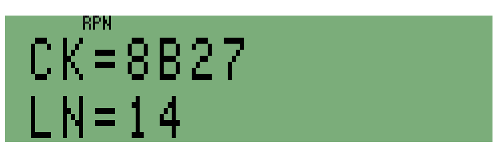


Figure 2

If the checksum of the program just entered does not equal 8B27, then you have not entered it correctly. To clear the checksum display press:

In RPN or algebraic mode: [↱] [PRGM]

Then, to exit the program environment, press:

In RPN or algebraic mode: [↱] [PRGM]

Store an initial guess for X of 10 into the variable X. Then set the function to X and solve for the value of X.

In RPN or algebraic mode: [1] [0] [↱] [STO] [X] [↰] [FN=] [X] [↱] [SOLVE] [X]

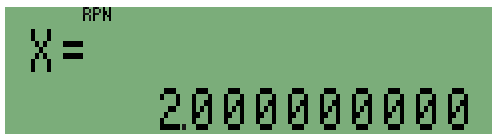


Figure 3

Since you feel this equation has a negative root as well, store a new guess for X of -10 into the variable X. There is no need to set the function to X (since it has already been done). Solve for the value of X.

In RPN or algebraic mode: [1] [0] [+/-] [↱] [STO] [X] [↱] [SOLVE] [X]

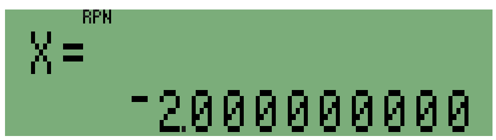


Figure 4

Answer: Roots found for the equation are –2 and +2.

Example 2: Solve for the roots of $Y = X^2 – 7X + 12$

Solution: We're looking for values of X such that $X^2 – 7X + 12 = 0$. First, we'll enter a program that computes the value of the function. If a program already exists in program memory with the name of X, then it will need to be cleared. This can be done by pressing [↰] [MEM] [>] [ENTER] to have the HP 35s display the list of programs in the calculator and then press [∨] to step through the program labels. When the label of the program to be deleted is shown in the display, pressing [↱] [CLEAR] will delete that program from the calculator's memory. Pressing [C] will then clear the display and allow you to proceed.

In RPN or algebraic mode: [↱] [PRGM] [↱] [LBL] [X] [EQN]
[RCL] [X] [y^x] [2] [−] [7] [×] [RCL] [X] [+] [1] [2] [ENTER]
[↰] [RTN]

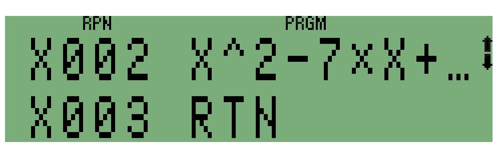


Figure 5

To show the checksum and length of this program, press the following in RPN or algebraic mode. Note that the symbol [>] means to press the right arrow direction cursor key.

In RPN or algebraic mode: [↰] [MEM] [>] [ENTER] [↰] [SHOW]

Figure 6

If the checksum of the program just entered does not equal 1086, then you have not entered it correctly.

To clear the checksum display press:

In RPN or algebraic mode: [↱] [PRGM]

Then, to exit the program environment, press:

In RPN or algebraic mode: [↱] [PRGM]

Store an initial guess for X of 10 into the variable X. Then set the function to X and solve for the value of X.

In RPN or algebraic mode: [1] [0] [↱] [STO] [X] [↰] [FN=] [X] [↱] [SOLVE] [X]

Figure 7

Since you feel this equation might have a root larger than this, store a new guess for X of 100 into the variable X. There is no need to set the function to X (since it has already been done). Then solve for the value of X.

In RPN or algebraic mode: [1] [0] [0] [↱] [STO] [X] [↱] [SOLVE] [X]

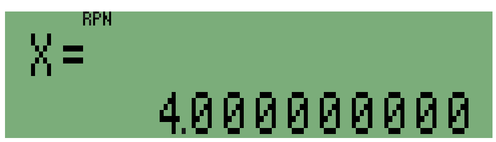


Figure 8

The same root is returned. This is a good indication (but certainly not foolproof) that there are no roots larger than +4 for this equation.

To see if there is a root less than +4 for this equation, store a new guess for X of –10 into the variable X. Then solve for the value of X.

In RPN or algebraic mode: [1] [0] [+/–] [↱] [STO] [X] [↱] [SOLVE] [X]

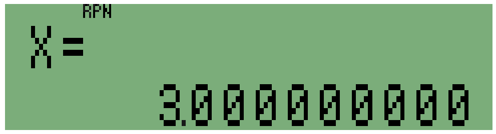


Figure 9

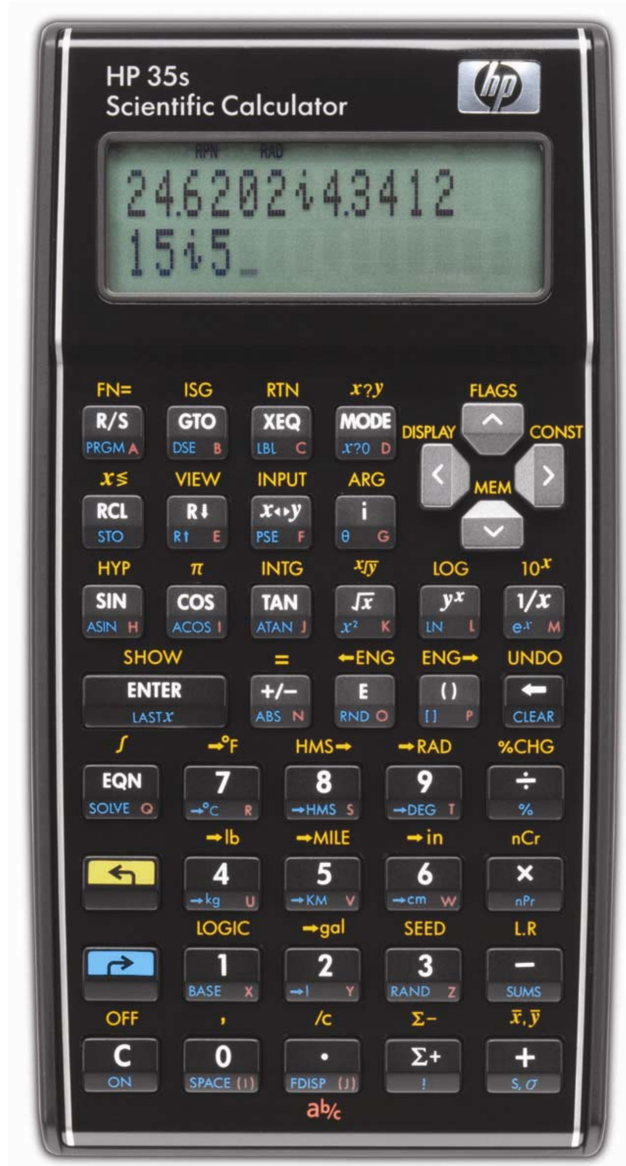
<u>Answer:</u> Roots found for the equation are +3 and +4. Note that the HP 35s owners manual provides much more information about providing initial guesses for the SOLVE feature.

hp calculators

HP 35s Base conversions and arithmetic

Numbers in different bases

Practice working with numbers in different bases



Numbers in different bases

Most numbers we work with day-to-day are in base 10. There are applications within the computer world that require the use of numbers in other bases. The number 24 in base 10 can be translated into base 16 by the following procedure. Just as each digit's location in base 10 can be thought of as a power of ten (the ones' place, the tens' place, the hundreds' place, etc), each digit's location in base 16 can be thought of as a power of 16. Each digit in a base ten number can hold a value from 0 to 9. In base 16, each digit can hold a value from 0 to F, where F corresponds to the value 15 in a base 10 number. Translating 24 from base 10 to base 16 would require a 1 in the second location of the base 16 number (and would convert 16 of the 24 number's value) and an 8 in the second location of the base 16 number. Therefore, 24 base 10 is equal to 18 in base 16. A similar process could be used to convert 24 base 10 to base 8 or base 2.

On the HP 35s, numbers can be represented in bases 2, 8, 10 and 16, or binary, octal, decimal and hexadecimal. The HP 35s can work with numbers in bases 2, 8 and 16 that are 36 bits in length or less. Since the leftmost "bit" is used to indicate a negative number, the largest positive binary number is 0 followed by thirty-five 1's. This means that the largest hexadecimal number that can be entered or generated as an answer is 7FFFFFFFF, (equal to 34,359,738,367 in base 10, and 377777777777 in base 8). This is because the HP 35s uses a 36 bit binary word space to represent numbers in these different bases. Decimal numbers are not limited in this fashion, since they can be represented as floating point numbers.

In RPN mode, the third row of keys on the HP 35s ([SIN] through [1/x]) can be used to enter the hexadecimal digits A through F. In algebraic mode, it is necessary to press [RCL] and then the appropriate letter key to enter these digits.

The HP 35s calculator provides the ability to easily work with numbers in different bases, as the following sample problems illustrate.

Note: Numbers entered into the HP 35s are assumed to be decimal numbers, regardless of the base mode, unless the proper suffix of "b", "o", or "h" is supplied. These suffix characters are found in the BASE menu as choices 5 through 8, and are shown below in Figure 1. It is not necessary to enter the "d" for decimal numbers, except for clarity in a program.

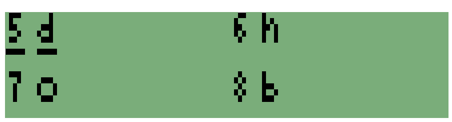


Figure 1

Practice working with numbers in different bases

Example 1: Convert 4000 base 10 to a base 8 octal number.

Solution: The keystrokes to do this are the same for both RPN and algebraic modes. First, make sure the HP 35s is in DEC mode to enter the base 10 number.

[↱] [BASE] [1]
[4] [0] [0] [0] [↱] [BASE] [3]

Figure 2

Answer: 7640 base 8. Figure 2 shows the result in algebraic mode.

Example 2: Add 7F6 base 16 to 1011001 base 2 and display the result in base 10.

Solution: First, make sure the calculator is in HEX mode to enter the base 16 number.

[↱] [BASE] [2]

In RPN mode (note that [1/x] enters the hexadecimal digit F)

[7] [1/x] [6] [↱] [BASE] [6]
[↱] [BASE] [4]
[1] [0] [1] [1] [0] [0] [1] [↱] [BASE] [8]
[↱] [BASE] [1]
[+]

In algebraic mode:

[7] [RCL] [F] [6] [↱] [BASE] [6]
[↱] [BASE] [4]
[+]
[1] [0] [1] [1] [0] [0] [1] [↱] [BASE] [8]
[↱] [BASE] [1]

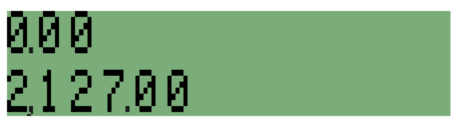


Figure 3

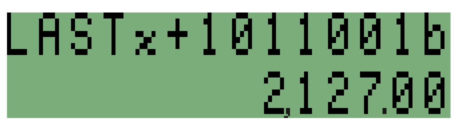


Figure 4

Answer: 2127 base 10. Figure 3 shows the result in RPN mode. Figure 4 shows the result in algebraic mode. Note how entering the calculation as shown in algebraic mode makes use of the LASTx register.

Example 3: Multiply FFF base 16 by 777 base 8 and display the result as a real number.

Solution: First, make sure the calculator is in HEX mode to enter the base 16 number.

[↱] [BASE] [2]

In RPN mode:

[1/x] [1/x] [1/x] [↱] [BASE] [6] [↱] [BASE] [3]
[7] [7] [7] [↱] [BASE] [7] [↱] [BASE] [1] [×]

In algebraic mode:

[RCL] [F] [RCL] [F] [RCL] [F] [↱] [BASE] [6] [↱] [BASE] [3] [×]
[7] [7] [7] [↱] [BASE] [7] [↱] [BASE] [1]

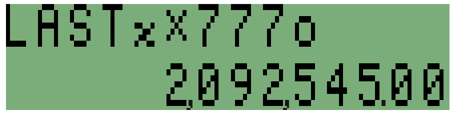


Figure 5

Answer: The result is 2,092,545. Figure 5 shows the result in algebraic mode.

Example 4: Subtract 42 base 8 from 101111 base 2 and then display the two's complement of the result in base 2.

Solution: First, make sure the calculator is in BIN mode to enter the base 2 number.

[↱] [BASE] [4]

In RPN mode:

[1] [0] [1] [1] [1] [1] [↱] [BASE] [8] [↱] [BASE] [3]
[4] [2] [↱] [BASE] [7] [↱] [BASE] [4] [−] [+/−]

In algebraic mode:

[1] [0] [1] [1] [1] [1] [↱] [BASE] [8] [↱] [BASE] [3] [−]
[4] [2] [↱] [BASE] [7] [↱] [BASE] [4] [−] [ENTER] [+/−]

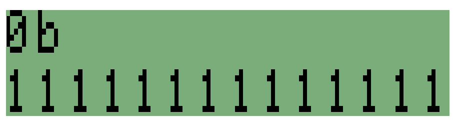


Figure 6

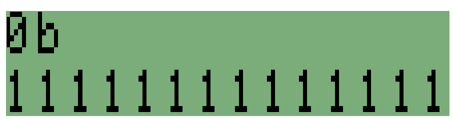


Figure 7

Figure 8

Answer: The result is 11111111111111111111111111110011. This is equivalent to –13 in base 10.

Figure 9

Figures 6, 7, and 8 display portions of the answer in RPN mode.

Note that when the result is displayed, there is an arrow pointing to the left in the display to indicate that the result has digits in the answer that flow off the display screen to the left. Press the left cursor key one time to view the next 12 digits of the answer to the left and then press it again to view the leftmost 12 digits of the answer. Figure 9 shows the result converted into base 10.

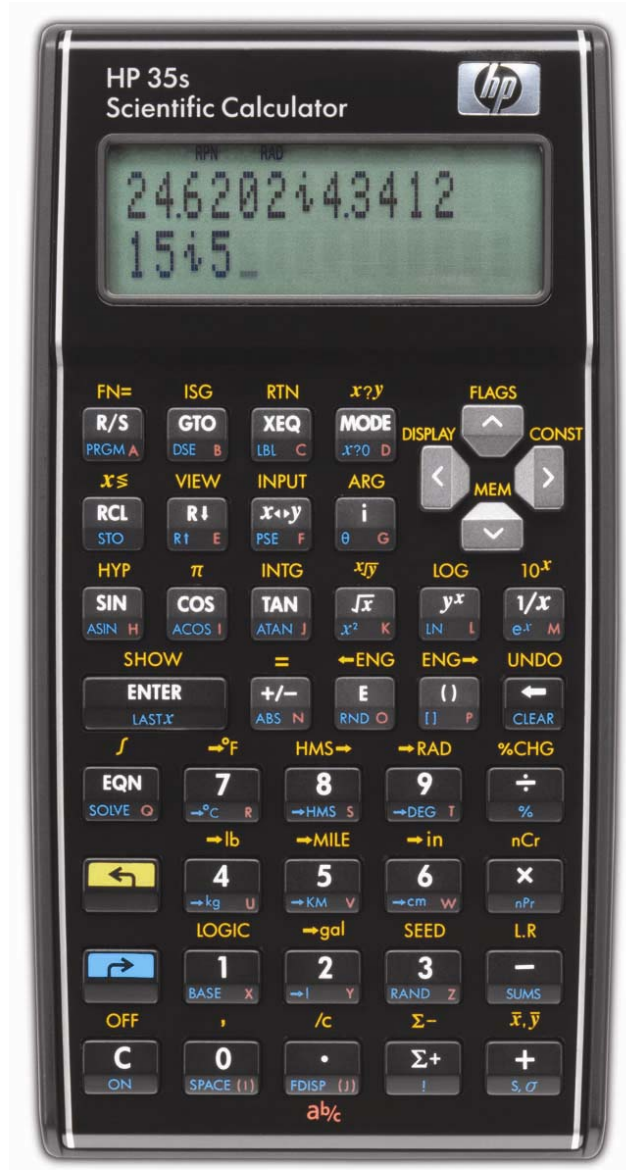
hp calculators

HP 35s Using the LOGIC functions

Numbers in different bases

Operations on binary numbers

Practice manipulating binary numbers



Numbers in different bases

Most numbers we work with day-to-day are in base 10. There are applications within the computer world that require the use of numbers in other bases. The number 24 in base 10 can be translated into base 16 by the following procedure. Just as each digit's location in base 10 can be thought of as a power of ten (the ones' place, the tens' place, the hundreds' place, etc), each digit's location in base 16 can be thought of as a power of 16. Each digit in a base ten number can hold a value from 0 to 9. In base 16, each digit can hold a value from 0 to F, where F corresponds to the value 15 in a base 10 number. Translating 24 from base 10 to base 16 would require a 1 in the second location of the base 16 number (and would convert 16 of the 24 number's value) and an 8 in the second location of the base 16 number. Therefore, 24 base 10 is equal to 18 in base 16. A similar process could be used to convert 24 base 10 to base 8 or base 2.

On the HP 35s, numbers can be represented in bases 2, 8, 10 and 16, or binary, octal, decimal and hexadecimal. The HP 35s can work with numbers in bases 2, 8 and 16 that are 36 bits in length or less. Since the leftmost "bit" is used to indicate a negative number, the largest positive binary number is 0 followed by thirty-five 1's. This means that the largest hexadecimal number that can be entered or generated as an answer is 7FFFFFFFF, (equal to 34,359,738,367 in base 10, and 377777777777 in base 8). This is because the HP 35s uses a 36 bit binary word space to represent numbers in these different bases. Decimal numbers are not limited in this fashion, since they can be represented as floating point numbers. The HP 35s calculator provides the ability to easily work with numbers in different bases, as the following sample problems illustrate.

In RPN mode, the third row of keys on the HP 35s (SIN through 1/x) can be used to enter the hexadecimal digits A through F. In algebraic mode, it is necessary to press RCL and then the appropriate letter key to enter these digits.

Operations on binary numbers

Any binary number, regardless of the base in which it is displayed, can still be thought of as a collection of 1's and 0's. For example, the number 24 in base 10 is also the number 11000 in binary. This is because 11000 in binary is equal to 1 x 24 + 1 x 23, or 24. The HP 35s contains many functions in the LOGIC menu, shown below, that operate on binary numbers.

Figure 1

Figure 2

The AND function compares two binary numbers at the bit-by-bit level and creates a new binary number with a 1 for each bit position that contains a 1 in both numbers in the same position.

The XOR function (which stands for exclusive OR), does the same thing as the OR function, but only for positions where the original numbers contained a 1 and/or 0, but not where both contain a 1.

The OR function compares two binary numbers at the bit-by-bit level and creates a new binary number with a 1 for each bit position if either original number contains a 1 at the same bit position.

The NOT function creates a new binary number where each bit position's value has been "flipped", with each 1 becoming a 0 and each 0 becoming a 1. This is referred to as the one's complement of the argument.

The NAND function creates a new binary number from two input binary numbers where each bit position's value is based upon a NOT (x AND y). In essence, it returns a bit of one unless both bit positions in the two input binary numbers are ones.

The NOR function creates a new binary number from two input binary numbers where each bit position's value is based upon a NOT (x OR y). In essence, it returns a bit of one ONLY when both of the bit positions in the two input binary numbers are zeroes.

Note: Numbers entered into the HP 35s are assumed to be decimal numbers, regardless of the base mode, unless the proper suffix of "b", "o", or "h" is supplied. These suffix characters are found in the BASE menu as choices 5 through 8, and are shown below in Figure 1. It is not necessary to enter the "d" for decimal numbers, except for clarity in a program.

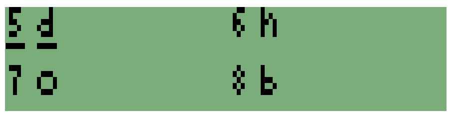


Figure 3

Practice manipulating binary numbers

Example 1: Evaluate NOT(#4567 d). Make sure the HP 35s is in DEC mode to enter the base 10 number.

Solution: In RPN mode, press: [↱] [BASE] [1] then press [4] [5] [6] [7] [↰] [LOGIC] [4]

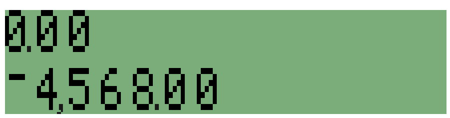


Figure 4

In algebraic mode, press: [↱] [BASE] [1] then press [↰] [LOGIC] [4] [4] [5] [6] [7] [ENTER]

Figure 5

Answer: -4568 base 10. Figure 4 shows the result in RPN mode while figure 5 shows the result in algebraic mode.

Example 2: Perform an OR on these two binary numbers: #70114 o and #57610 o. Make sure the calculator is in OCTAL mode to enter the base 8 numbers.

Solution: [↱] [BASE] [3]

In RPN mode, press:

[7] [0] [1] [1] [4] [↱] [BASE] [7] [ENTER] [5] [7] [6] [1] [0] [↱] [BASE] [7] [↰] [LOGIC] [3]

In algebraic mode, press:

[↰] [LOGIC] [3]
[7] [0] [1] [1] [4] [↱] [BASE] [7] [>] [5] [7] [6] [1] [0] [↱] [BASE] [7] [ENTER]

Figure 6

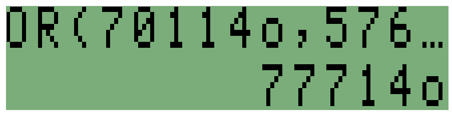


Figure 7

<u>Answer:</u> 77714 base 8. Figure 6 shows the result in RPN mode. Figure 7 shows the result in algebraic mode.

<u>Example 3</u>: Perform an NOR on these two binary numbers: #1011 b and #1001 b. Make sure the calculator is in BINARY mode to enter the base 2 numbers. Do not forget to append the “b” suffix to the binary numbers.

<u>Solution:</u> [↱] [BASE] [4]

In RPN mode, press:

[1] [0] [1] [1] [↱] [BASE] [8] [ENTER] [1] [0] [0] [1] [↱] [BASE] [8] [↰] [LOGIC] [6]

In algebraic mode, press:

[↰] [LOGIC] [6]
[1] [0] [1] [1] [↱] [BASE] [8] [>] [1] [0] [0] [1] [↱] [BASE] [8] [ENTER]

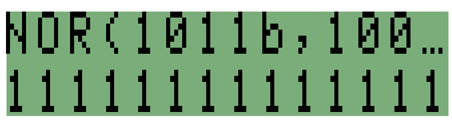


Figure 8

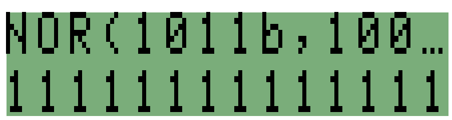


Figure 9

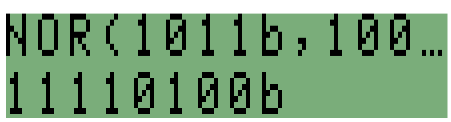
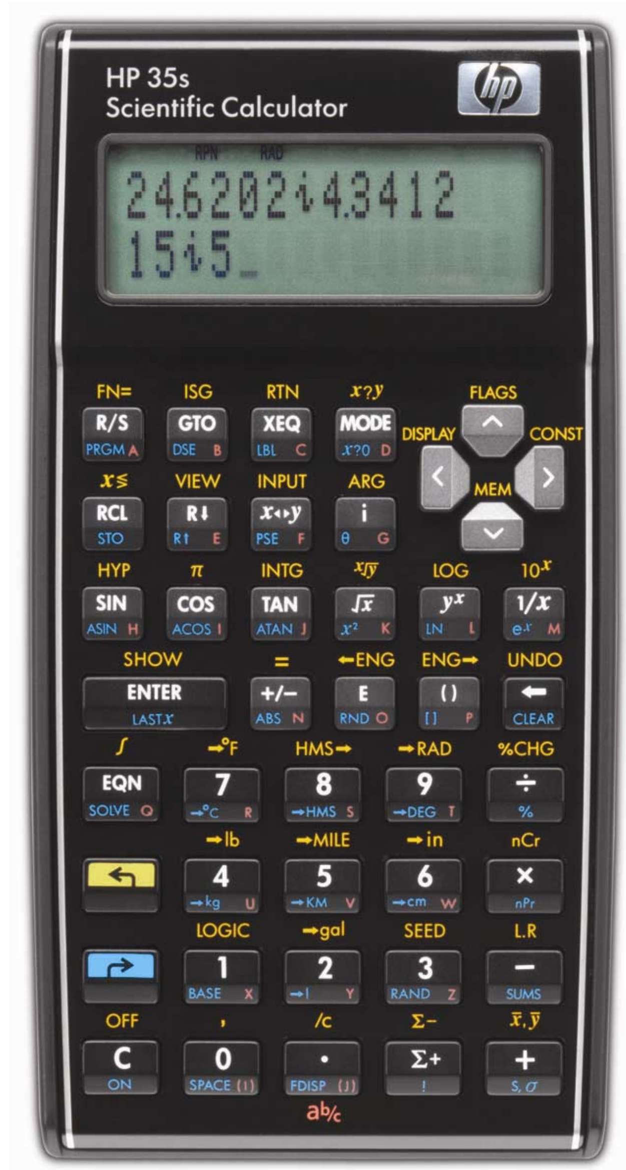


Figure 10

<u>Answer:</u> Figures 8, 9, and 10 show the result in algebraic mode. This display indicates an arrow pointing to the right which indicates that the answer scrolls off the screen in that direction. Press [↱] [>] to view the rest of the result. The leading 1’s in the answer are due to the 36 bit word length on the HP 35s. Since both binary numbers would have had all leading bits equal to zero, the NOR function returns a 1 for each of those zero bits. The last four bits reflect the NOR of the entered digits. Only the second entered bit was a zero in both numbers and NOR returns a 1 for that bit location.

hp calculators



HP 35s Using the formula solver – part 1

What is a solution?

Practice Example: Finding roots of polynomials

Practice Example: Finding the root of a log equation

Practice Example: Where there is no solution

What the solver can and can not find

What is a solution?

Given a **formula** or equation such as:

$$7x + 12 = 33$$

it is easy to find that:

$$x = 3$$

This is the **solution** or **root** of the formula. It answers the question "What value of x makes the formula correct?"

It is rarely this easy to solve a formula or equation. For example look at this one:

$$4x^2 - 14LOG(x) = 33$$

It seems likely that there is a value of x for which the formula is true, but there is no quick and easy way to find what this value is. A special method to find the solution is needed.

The HP 35s has a **Formula Solver** built into it. This can be used to solve problems like the example above, and many others. This practice aid will show some simple applications. Part 2 will show further details.

The Formula Solver is one part of the HP Solve application. Other practice aids show other uses of the HP Solver, for example its use to solve a formula typed as a program.

Practice Example: Finding roots of polynomials

Example 1: Solve the polynomial equation $x^3 + 15x^2 + 47x = -33$

Solution: The HP 35s manual gives a program for finding the roots of polynomials up to the fifth order, but it is often simpler to use the formula solver. The following steps show how this can be done.

Before a solution is looked for, it is useful to store a guess in the variable to be used. In this case, the variable will be "X", and to store a zero in it, the following leys are pressed:

[0] [↱] [STO] [X]

When [↱] [STO] is pressed, the symbol **A..Z** is shown at the top of the screen as a signal that one of the keys marked A through Z at their bottom right must be pressed. To enter the variable X press the [1] key, which has a small "X" at its lower right to show that it is also the [X] key.

Next, the equation must be entered. This is done in the HP 35s "Equation mode." Go to equation mode by typing [EQN]. Equation mode stores a list of equations and a new equation can be typed anywhere in this list. If necessary it is possible to put the new equation in a particular place by moving up or down through the list with the up and down cursor keys.

Enter the equation by typing:

RCL X y^x 3 + 1 5 × RCL X y^x 2 + 4 7 × RCL X ↰ = +/– 3 3 ENTER

To enter a variable into an equation, press the RCL key and then one of the letter keys. As with ↱ STO, the symbol **A..Z** at the top of the screen is shown as a signal that one of the keys marked A through Z must be pressed. To enter the variable X in this formula press the 1 key again.

To solve the equation, press the ↱ SOLVE key. This is the lower left key below the display. The HP 35s asks which variable to solve for:

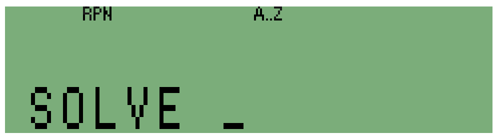


Figure 1

The symbol **A..Z** is at the top of the screen yet again. The variable in this formula is X so press the 1 key again to fill in X.

Figure 2

The word "SOLVING" is shown while a solution is looked for. If the search lasts more than a short time, the busy indicator **B** is shown as well. When a solution is found, it is displayed. It is also stored in the variable.

Figure 3

Answer: X = -1 is a solution of the equation.

The equation is a cubic, so there are two other solutions. If all three solutions are real numbers then the solution found depends on the initial guess given. Try finding a different solution.

Example 2: Solve the same polynomial equation with a guess of –50.

Solution: Store the new guess in the variable:

5 0 +/– ↱ STO X

Enter equation mode again by typing EQN. The equation is shown again. As equation mode stores a list of equations, it is possible to select a different equation to solve by moving up or down through the list with the up and down cursor keys below the screen. In this case the same equation is to be solved.

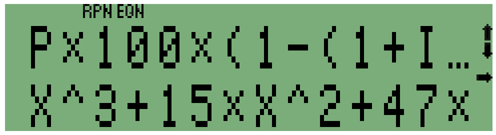


Figure 4

To solve the equation, press [↱] [SOLVE], then press [1] again to show that the formula is to be solved for X.

Figure 5

<u>Answer:</u> X = -11 is a second solution of the equation. There is a third solution, or root, which can be found if a suitable guess is tried.

Practice Example: Finding the Root of a Log Equation

<u>Example 3:</u> Polynomial equations of order up to 5 can also be solved using the polynomial solver program in the HP 35s manual, but many equations can only be solved using the function solver. Try solving the equation given at the beginning: $4x^2 - 14 \text{ LOG } (x) = 33$

<u>Solution:</u> Enter the equation as before. Go to equation mode by typing [EQN]. Type the new equation immediately below the previous one, or move up or down through the list with the up and down cursor keys below the screen to place the new equation somewhere else in the list.

Enter the equation by typing:

[4] [×] [↱] [x^2] [RCL] [X] [>] [−] [1] [4] [×] [↰] [LOG] [RCL] [X] [>] [↰] [=] [3] [3] [ENTER]

This time, x^2 has been typed by use of the [↱] [x^2] key. Note that the function name is shown as SQ in equation mode:

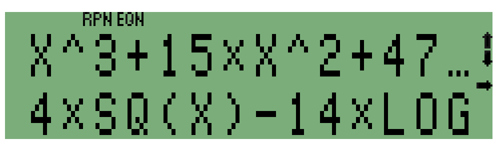


Figure 6

To solve the equation, press the [SOLVE] key. Then press [X] to show that this is the variable for which a solution is desired. A different variable name could have been used, but the same variable can be used in different equations.

The word "SOLVING" is shown as before. This time an error message follows. Although the solver knows which equation is being solved, it has started the search from the previous value stored in X, and that was –11, or one of the other negative roots of the polynomial in examples 1 and 2.

Figure 7

This shows that it can be very important to begin with a good guess. Obviously, only positive numbers should be used in the search for a solution this time. To make sure that only positive numbers are used in the search, two guesses can be given. One is the number in the variable being solved for. The other is the number displayed in the lower line of the screen. These can be the same, in which case the HP 35s generates its own second guess. In this example, try using 1 and 10 as the guesses: Press the cancel key C key at the bottom left of the keyboard twice, to cancel the error message, and to leave equation mode. Then enter the two guesses, and solve again.

C C 1 ↱ STO X ↰ 10^x EQN ↱ SOLVE X

Figure 8

Answer: Unlike the results of examples 1 and 2, the answer is not a whole number. To 12 significant figures it is 3.16227766017. The true answer is √10, which is an irrational number and can not be displayed exactly on a calculator.

The Solver provides additional information about the solution it has found. If the example was tried in RPN mode, press the back-arrow key ← to remove the text "X=" from the upper line. (Figure 9 shows the display in the ALL setting).

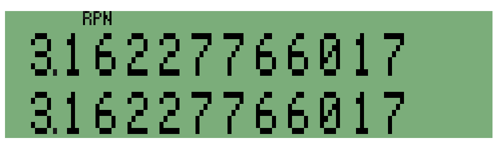


Figure 9

In RPN mode the lower line is stack register X and shows the best value that the solver could find. The upper line, stack register Y, shows the previous value tried. If two are the same then this is an exact solution. Register Z shows the value of the formula using the best answer. Press R↓ to see the value in register Z.

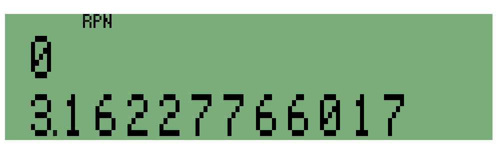


Figure 10

The number in Z is now on the upper line. It is zero, which means that 3.16227766017 is an exact solution to the 12 digit precision of the HP 35s.

The Solver works in the same way in Algebraic mode, but to see the previous value tried and the best answer, press the R↓ key to see a menu.

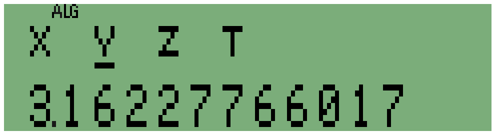


Figure 11

The number in x is the best answer, the number in y, shown in Figure 11, is the previous value, and the number in z is the value of the formula. Use the left and right arrow keys to see each of these numbers, and press [ENTER] to copy the number shown into a calculation.

If the numbers in stack registers X and Y differ by 1 in the last digit then there is no solution exactly correct to 12 digits, and the two values are on either side of the exact answer. This is confirmed if the value in stack register Z is very small. Press [C] to cancel the menu.

If an error condition has occurred, such as the log of a negative number, and the Solver has not yet calculated **f(x)** at two values of **x**, then the three values will not have been put on the stack or in the menu.

Practice Example: Where there is no solution

Example 4: Sometimes a formula or equation has no exact or approximate solution. For example $a^2 = -4$ clearly has two complex roots a = (0,2) and (0,-2), but no real root that the solver can find. Try solving this to see how the formula solver handles such cases.

The formula solver always begins by moving everything from the right of the equals sign to the left side, so the above equation would become $a^2 + 4 = 0$. Then it looks for a value of the variable to make the left hand side equal to zero. If the formula to be solved already has zero to the right of the equals sign, then there is no need to include "= 0", only the formula to be solved needs to be typed.

Solution: Go to equation mode and enter the formula $A^2 + 4$

[EQN] [RCL] [A] [y^x] [2] [+] [4] [ENTER]

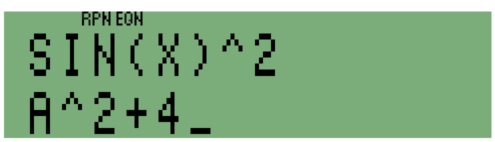


Figure 12

To solve the formula, press [↱] [SOLVE] and [A]. [A] is on the [R/S] key.

The word "SOLVING" is shown as before. There is no root, so the search can take some time. To interrupt a long-lasting search, press the cancel key [C]. If the search is not interrupted, it will finally display:

Figure 13

Answer: The solver indicated that there was no root.

What the Solver can and can not find

The examples above have shown the basics of what the formula solver can find and what it can not find.

In a formula or equation with one unknown variable the solver can find one or more roots if there are any.

If the solution can not be represented exactly, the solver finds the two nearest numbers on either side of it.

The solver can not find a solution if two or more variables are unknown.

The solver can not find complex roots, as these have two unknown variables, the real and imaginary parts. Note that the HP 35s manual has a polynomial root finder program that will find complex roots.

The solver can not find roots of matrix equations.
Note that the HP 35s manual has a matrix program for solving three simultaneous equations.

The solver can not find a root if there is no root, but in this case it can find a minimum.

If there is a solution that is not zero but is less than 10^{-499} the solver returns zero.

If there is a solution that is greater than 10^{499} the solver gives an OVERFLOW error.

If an error condition occurs in a calculation, for example the log of a negative number, the solver stops.

In addition there are some special cases that are explained in the second part of this aid.

The solver has many more features. The second part of this training aid will describe some of them.

hp calculators

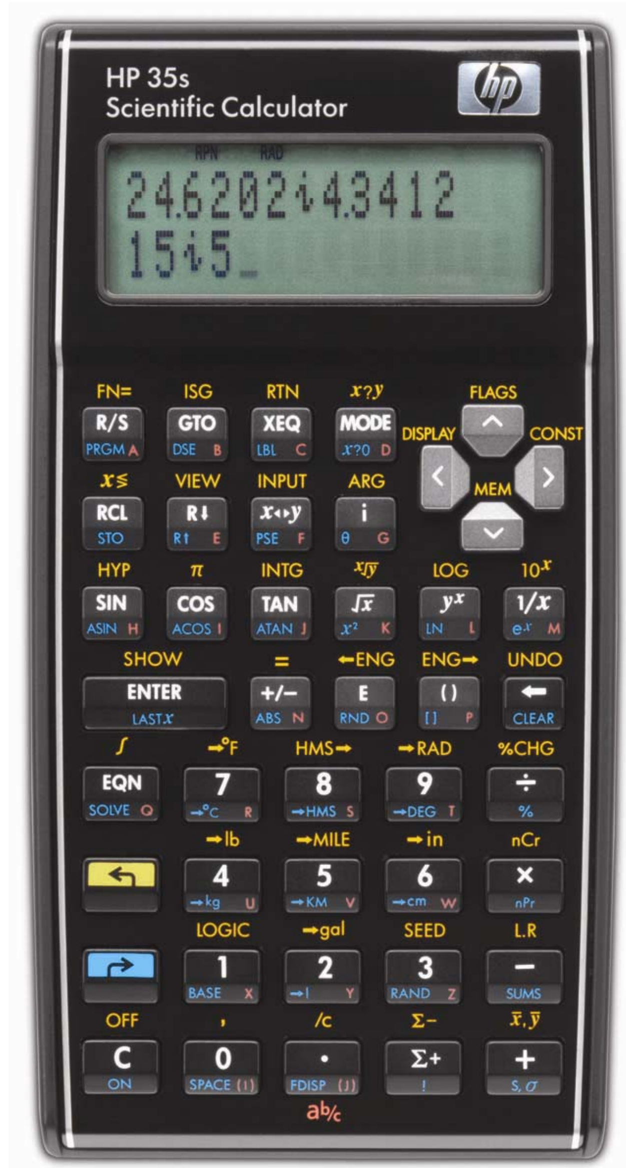
HP 35s Using the formula solver – part 2

Overview of the formula solver

Practice Example: A formula with several variables

Practice Example: A direct solution

Practice Example: Where two functions intersect



Overview of the Formula Solver

Given an expression of the form:

$$f(x) = y$$

The HP Solve Application searches for a value of **x** that gives:

$$f(x) = y = 0$$

A value of **x** for which this is true is called a **root**, and it provides a **solution** of the equation **f(x) = 0**. The graph in Figure 1 shows this graphically – there is a root at the value of **x** where **f(x)** is zero.

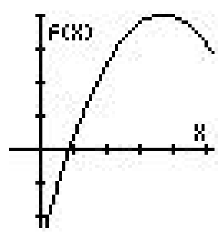


Figure 1

On the HP 35s, **f(x)** can be typed as a formula, in equation mode, or it can be typed as a program. When the Solver is used to find a root of a formula or equation typed in equation mode, it is referred to as the Formula Solver.

Part 1 of this training aid provided an introduction to the Formula Solver, using a few simple examples. This second part explains how the Solver works, and shows some more examples.

The Formula Solver works with **f(x)** as a **formula** containing **x**, for example

$$3x^2 - 3x - 15 \quad \text{or} \quad 5\sin(x) - 7\log(x)$$

If the Formula Solver is given an **equation** with terms on both sides of the equals sign, such as:

$$3x^2 + 4x = 7x + 15$$

then it begins by moving everything to one side of the equals sign, so the above equation would become the formula:

$$f(x) = 3x^2 - 3x - 15 = 0$$

The Formula Solver ignores the **= 0** part, as it is trying to find a value for **x** to make the formula zero. So there is no need to type an equation with **= 0** in it; it is enough to type the formula.

The variable **x** in the above is called the **unknown variable**. It can be represented by any of the HP 35s variables A through Z. A formula can contain more than one variable, the Solver will ask which is the unknown variable and will then ask for the **known values** of all the other variables.

The Formula Solver then tries to rearrange the equation **f(x) = 0** to give a **direct solution** for **x**. An example will be shown later.

If a direct solution is not found, the Solver begins by first trying two guesses for the unknown variable. The user can give one or two guesses for the Solver to start from. The first part showed that this can be very useful, either to direct the Solver **towards** one root of several, or to direct the Solver **away** from values that would cause an error. Good guesses can also speed up the search for a root. In some cases the function varies very slowly over some values, and a good guess is needed to direct the Solver away from them and towards the range of values where a solution is expected.

Beginning from the values obtained for the first two guesses, the Solver searches for values of the unknown variable that make **f(x)** smaller. If two guesses have the opposite sign, the Solver tries to narrow down the region between them until it finds where the sign changes and **f(x)** is zero. If two guesses have the same sign, the Solver uses the difference between them to pick the direction in which to change **x** to look for a third value closer to zero.

The process is repeated until one of the following happens.

A value of **x** is found for which **f(x)** is exactly zero.

Two neighboring values of **x** are found, differing by 1 or 2 in the twelfth significant digit, such that **f(x)** changes sign between them. An example of this was given in part 1.

No value can be found, but the Solver finds a minimum. An example was given in part 1.

No value can be found because the Solver is looking at values of **x** for which **f(x)** is constant.

No value can be found because **f(x)** is decreasing asymptotically towards a non-zero value.

Two more cases arise because the HP 35s works with a finite range of numbers, negative numbers between -10^{500} and -10^{-499}, 0 and positive numbers between $+10^{-499}$ and $+10^{500}$. This range is sufficient to cover all physical measurements, and even all numbers in government finances, but problems in number theory and in combinatorial operations may require numbers outside this range. (To be exact, the largest absolute value that the HP 35s can work with is 9.99999999999E499.)

No value can be found because the root is at a value of **x** that is not zero but lies between -10^{-499} and $+10^{-499}$. In such a case the Solver gives a result of 0.

No value can be found because the root is at **x** that is more negative than, or equal to, -10^{500} or greater than or equal to $+10^{500}$. In such a case the Solver stops with an OVERFLOW error.

To help the user distinguish between the above, the Solver returns the last value it tried for x, the last but one value tried, and the value of f(x) at the last value. Part 1 showed how these values can be seen in RPN mode and in Algebraic mode.

The following examples show some of the features that were not included in part 1.

Practice Example: A formula with several variables

Example 1: A factory is to produce tin cans with a volume of 100 cubic centimeters. The designer estimates that the height should be 10 cm and the radius about 2 cm. Calculate the exact volume of this can, and if it is not close to 100 cubic centimeters then recalculate the radius to give the required volume.

Solution: The equation for a cylinder's volume V, given its radius r, and height h, is $V = \pi r^2 h$. Enter this as the formula $\pi r^2 h - V$ in equation mode and then use the Solver.

Go to equation mode by typing [EQN]. If necessary, put the new equation in a particular place in the list of equations by moving up or down through the list with the up and down cursor keys below the HP 35s screen.

Enter the formula by typing:

[↰] [π] [×] [RCL] [R] [y^x] [2] [×] [RCL] [H] [−] [RCL] [V] [ENTER]

As was explained in part 1, to enter a variable into an equation, press the [RCL] key and then one of the letter keys. As with [↱] [STO], the symbol A..Z at the top of the screen is shown as a reminder that one of the keys marked A through Z must be pressed. For example press the [5] key to enter the variable V.

Figure 2

To solve the equation, press the [↱] [SOLVE] key. The Solver asks which variable to solve for:

Figure 3

The symbol A..Z is at the top of the screen again. The variable in this formula is V so press [5] again. The Solver now knows that V is the unknown variable and it asks for the values of the known variables.

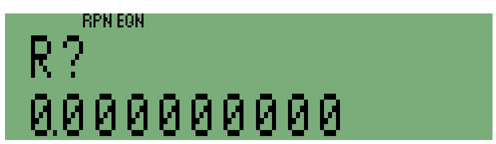


Figure 4

The value that is already stored in R is shown too. If this is the required value then it is enough to press [R/S]. If the variable R has not been used before, then its value is zero. In this example, type the radius 2 and press [R/S].

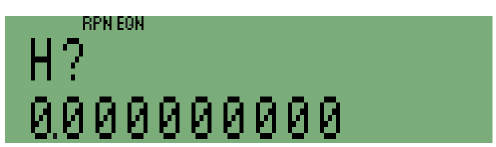


Figure 5

The Solver asks for the other known variable. Type the height, 10, and press [R/S] again. The HP 35s displays SOLVING for a moment, then the result.

Figure 6

The volume is over 125 cubic centimeters, considerably more than the intended 100. Repeat the calculation, but this time use the known volume of 100, and solve for the radius. Solve the equation again by pressing [EQN] [↱] [SOLVE]. The Solver asks for the unknown variable, press [R]. The Solver then asks for the known variables, first H.

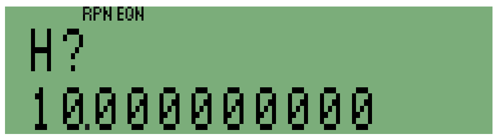


Figure 7

The present value of H is the value previously given. As this is to remain the same, just press [R/S] again. The Solver now asks for the other variable, V.

Figure 8

The present value of V is shown; this is the volume just calculated. As the volume should be 100, type 100 and press [R/S]. The Solver calculates and displays the radius needed to give the required volume.

Figure 9

<u>Answer:</u> The cans should have a radius of 1.78 cm.

Practice Example: A direct solution

<u>Example 2:</u> To show that the HP 35s looks for a direct solution before starting to search for a root, try to solve ln(z) = 0 beginning from a negative number for the guess.

<u>Solution:</u> Store –5 in Z. Then store LN(z) as the formula to solve. This means that a solution is wanted for the equation LN(z) = 0.

[5] [+/–] [↱] [STO] [Z] [EQN] [↱] [LN] [RCL] [Z] [ENTER]

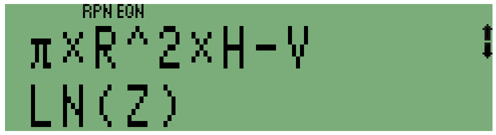


Figure 10

To solve the equation, press SOLVE Z. The Solver immediately displays the answer:

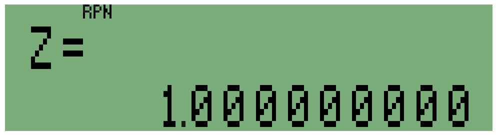


Figure 11

<u>Answer:</u> Z = 1 is the solution to LN(z) = 0. This is obvious, the point of this example is that the answer was found immediately, and the negative guess was not tried. If the negative guess had been tried, it would have caused a LOG(NEG) error, as in Example 3 of part 1. The Formula Solver recognized that Z appears only once in the formula, and that LN(Z) = 0 can therefore be rewritten as Z = exp(0) to solve for Z directly. Such direct solutions can speed up the use of Solver, specially when a complicated formula with several variables is being solved several times for different variables.

Note: Where more than one solution is possible, for example ASIN(Y)=0, the direct solution is the "principal" value. For example, for ASIN(Y)=0, this is 0 degrees, not 180 degrees, or –180 degrees, or any other possible value. In the same way, an equation such as $X^2=4$ is solved directly and returns the positive root 2. To find other roots, it is necessary to write the expression in such a way that the Solver does not find a direct solution. An easy way to achieve this is to add $0\times$ the unknown variable into an expression, for example ASIN(Y) + $0\times$Y = 0 or $X^2 + 0\times X = 0$. This is because the Solver stops looking for a direct solution as soon as it sees the unknown variable more than once in an expression.

Practice Example: Where two functions intersect

The Formula Solver can also be used to solve problems of the form:

$$\mathbf{g(x) = h(x)}$$

This requires a value of **x** at which one function **g(x)** is equal to another function **h(x)**. In other words, the problem is to find **x** at which these functions intersect.

The equation can be rewritten as:

$$\mathbf{f(x) = g(x) - h(x) = 0}$$

Solving the formula g(x) – h(x) will give the value of x at which the two functions cross over.

<u>Example 3:</u> The factory from Example 1 is interested in designing spherical containers with the same volume and the same radius as their tin cans. This means that they want to find a radius r such that:

$$\mathbf{V = \pi r^2 h = 4/3 \pi r^3}$$

<u>Solution:</u> Modify the formula from Example 1 to find r such that $\pi r^2 h - 4/3 \pi r^3$ is zero.

A quick look at this expression shows that one solution is r = 0. This is not a useful solution so it would be helpful to provide a guess to direct the Solver away from zero. One guess is the value already in R. Type 8 on the lower line of the display as the second guess.

Go to equation mode by typing [EQN]. Find the old equation by moving up or down through the equation list with the [▲] and [▼] keys.

Begin editing the formula by pressing the left cursor key [◄]. The cursor appears at the end of the formula.

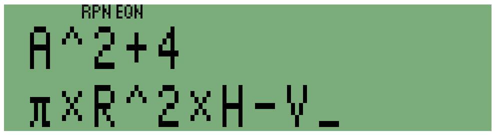


Figure 12

Press [←] to delete the V. Then type the formula for the volume of a sphere.

[4] [÷] [3] [×] [↰] [π] [×] [RCL] [R] [y^x] [3] [ENTER]

Press the right-arrow [►] key a few times to see the last part of the changed formula. It should look as in Figure 13.

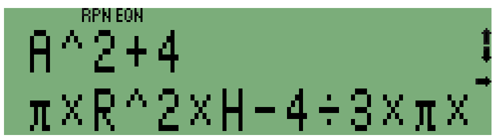


Figure 13

To solve the equation, press the [SOLVE] key. The Solver asks which variable to solve for: The unknown variable is R so press [R]. The Solver now asks for the value of the known variable H.

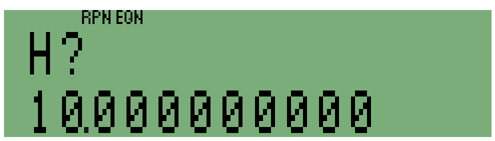


Figure 14

This value is to stay unchanged, so press [R/S]. The Solver looks for a solution.

Figure 15

<u>Answer:</u> If both the radius of the sphere and that of the base of the cylindrical can are 7.5 then the sphere and the can will have the same volume.

The Solver can be used for many kinds of problems, further information is given in the HP 35s manual, and a detailed description of the Solver is provided in Appendix D of the manual.

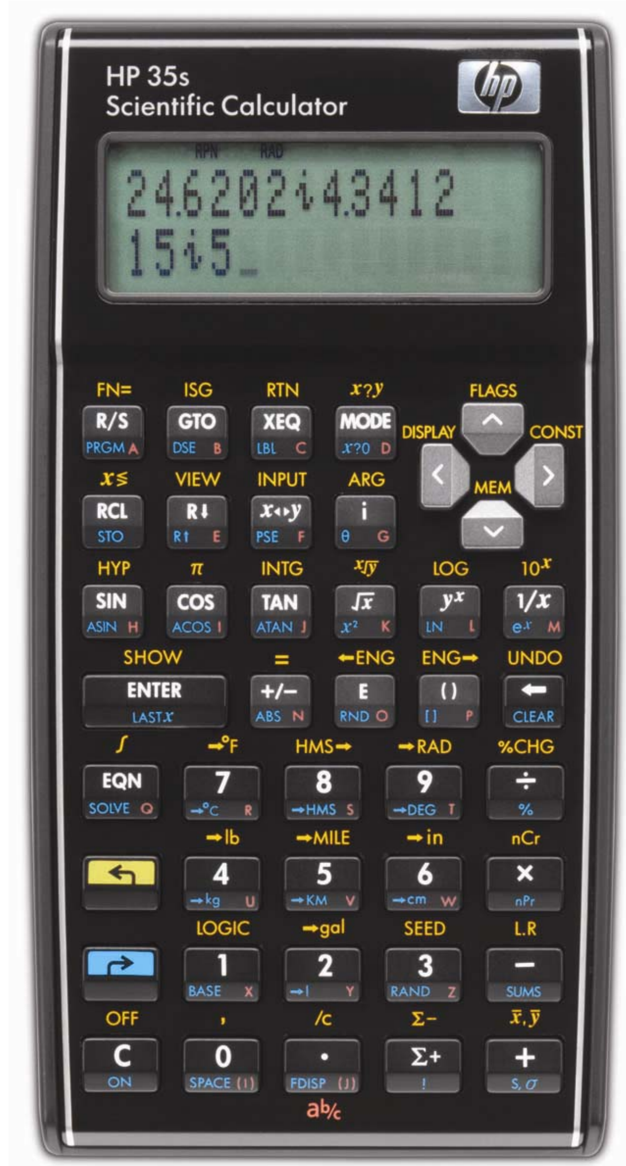
hp calculators

HP 35s Solving numeric integration problems

Numeric integration

Using the integration function

Practice solving numeric integration problems



Numeric integration

Numeric integration has many uses in different areas of science. One of the more common ways to visualize integration is that of the area under a curve to the X-axis between two points.

Using the integration function

The HP 35s has a very powerful numeric integrator built into the calculator. This function is found above the EQN key and is access by pressing ⬑ ∫. The method used in this training aid will be to enter the function to integrate as an equation and then to integrate it between an upper and lower limit of integration.

The general approach to integrate an equation will be:

Step 1: If the equation that defines the integrand's function isn't stored in the equation list, key it in and leave Equation mode. The equation usually contains just an expression.

Step 2: Enter the limits of integration:

in RPN mode, key in the lower limit and press ENTER, then key in the upper limit;

in algebraic mode, key in the lower limit, press x↔y, then key in the upper limit.

Step 3: Display the equation: Press EQN and, if necessary, scroll through the equation list (press the ↓ or ↑ cursor keys) to display the desired equation.

Step 4: Select the variable of integration: Press ⬑ ∫ and then press the appropriate key on the HP 35s to indicate the proper variable. This starts the calculation.

Note that using the integration function uses much more of the calculator's memory than any other operation and, although highly unlikely, if a MEMORY FULL message is shown, refer to appendix B in the HP 35s manual for more information on what steps to take.

You can halt a running integration calculation by pressing C or R/S. However, no information about the integration is available until the calculation finishes normally.

The display format setting chosen through the ⬑ DISP menu affects the level of accuracy assumed for your function and used for the result. The integration is more precise but takes much longer in the **ALL** setting (⬑ DISP 4) and in the **FIX** (⬑ DISP 1), **SCI** (⬑ DISP 2), and **ENG** (⬑ DISP 3) modes with more digits displayed. The uncertainty of the result ends up in the Y–register, pushing the limits of integration up into the T– and Z–registers.

This training aid cannot begin to illustrate the wide range of applications available using the built-in numeric integration function, but it can illustrate some of the more common uses. For additional information, see chapters 8 and 15 of the HP 35s User’s Guide.

Practice solving numeric integration problems

Example 1: Integrate the function 1/X from 1 to 10. Use FIX 4 as the display setting.

Solution: In either RPN or algebraic mode: [↰] [DISP] [1] [4] [EQN] [1/x] [RCL] [X] [ENTER]
The display should look similar to the one shown in Figure 1. Note, if you have other equations already in the HP 35s calculator, the top line of the display may not indicate "3*3 lin. solve" but may show another equation.

Figure 1

To show the checksum and length of this equation, press the following in RPN or algebraic mode

In RPN or algebraic mode: [↰] [SHOW]

Figure 2

If the checksum of the equation just entered does not equal B3AA, then you have not entered it correctly. To exit equation mode, press:

In RPN or algebraic mode: [EQN]

Now enter the lower and upper limits of the integration.

In RPN mode: [1] [ENTER] [1] [0] [EQN]

In algebraic mode: [1] [x↔y] [1] [0] [EQN]

Integrate the function using X as the variable of integration.

[↰] [∫] [X]

After a few moments, the HP 35s will display the answer shown below.

Figure 3

Now view the uncertainty of the result.

In RPN mode: [C]

In algebraic mode: [R↓]

Figure 4

Answer: The area under the 1/X curve from 1 to 10 is approximately 2.3026. Figure 4 shows the uncertainty of the result assuming algebraic mode. In RPN mode, the uncertainty is shown in the second level of the stack.

Example 2: Integrate the function $\text{Sin}^2(X)$ from 0 to ∏. Use FIX 4 as the display setting. Make sure the HP 35s is in radians mode.

Solution: In either RPN or algebraic mode: [↰] [DISP] [1] [4] [MODE] [2]
[EQN] [SIN] [RCL] [X] [>] [y^x] [2] [ENTER]

Note: It is possible to write the equation using the [x^2] function, but the equation displayed using the [y^x] function is may be clearer to read. The display should look similar to the one shown in Figure 5.

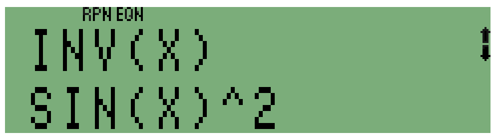


Figure 5

To show the checksum and length of this equation, press the following in RPN or algebraic mode. Note that the symbol [⟶] means to press the right arrow cursor key.

In RPN or algebraic mode: [↰] [SHOW]

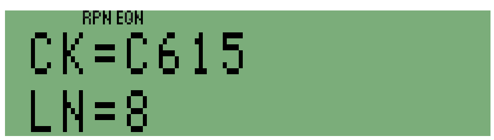


Figure 6

If the checksum of the equation just entered does not equal C615, then you have not entered it correctly. To exit equation mode, press:

In RPN or algebraic mode: [EQN]

Now enter the lower and upper limits of the integration.

In RPN mode: [0] [ENTER] [↰] [π] [EQN]

In algebraic mode: [0] [$x\leftrightarrow y$] [↰] [π] [EQN]

Integrate the function using X as the variable of integration.

[↰] [∫] [X]

After a few moments, the HP 35s will display the answer shown below.

Figure 7

Now view the uncertainty of the result.

In RPN mode: C

In algebraic mode: R↓

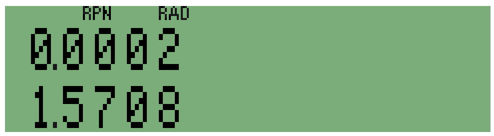


Figure 8

<u>Answer:</u> The area under $\text{Sin}^2(X)$ from 0 to ∏ is approximately 1.5708. The uncertainty of the result is 0.0002, as shown in the Y level of the stack, in Figure 8 (assuming RPN mode).

<u>Example 3:</u> Integrate the function shown below from 0 to 2∏. Use FIX 4 as the display setting. Make sure the HP 35s is in radians mode.

$$\frac{1}{1-\text{COS}(X)+0.25}$$

Figure 9

<u>Solution:</u> In either RPN or algebraic mode: ↰ DISP 1 4 MODE 2
EQN 1 ÷
( ) 1 − COS RCL X > + 0 . 2 5
ENTER

The display should look similar to the one shown in Figure 10.

Figure 10

To show the checksum and length of this equation, press the following in RPN or algebraic mode. Note that the symbol ⟶ means to press the right arrow cursor key.

In RPN or algebraic mode: ↰ SHOW

Figure 11

If the checksum of the equation just entered does not equal BB03, then you have not entered it correctly. To exit equation mode, press:

In RPN or algebraic mode: EQN

Now enter the lower and upper limits of the integration. Note that the algebraic keystrokes are to allow for the computation of the upper limit of integration.

In RPN mode: [0] [ENTER] [↰] [π] [2] [×] [EQN]

In algebraic mode: [2] [×] [↰] [π] [ENTER] [x↔y] [0] [x↔y] [EQN]

Integrate the function using X as the variable of integration.

[↰] [∫] [X]

After a few moments, the HP 35s will display the answer shown below.

Figure 12

Now view the uncertainty of the result.

In RPN mode: [C]

In algebraic mode: [R↓]

Figure 13

<u>Answer:</u> The area under the function from 0 to 2∏ is approximately 8.3776. The uncertainty in the result is 0.0008. Figure 13 assumes algebraic mode. In RPN mode, the uncertainty is shown in the second level of the stack.

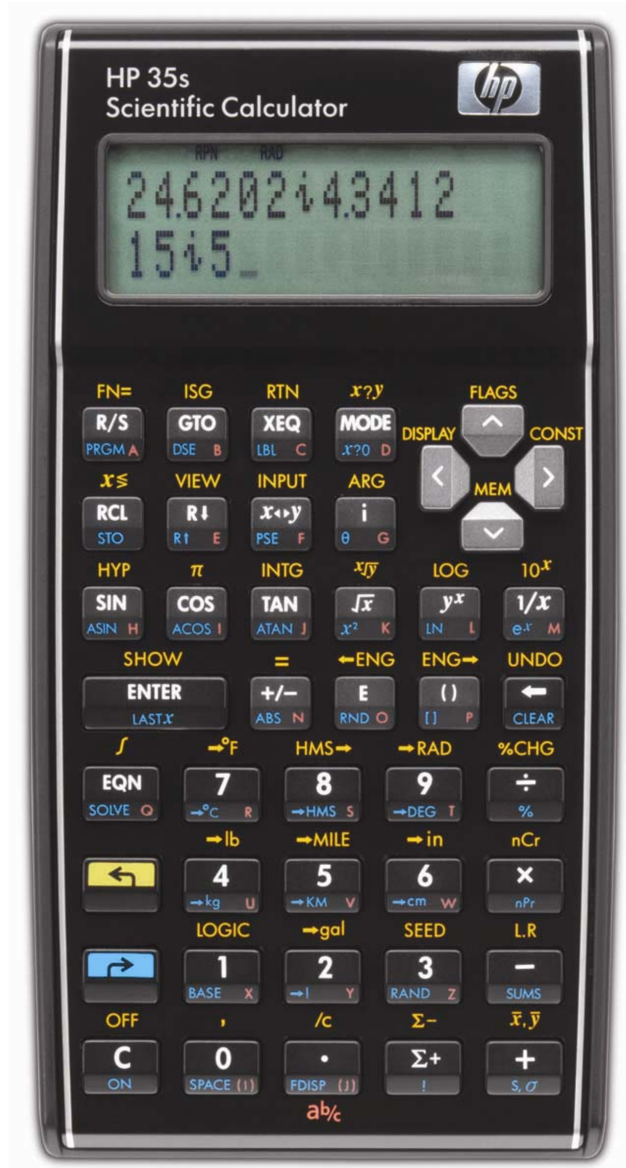
hp calculators

HP 35s Solving Trigonometry Problems

The trigonometric functions

Trigonometric modes

Practice working problems involving trig functions



The trigonometric functions

The trigonometric functions, sine, cosine, tangent, and related functions, are used in geometry, surveying, and design. They also occur in solutions to orbital mechanics, integration, and other advanced applications.

The HP 35s provides the three basic functions, and their inverse, or "arc" functions. These work in degrees, radians and gradians modes. In addition, π is provided as a function on the left-shifted "cos" key, and the sign function is found in the INTG menu on the left-shifted "tan" key.

The secant, cosecant and cotangent functions are easily calculated using the COS, SIN, and TAN keys respectively, followed by $1/x$. To help remember whether the secant function corresponds to the inverse sine or cosine, it can be helpful to note that the first letters of "secant" and "cosecant" are inverted in relation to those of "sine" and "cosine", just as the secant and cosecant are the inverted cosine and sine functions.

The display mode can be changed to show either rectangular and radial coordinates. This can therefore be useful in some trigonometric calculations.

Trigonometric modes

The HP 35s can calculate trigonometric functions in any of these three modes: Degrees, Radians or Gradians.

Practice working problems involving trig functions

<u>Example 1:</u> Select the appropriate angle mode.

<u>Solution:</u> Press the MODE key.

Figure 1

Press 1, 2 or 3 to select DEGrees, RADians or GRADians mode, or use the arrow keys ◄, ►, ▲ and ▼ to select the required mode and then press ENTER. For example, to select RAD, press 2.

<u>Answer:</u> The selected trigonometric mode is displayed at the top of the screen if it is RAD or GRAD. If no angle mode is shown, then it is degrees. The MODE command works the same way in algebraic and in RPN modes.

There are 360 degrees, or 2 π radians in a circle. Gradians mode divides each quarter of a circle into 100 parts, in a sort of decimal system, making 400 gradians in a circle.

Note: It is very easy to forget that one angle mode is set but angles are being entered in a different mode. It is a good policy to make it a habit to check the angle mode before every calculation. The commands DEG, RAD and GRAD can be entered into programs, and it is worth using them to ensure that a program will work as required.

<u>Example 2:</u> What is the sine of π/2 radians?

Solution: In RPN mode, calculate π/2, then press [SIN].

[↰] [π] [2] [÷] [SIN].

In algebraic mode, press [SIN] then calculate π/2.

[SIN] [↰] [π] [÷] [2] [ENTER].

```
SIN(π÷2)
           1.000
```

Figure 2

Answer: The sine of π/2 radians is calculated as exactly 1

Example 3: Show that the rule $\sin^2(x) + \cos^2(x) = 1$ applies correctly when x is 30°.

Solution: First, remember to set the required angle mode. Press [MODE] [1].

In algebraic mode:

[↱] [x^2] [SIN] [3] [0] [>] [>] [+] [↱] [x^2] [COS] [3] [0] [ENTER]

```
SQ(SIN(30))+S…
           1.000
```

Figure 3

In RPN mode:

[3] [0] [SIN] [↱] [x^2] [3] [0] [COS] [↱] [x^2] [+]

```
1.000
1.000
```

Figure 4

Answer: Both the algebraic and the RPN calculations confirm that the rule $\sin^2(x) + \cos^2(x) = 1$ applies correctly when x is 30°.

Example 4: 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: Use the cosine rule to calculate the angle. The cosine rule states that for any triangle with sides a, b and c, and angle A facing side a:

$$a^2 = b^2 + c^2 - 2 \cdot b \cdot c \cdot \mathrm{COS}(A)$$

Figure 5

From this, A can be calculated as:

$$A=ACOS\left(\frac{b^2+c^2-a^2}{2\cdot b\cdot c}\right)$$

Figure 6

In RPN mode, the calculation can be done like this:

[5] [↱] [x^2] [3] [↱] [x^2] [+] [7] [↱] [x^2] [−] [2] [÷] [5] [÷] [3] [÷] [↱] [ACOS]

In algebraic mode, calculate:

[↱] [ACOS] [( )] [↱] [x^2] [5] [>] [+] [↱] [x^2] [3] [>] [−] [↱] [x^2] [7] [>] [>] [÷] [2] [÷] [5] [÷] [3] [ENTER]

Figure 7

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.

Example 5: A ladder is leaning against a vertical wall. The ladder is 6 meters long and the foot of the ladder is 3 meters from the base of the wall. What is the angle between the top of the ladder and the wall?

Solution: In RPN mode, divide the side opposite the angle by the long side and get the arc sine:

[3] [ENTER] [6] [÷] [↱] [ASIN]

In algebraic mode, press:

[↱] [ASIN] [3] [÷] [6] [ENTER].

Figure 8

Answer: The ladder is at an angle of 30 degrees from the wall.

Example 6: A vector has components –5 in the X direction and –8 in the Y direction. In what direction does it point?

Solution: It would be possible to divide –5 by –8 and calculate the arc tangent, giving approximately 32 degrees, but this would not specify the quadrant in which the vector lies. Fortunately, the 35s complex display modes provide a way to view the complete arc tangent function that recognizes in which quadrant an angle lies.

The solution is the same in either RPN or algebraic mode.

First, set the display mode to rΘa.

Then, enter the Y magnitude, press the [i] key, and enter the X magnitude. Then press [ENTER].

[8] [+/-] [i] [5] [+/-] [ENTER]

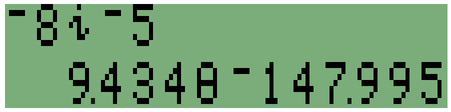


Figure 9

Answer: The vector direction is very nearly –148 degrees as indicated by the value shown after the Θ.

Example 7: A program is being written to automate calculations with vectors. The program needs to know whether the Y component of directions in calculations such as the above is in the +Y or the –Y direction. How can the direction be obtained?

Solution: The SIGN function (the first choice in the [↰] [INTG] menu) gives the sign of a number, +1 or –1. Thus it is enough to obtain the sign of the angle calculated in the previous example and to check whether it is +1 or –1.

In RPN mode follow the above calculation with:

[↰] [ARG] [↰] [INTG] [ENTER]

In algebraic mode follow the above calculation with:

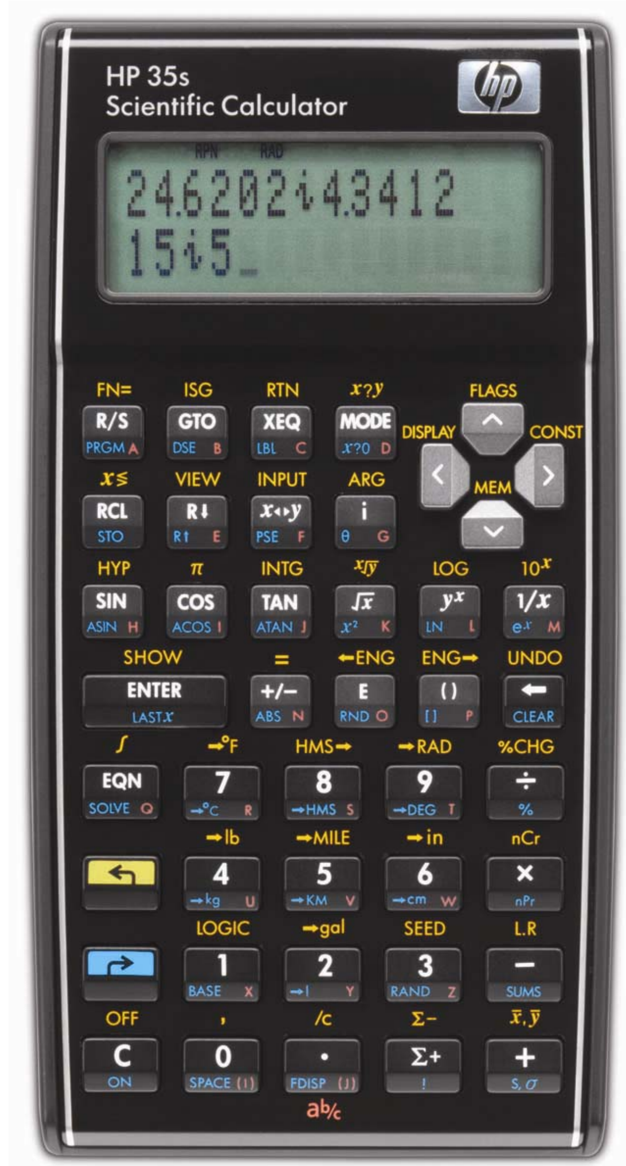
[↰] [INTG] [ENTER] [↰] [ARG] [↱] [LAST x] [ENTER]

Figure 10

Answer: The sign is –1, so the vector direction is down, not up. Note that the [ENTER] following [↰] [INTG] will choose the first option in the displayed menu.

hp calculators

HP 35s Solving systems of linear equations



Systems of linear equations

Using the built-in solver equations

Practice solving linear systems

Systems of linear equations

A system of linear equations is a set of linear equations involving two or more variables. A basic problem is to determine if there are values for the variables that will allow each equation in the set to be solved so that the left side of the equation equals the right side of the equation. Linear systems appear in many applications such as forecasting, optimization, etc. Systems are often described as 2x2, 3x3, 4x4, etc., referring to the number of variables and the number of equations in the set.

An example of a 2x2 linear system might be:

$$\begin{aligned} 3X + \;\; Y &= 10 \\ X - 2Y &= 8 \end{aligned}$$

which has the solution set of { X = 4, Y = -2 }. Not every system of linear equations has a solution. Other systems have an infinite number of solutions.

Using the built-in solver equations

The HP 35s two build-in solver equations to find solutions to 2x2 and 3x3 linear systems. These can detect situations where no solution exists or where an infinite number of solutions exist. These solver equations are part of the HP 35s ROM and are always present at the top of the equation list. If you press [EQN], then the two equations should be visible as shown below (if you have entered equations of your own, then you may need to use the up or down cursor keys to move through the equation catalog to find them):

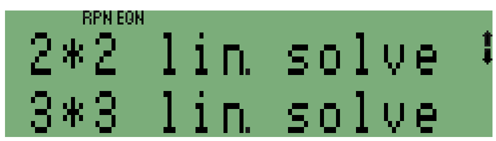


Figure 1

The equation at the bottom of the display is the one that will be solved when [↱] [SOLVE] is pressed.

These equations store the values from the linear system into the lettered variables/registers beginning with A. 2x2 systems require a total of 6 coefficients to be entered. In this example system,

$$\begin{aligned} 3X + \;\; Y &= 10 \\ X - 2Y &= 8 \end{aligned}$$

the coefficient 3 (from the 3 X term) would be stored into A, the 1 (from the implied 1 in front of the Y term) would be stored into B, the constant 10 would be stored into C, the 1 (from the implied 1 in front of the X in the second linear equation) would be stored into D, the -2 into E, and the 8 into F.

A 3x3 system would use a total of 12 lettered variables/registers, A through L.

Practice solving linear systems

<u>Example 1:</u> Solve the 2x2 linear system:

$$\begin{aligned} 3X + \;\; Y &= 10 \\ X - 2Y &= 8 \end{aligned}$$

Solution: In either RPN or algebraic mode, make sure the "2*2 lin. solve" equation is shown at the bottom of the equation screen and press [↱] [SOLVE] equation is. The display should appear like the one below before beginning the solution by pressing [↱] [SOLVE].

Figure 2

Figure 3

The HP 35s prompts you to enter the value of the first coefficient. It displays the current contents of the A register in case you wish to use it again. If you have previously stored a value into A, it may not show 0.0000 as depicted above.

In RPN or algebraic mode: [3] [R/S]

Figure 4

The HP 35s now prompts for the second coefficient which it will store in B.

In RPN or algebraic mode: [1] [R/S]

Continue to enter the remaining coefficients as below.

In RPN or algebraic mode: [1] [0] [R/S]
In RPN or algebraic mode: [1] [R/S]
In RPN or algebraic mode: [2] [+/-] [R/S]
In RPN or algebraic mode: [8] [R/S]

After entering the last coefficient, the HP 35s displays the solution found beginning with X, as shown below. To view the solution for Y, press the down cursor key, [▽].

Figure 5

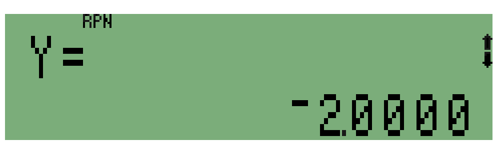


Figure 6

<u>Answer:</u> The system has the solution X = 4, Y = -2.

<u>Example 2:</u> Solve the 3x3 linear system:

$$\begin{aligned} 4X + 5Y + Z &= 0 \\ 3X + 2Y - Z &= 7 \\ -1X + 112Y + 3Z &= 127 \end{aligned}$$

.

<u>Solution:</u> In either RPN or algebraic mode, make sure the "3*3 lin. solve" equation is shown at the bottom of the equation screen and press [↱] [SOLVE] equation is. The display should appear like the one below before beginning the solution by pressing [↱] [SOLVE].

Figure 7

Figure 8

As in the previous example, key in each coefficient and press [R/S]. The keystrokes are the same in RPN or algebraic mode.

[4] [R/S]	(stored into A)
[5] [R/S]	(stored into B)
[1] [R/S]	(stored into C)
[0] [R/S]	(stored into D)
[3] [R/S]	(stored into E)
[2] [R/S]	(stored into F)
[1] [+/-] [R/S]	(stored into G)
[7] [R/S]	(stored into H)
[1] [+/-] [R/S]	(stored into I)
[1] [1] [2] [R/S]	(stored into J)
[3] [R/S]	(stored into K)
[1] [2] [7] [R/S]	(stored into L)

After entering the last coefficient, the HP 35s displays the solution found beginning with X, as shown below. To view the solution for Y and Z, press the down cursor key, [▽].

Figure 9

Figure 10

Figure 11

To view the solutions as fractions, when X, Y, and Z are displayed, press FDISP and the results are shown as:

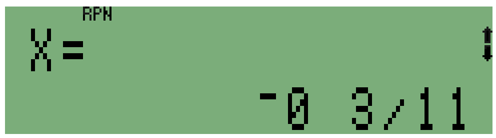


Figure 12

Figure 13

Figure 14

Answer: The solution to the system of linear equations is { X = -3/11, Y = 1 3/11, Z = -5 3/11 }

hp calculators

HP 35s Roots of polynomials

Polynomials

Roots of a polynomial

Using the SOLVE function

Practice solving for roots of polynomials

Polynomials

A polynomial is an expression containing one or more terms called monomials. These terms contain one or more variables multiplied by a constant coefficient. Each of these variables will have a positive exponent. A term may have an exponent of zero, in which case it is a constant term. A polynomial will generally not contain negative exponents or division by a term or expression containing a variable.

The degree of a polynomial is determined by the largest exponent of a variable within the expression.

Roots of a polynomial are values that when substituted into the expressions variable cause the polynomial's value to be zero. These would correspond to the X-intercept of a polynomial's graph. Some polynomials do not have roots that are real numbers. However, from the fundamental theorem of algebra, every polynomial has at least one root, if the allowable values are expanded to include complex numbers.

Roots of a polynomial

The roots of a polynomial are values of X where the value of the function of x (or the value of the polynomial) is equal to zero. For example, the polynomial $f(x) = X - 2$ has a real root at the value +2. The polynomial $X^2 - 9$ has real roots at the values of + 3 and – 3. Not every polynomial has roots that are real numbers. For example, the $X^2 + 4$ has no real roots, meaning there are no real values for X that will cause $X^2 + 4$ to equal zero.

Using the SOLVE function

The HP 35s has a very powerful root finding capability built into its SOLVE function. As applied in this training aid, the SOLVE function, accessed by pressing the [SOLVE] key, will be used to find roots from user-written programs computing the value of a function. This will involve entering a small program, keying in a small equation into the program using a variable, indicating to the HP 35s which variable is being considered as the current function, and then solving for the value of that variable when the function is equal to zero. The HP 35s knows which variable to solve for by setting the value of the function under consideration using the [↰] [FN=] function. To indicate to the HP 35s that the variable X is to be used, press [↰] [FN=] [X].

This training aid cannot begin to illustrate the wide range of applications available using the built-in solver, but it can illustrate some of the more common uses.

Practice solving for roots of polynomials

Example 1: Solve for the roots of $4X^2 - 2X - Y = 12$

Solution: First, rearrange the equation so that the variable Y is isolated. This is necessary to use the SOLVE function as we are doing in this training aid. The rearranged equation is $Y = 4X^2 - 2X - 12$. This is a polynomial.

We're looking for values of X such that $4X^2 - 2X - 12 = 0$. First, we'll enter a program that computes the value of the function. If a program already exists in program memory with the name of X, then it will need to be cleared. This can be done by pressing [↰] [MEM] [>] [ENTER] to have the HP 35s display the list of programs in the calculator and then press [∨] to step through the program labels. When the label of the program to be deleted is shown in the display, pressing [↱] [CLEAR] will delete that program from the calculator's memory. Pressing [C] will then clear the display and allow you to proceed.

In RPN or algebraic mode: [↱] [PRGM] [↱] [LBL] [X] [EQN]
[4] [×] [RCL] [X] [y^x] [2] [−] [2] [×] [RCL] [X] [−] [1] [2] [ENTER]
[↰] [RTN]

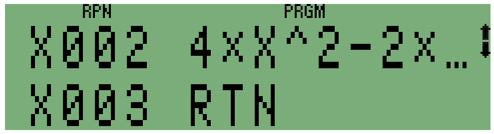


Figure 1

To show the checksum and length of this program, press the following in RPN or algebraic mode. Note that the symbol [>] means to press the right arrow direction of the cursor key.

In RPN or algebraic mode: [↰] [MEM] [>] [ENTER] [↰] [SHOW]

Figure 2

If the checksum of the program just entered does not equal 8BFA, then you have not entered it correctly.

To clear the checksum display press:

In RPN or algebraic mode: [↱] [PRGM]

Then, to exit the program environment, press:

In RPN or algebraic mode: [↱] [PRGM]

Store an initial guess for X of 10 into the variable X. Then set the function to X and solve for the value of X.

In RPN or algebraic mode: [1] [0] [↱] [STO] [X] [↰] [FN=] [X] [↱] [SOLVE] [X]

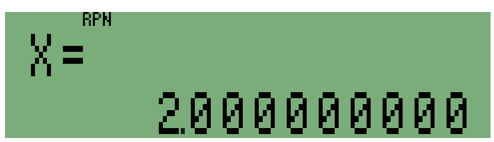


Figure 3

Since you feel this equation might have a root larger than this, store a new guess for X of 100 into the variable X. There is no need to set the function to X (since it has already been done). Then solve for the value of X.

In RPN or algebraic mode: [1] [0] [0] [↱] [STO] [X] [↱] [SOLVE] [X]

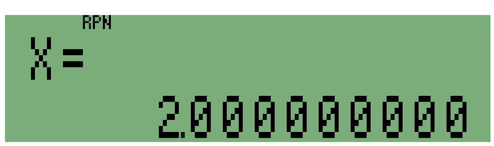


Figure 4

The same root is returned. This is a good indication (but certainly not foolproof) that there are no roots larger than +2 for this equation.

To see if there is a root less than +2 for this equation, store a new guess for X of –10 into the variable X. Then solve for the value of X.

In RPN or algebraic mode: [1] [0] [+/–] [↱] [STO] [X] [↱] [SOLVE] [X]

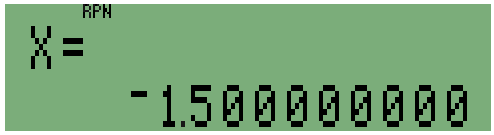


Figure 5

Answer: Roots found for the equation are –1.5 and +2. Note that the HP 35s owners manual provides much more information about providing initial guesses for the SOLVE feature.

Example 2: Solve for the roots of f(x) = (1/5) x^3 + (4/5) x^2 – (7/5) x - 2

Solution: We're looking for values of X such that (1/5) x^3 + (4/5) x^2 – (7/5) x – 2 = 0. We expect three roots.

First, we'll enter a program that computes the value of the function. If a program already exists in program memory with the name of X, then it will need to be cleared. This can be done by pressing [↰] [MEM] [>] [ENTER] to have the HP 35s display the list of programs in the calculator and then press [∨] to step through the program labels. When the label of the program to be deleted is shown in the display, pressing [↱] [CLEAR] will delete that program from the calculator's memory. Pressing [C] will then clear the display and allow you to proceed.

In RPN or algebraic mode: [↱] [PRGM] [↱] [LBL] [X] [EQN]

[1] [÷] [5] [×] [RCL] [X] [y^x] [3] [+] [4] [÷] [5] [×] [RCL] [X] [y^x] [2] [–] [7] [÷] [5] [×] [RCL] [X] [–] [2] [ENTER] [↰] [RTN]

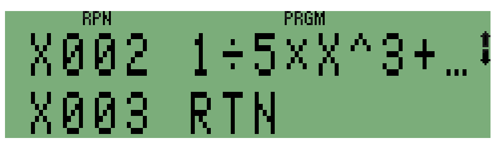


Figure 6

To show the checksum and length of this program, press the following in RPN or algebraic mode. Note that the symbol [>] means to press the right arrow direction of the cursor key.

In RPN or algebraic mode: [↰] [MEM] [>] [ENTER] [↰] [SHOW]

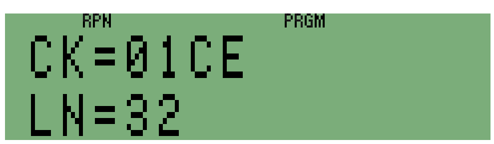


Figure 7

If the checksum of the program just entered does not equal 01CE, then you have not entered it correctly.

To clear the checksum display press: [↱] [PRGM]

Then, to exit the program environment, press: ↱ PRGM

Store an initial guess for X of 10 into the variable X. Then set the function to X and solve for the value of X.

In RPN or algebraic mode: 1 0 ↱ STO X ↰ FN= X ↱ SOLVE X

Figure 8

Since you feel this equation might have a root larger than this, store a new guess for X of 100 into the variable X. There is no need to set the function to X (since it has already been done). Then solve for the value of X.

In RPN or algebraic mode: 1 0 0 ↱ STO X ↱ SOLVE X

Figure 9

The same root is returned. This is a good indication (but certainly not foolproof) that there are no roots larger than +2 for this equation.

To see what the values of roots less than +2 for this equation might be, store a new guess for X of –10 into the variable X. Then solve for the value of X.

In RPN or algebraic mode: 2 +/- ↱ STO X ↱ SOLVE X

Figure 10

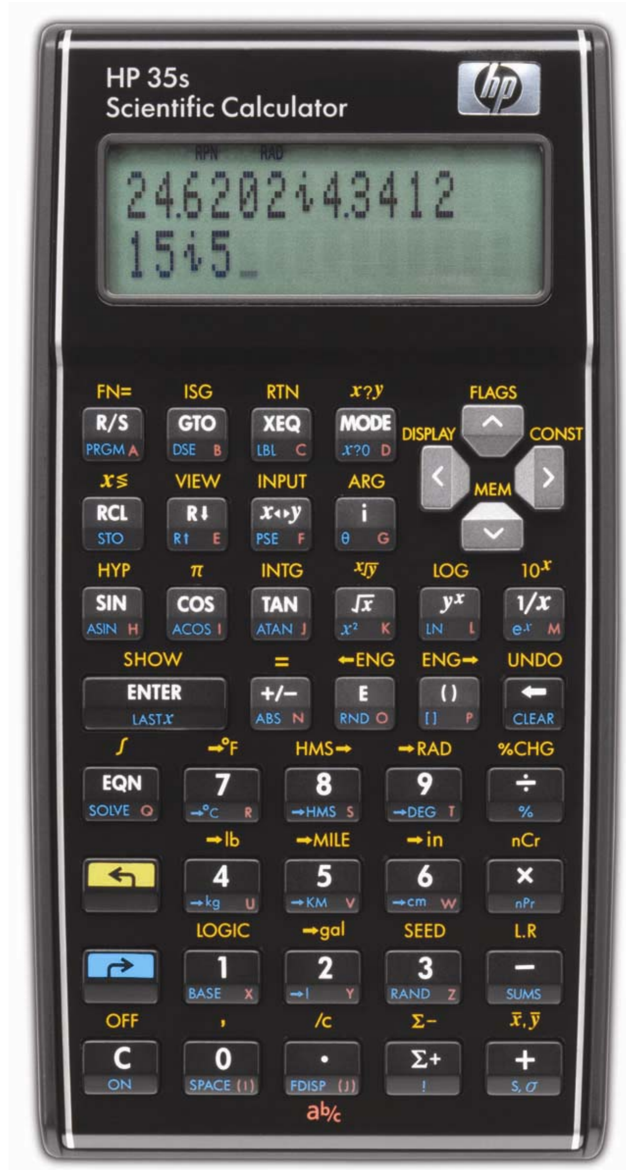
In RPN or algebraic mode: 1 0 +/- ↱ STO X ↱ SOLVE X

Figure 11

<u>Answer:</u> Roots found for the polynomial are 2, -1, and -5. Note that the HP 35s owners manual provides much more information about providing initial guesses for the SOLVE feature.

hp calculators

HP 35s Advanced uses of logarithmic functions



Log and antilog functions

Practice using log and antilog functions

Log and antilog functions

Before calculators like the HP 35s became easily available, logarithms were commonly used to simply multiplication. They are still used in many subjects, to represent large numbers, as the results of integration, and even in number theory.

The HP 35s has four functions for calculations with logarithms. These are the “common” logarithm of “x”, [↰] [LOG], its inverse, [↰] [10^x], the “natural” logarithm of “x”, [↱] [LN] and its inverse, [↱] [e^x].

Common logarithms are also called “log to base 10” and the common logarithm of a number “x” is written

$$\mathbf{LOG_{10}\ x} \quad \text{or just} \quad \mathbf{LOG\ x}$$

Natural logarithms are also called “log to base *e*” and the natural logarithm of a number “x” is written

$$\mathbf{LOG_e\ x} \quad \text{or} \quad \mathbf{LN\ x}$$

Logarithms can be calculated to other bases, for example the log to base two of x is written

$$\mathbf{LOG_2\ x}$$

Some problems need the logarithm of a number to a base n, other than 10 or *e*. On the HP 35s these can be calculated using one of the formulae

$$\mathbf{LOG_n\ x = LOG_{10}\ x \div LOG_{10}\ n}$$

$$\mathbf{LN_n\ x = LN_e\ x \div LN_e\ n}$$

[↰] [10^x] and [↱] [e^x] are also called “antilogarithms” or “antilogs”. [↱] [e^x] is also called the “exponential” function or “exp”. Apart from being the inverses of the log functions, they have their own uses. [↰] [10^x] is very useful for entering powers of 10, especially in programs where the [E] key can not be used to enter a power that has been calculated. [↱] [e^x] is used in calculations where exponential growth is involved.

The [y^x] function can be seen as the base “n” antilog function. If 10^x is the inverse of $\log_{10} x$ and e^x is the inverse of $\log_e x$, then y^x is the inverse of $\log_y x$.

Practice using log and antilog functions

<u>Example 1:</u> Find the common logarithm of 2.

<u>Solution:</u> In RPN mode type [2] [↰] [LOG]
In algebraic mode type [↰] [LOG] [2] [ENTER]

Figure 1

<u>Answer:</u> The common logarithm of 2 is very nearly 0.3010.

Example 2: A rare species of tree has a trunk whose cross-section changes as 1/x with the height x. (Obviously this breaks down at ground level and at the tree top.) The cross section for any such tree is given by A/x, where A is the cross-section calculated at 1 meter above the ground. What is the volume of the trunk between 1 meter and 2 meters above ground?

Solution: The volume is obtained by integrating the cross-section along the length, so it is given by the integral:

$$\int_1^2 \frac{A}{x}\,dx$$

Figure 2

It is possible to evaluate this integral using the HP 35s integration function, but it is much quicker to note that the indefinite integral of 1/x is LN x. The result is therefore

V = A (LN2 – LN1)

Since LN 1 is 0, this simplifies to

V=A LN2

In RPN mode type [2] [↱] [LN]. In algebraic mode type [↱] [LN] [2] [ENTER].

No one is likely to measure tree heights to an accuracy of more than three significant digits, so set the HP 35s to display the answer with just 3 digits after the decimal point, by pressing [↰] [DISPLAY] [1] [3]

Figure 3

Answer: Figure 3 shows that the log to base *e* of 2 is close to 0.693, so the volume is 0.693A cubic meters.

Example 3: What is the log to base 3 of 5? Confirm the result using the [y^x] function.

Solution: Using the equations given above, the log to base 3 of 5 can be calculated as $(\log_{10} 5)/(\log_{10} 3)$.

In RPN mode, press: [5] [↰] [LOG] [3] [↰] [LOG] [÷]

In algebraic mode, press: [↰] [LOG] [5] [>] [÷] [↰] [LOG] [3] [ENTER]

Figure 4

That this is correct can be confirmed if the following keys are pressed.

In RPN mode: [3] [$x\leftrightarrow y$] [y^x]

In algebraic mode: [3] [y^x] [↱] [LASTx] [ENTER]

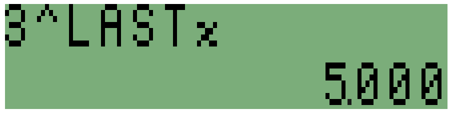


Figure 5

Answer: The log to base 3 of 5 is 1.465 within the current accuracy setting of the calculator, as shown by Figure 5. Calculating 3 to this power gives 5.000 which confirms that the correct value for the log had been obtained.

Example 4: An activity of 200 is measured for a standard of Cr^{51} (with a half-life of 667.20 hours). How much time will have passed when the activity measured in the sample is 170? The formula for half-life computations is shown in Figure 7.

$$A = A0 \cdot \left(\frac{1}{2}\right)^{\frac{t}{\tau}}$$

Figure 6

Solution: Rearrange the equation to solve for t, as in Figure 8.

$$t = \tau \cdot \frac{LN\left(\frac{A}{A0}\right)}{LN\left(\frac{1}{2}\right)}$$

Figure 7

Now calculate t. In RPN mode:

[6] [6] [7] [.] [2] [ENTER] [1] [7] [0] [ENTER] [2] [0] [0] [÷] [↱] [LN] [×] [.] [5] [↱] [LN] [÷]

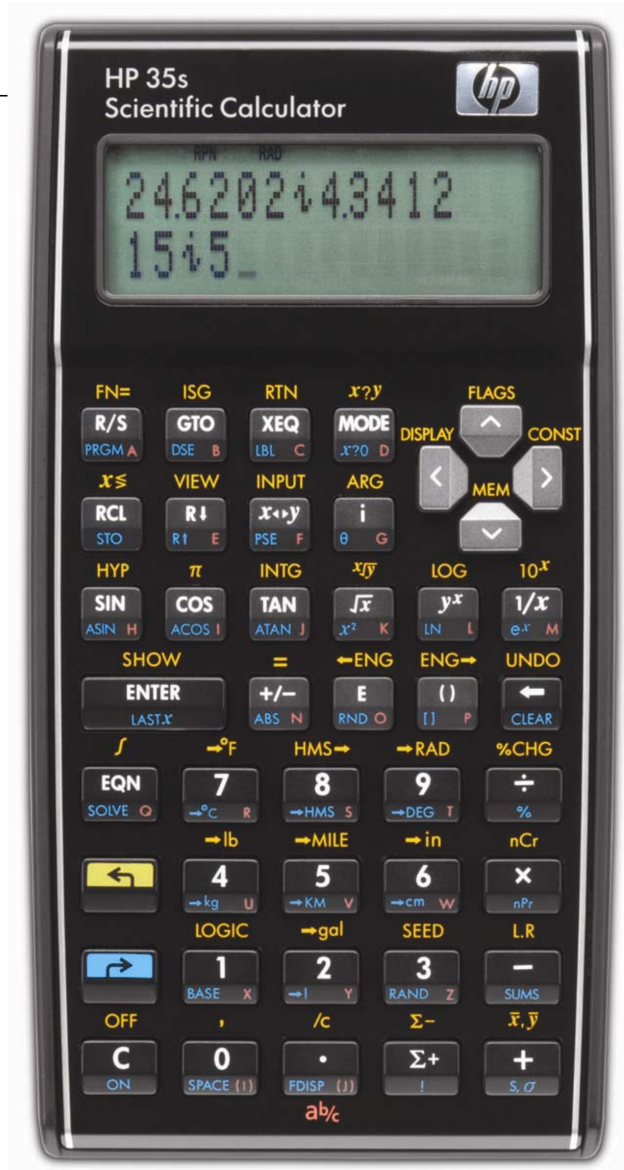
In algebraic mode:

[6] [6] [7] [.] [2] [×] [↱] [LN] [1] [7] [0] [÷] [2] [0] [0] [>] [÷] [↱] [LN] [.] [5] [ENTER]

Figure 8

Answer: 156.435 hours. Figure 8 shows the result in algebraic mode.

hp calculators



HP 35s Working with vectors

Vectors

Practice solving problems involving vectors

Vectors

From a mathematical point of view, a vector is an array of 2 or more elements arranged into a row or a column. Physical vectors that have two or three components and can be used to represent physical quantities such as position, velocity, acceleration, forces, moments, linear and angular momentum, angular velocity and acceleration, etc.

On the HP 35s, vectors are entered using the ↱ [] keystrokes. This opens an empty set of brackets to hold the values within the two dimensional or three dimensional vector. Elements of a vector are separated with a comma, which is entered by pressing ↰ ,. The elements that can be stored in a vector cannot be complex numbers or vectors themselves. Vectors can also be used in equations.

The HP 35s can add, subtract, multiply or divide vectors. The HP 35s can also compute the magnitude of a vector using the ↱ ABS function.

Vectors can also be used to pack real numbers into a register to increase the storage capacity of the HP 35s (or to store the same amount of information using less space). See the separate learning module for the indirect register data packing program for more information.

To construct a vector in an equation or within a program that is composed of values found in stack or data registers, see page 10-8 of the HP 35s User's Guide.

Practice solving problems involving vectors

Example 1: Perform this vector addition: [1 , 3] + [5 , 1]

Solution: In RPN mode: ↱ [] 1 ↰ , 3 ENTER ↱ [] 5 ↰ , 1 +

In algebraic mode: ↱ [] 1 ↰ , 3 > + ↱ [] 5 ↰ , 1 ENTER

Figure 1

Answer: [6 , 4]. Figure 1 shows the answer in RPN mode.

Example 2: Multiply the vector [1 , 3] by the scalar of 5

Solution: In RPN mode: ↱ [] 1 ↰ , 3 ENTER 5 ×

In algebraic mode: ↱ [] 1 ↰ , 3 > × 5 ENTER

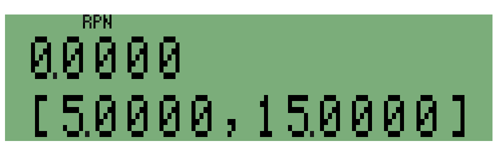


Figure 2

Answer: [5 , 15]. Figure 2 shows the answer in RPN mode.

<u>Example 3:</u> Determine the magnitude of the vector [1 , 3].

<u>Solution:</u> In RPN mode: [↱] [[]] [1] [↰] [,] [3] [↱] [ABS]

In algebraic mode: [↱] [ABS] [↱] [[]] [1] [↰] [,] [3] [ENTER]

Figure 3

<u>Answer:</u> The magnitude is approximately 3.16, which is the length of the hypotenuse of the right triangle with sides of length 1 and 3. Figure 3 shows the answer in RPN mode.

<u>Example 4:</u> Determine the dot product of [1 , 3] and [3 , 1]

<u>Solution:</u> In RPN mode: [↱] [[]] [1] [↰] [,] [3] [ENTER] [↱] [[]] [3] [↰] [,] [1] [×]

In algebraic mode: [↱] [[]] [1] [↰] [,] [3] [×] [↱] [[]] [3] [↰] [,] [1] [ENTER]

Figure 4

<u>Answer:</u> The dot product is equal to 6. Figure 4 shows the answer in RPN mode.

<u>Example 5:</u> Construct a 3-D vector that contains the elements found in variables A, B, and C within a program.

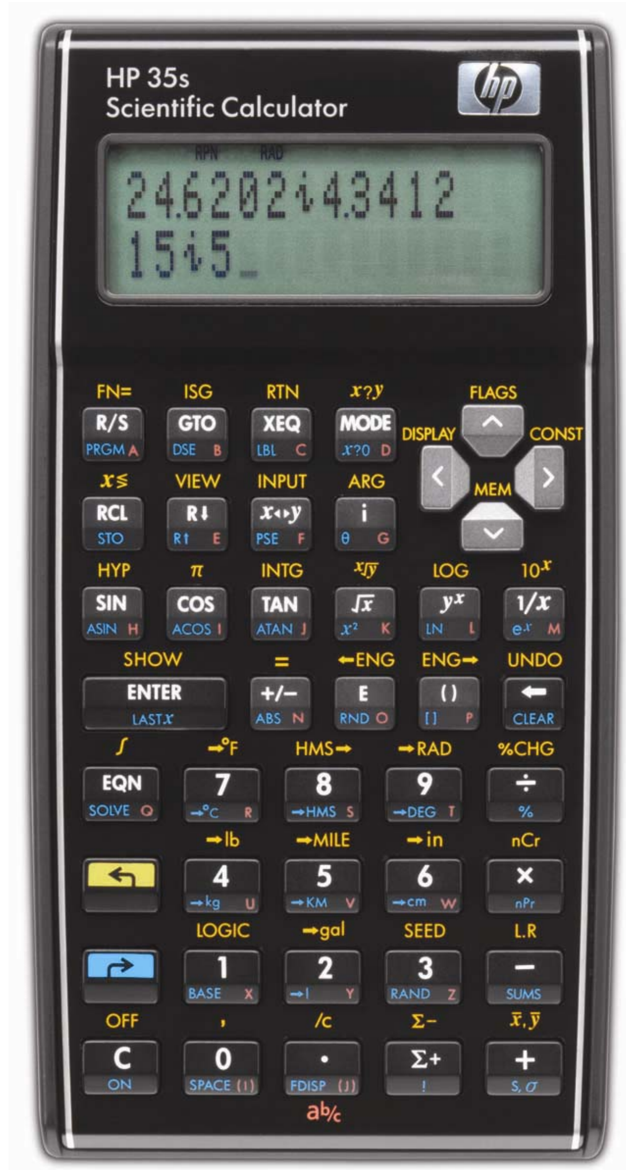
<u>Solution:</u> In either mode: [↱] [PRGM] [EQN] [↱] [[]] [RCL] [A] [↰] [,] [RCL] [B] [↰] [,] [RCL] [C] [ENTER]

Figure 5

<u>Answer:</u> Figure 5 shows the resulting program line. This line will properly create the vector for further use.

hp calculators

HP 35s Writing a Simple Program



Programming the HP 35s

Practice example: the area of a circle

Tools for programming

Programming the HP 35s

Doing a simple calculation once on the HP 35s is easy. Doing the same calculation many times, or doing a complicated calculation, takes longer. It can be better to store all the steps needed for the calculation in a **program**. A program is a set of instructions, stored all together. Once it is written, it can be tested to see if it works correctly. Then it can be used many times, without the need to press every key of the calculation each time.

A simple program is just a set of keystrokes stored so that they can be carried out with one key. The HP 35s provides many commands to let programs do more, for example stop and ask for input, or show an intermediate result. This training aid concentrates on simple programming; it also shows a few of the more advanced programming commands.

Practice example: the area of a circle

Given "r" the radius of a circle, the circle's area "A" is calculated from the formula A = π r ². For example to calculate the area of a circle with radius 3cm, the following keys are pressed.

In RPN mode: [3] [↱] [x^2] [↰] [π] [×]

And in algebraic mode: [↱] [x^2] [3] [>] [×] [↰] [π] [ENTER]

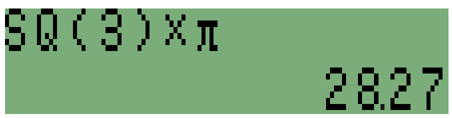


Figure 1

Repeating the same 6 keys in RPN mode or 8 keys in algebraic mode for many circles is a lot of work. Here is how a program would make it easier.

<u>Example 1:</u> Write a program in RPN mode to calculate the area of a circle, given its radius r.

<u>Solution:</u> An RPN program and an algebraic program are shown below. The RPN program is shown first, called "A" for "Area".

In RPN mode, type the same keys for calculating the area as before, but mark the beginning of the program with a **label** and the end of the program with a **return**.

First set program mode by typing [↱] [PRGM] and then go to the top of program memory (called PRGM TOP, see Figure 2), ready to begin a new program, by typing [GTO] [·] [·]. Now the program can be typed:

[↱] [LBL] [A] [↱] [x^2] [↰] [π] [×] [↰] [RTN]

The letter A is on the keyboard, below and to the right of the [R/S] key. Whenever [LBL] is typed, the HP 35s uses the keys with the letters A – Z marked next to them to enter those letters.

The program will look as shown in Figures 2 through 4 below.

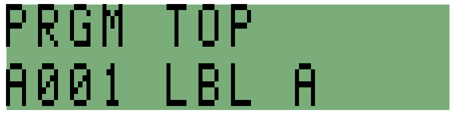


Figure 2

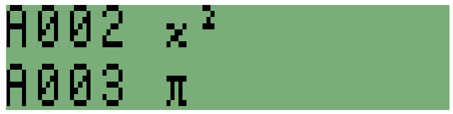


Figure 3

Figure 4

Each line of the program begins with the letter of the label, and then has a four-digit line number. The rest of the program line is a function or a program instruction. The program instructions are LBL A and RTN, the functions are x ², π and ×.

To use the program, it is necessary to move out of program mode, and to return to the beginning of the program. Then a radius is typed and the [R/S] key is pressed. The HP 35s **executes** (or **runs**) the program.

To calculate the area of a circle with radius 5, make sure RPN mode is set, then press:

[↱] [PRGM] [↰] [RTN] [5] [R/S]

Figure 5

<u>Answer:</u> The area of a circle with radius 5 cm is just over 78.54 square cm.

To calculate the area of another circle with a different radius, it is enough to type the new radius and press [R/S] again. The program works like a new function, executed by means of the [R/S] key instead of a key with the name of one of the functions built into the HP 35s.

<u>Example 2:</u> Write a program in algebraic mode to calculate the area of a circle, given its radius r.

<u>Solution:</u> In algebraic mode, the program looks very similar, but with the calculation keys typed in algebraic order. The HP 35s does not allow more than one program to have the same label, so the algebraic program below is given the label B.

Go to the beginning of program memory by typing [GTO] [·] [·] and set program mode by typing [↱] [PRGM]. Then type the algebraic mode program:

[↱] [LBL] [B] [MODE] [4] [↱] [x^2] [R↓] [<] [ENTER] [×] [π] [ENTER] [↰] [RTN]

To get [B] press the [GTO] key; it has a small B to its lower right. The program lines are as listed below.

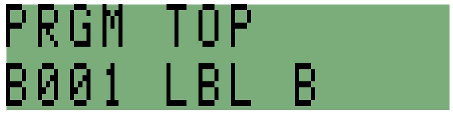


Figure 6

Figure 7

Figure 8

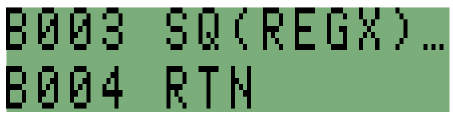


Figure 9

The second line is an instruction to set algebraic mode, to make sure program B is not used accidentally in RPN mode. If the user always works in algebraic mode, or always remembers to switch to the right mode before using a program then this program line is not needed, but it is always safer to use it. A similar line, setting RPN mode, could have been used in program A for the same reason.

Line B003 squares the value in the X register, referred to in the program as REGX. This value will be the value keyed in before the program is run.

This program works just like the RPN version. To use it, first move out of program mode, and to go to the beginning of the program. Then a radius is typed and the program is executed.

Therefore, to calculate the area of a circle with radius 5, press:

[↱] [PRGM] [↰] [RTN] [5] [R/S]

Figure 10

<u>Answer:</u> As in RPN mode, the area of a circle with radius 5 cm is calculated at just over 78.54 square cm.

To calculate the area of another circle with a different radius, it is enough to type the new radius and press [R/S] again. Like the RPN program, this program works similarly to a new function, executed by means of the [R/S] key instead of a key with the name of one of the functions built into the HP 35s.

Tools for programming

The HP 35s allows the user to create any or all of the labels from LBL A through LBL Z. The lines after a label all have that label at the beginning of their line numbers. When a new label is typed, the HP 35s starts over again at line 1, with the new label's name at the beginning of each line. Figure 7 shows an example of this; if both program A and program B were typed, then after the RTN in program B, the first line of program A is displayed on the calculator screen.

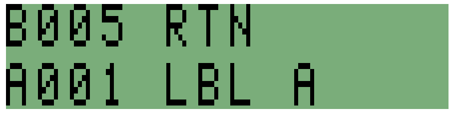


Figure 11

Each label can be used only one time, and the HP 35s treats the lines from one label until the next label as a separate program. It is also possible to have a program with no label, from the "PRGM TOP" until the first label.

To list the programs in the HP 35s, press the keys MEM to get the "Memory" menu, and then 2 to get a display of programs. If the algebraic version of the circle program has been entered then the calculator screen will look like Figure 12. If only program A was typed, the screen will be as in Figure 13.

Figure 12

This means that the program with label B is the first program in memory, and that it is 25 **bytes** long. A byte is a piece of calculator memory made up of 8 **bits**, and a bit is the smallest piece of memory, a single "0" or "1". The HP 35s has more than 29,000 bytes of memory available to hold programs and equations entered by the user. Given this much memory, a long program could have up to 999 program lines, and that is why program line numbers are 3 digits long. The up and down arrows at the right of the screen mean that there are more programs in the calculator – information about each program in turn is displayed if the up or down arrow keys are pressed. If both the programs A and B have been entered, press ∨ to see information about program A.

Figure 13

Another tool to help in writing programs is the **program checksum**. To see the checksum for program A, press SHOW. While the SHOW key is held down, the calculator will show:

Figure 14

CK=DAF1means that the checksum for program A is the hexadecimal number DAF1. (The checksum for program B is AD0A.) If the program was not typed correctly, then the checksum will be different. Press the key labeled C at the bottom left of the keyboard to cancel the display of information about programs.

The checksum has several purposes:

- If a program is correctly copied to the HP 35s from a web page or a book – the HP 35s manual has many useful example programs – then the checksum on the HP 35s will be the same as the checksum given with the program. If the checksum is not the same, a mistake was made and the program should be checked and corrected before it is used.

- If a user creates a new program on an HP 35s and then writes it down for future use, it is worth keeping a note of the checksum with the written program. That way, the program can be checked if it is typed into the HP 35s again later.

- If a user wants to offer a program to other users, the checksum should be given with the program, so the other users can check if they have entered the program correctly into their HP 35s.

The checksum can be very helpful, but it does not have to be used – for short programs such as the above it can be enough to step through the program with the up and down arrow keys and correct any mistakes.

Mistakes can be either wrongly typed lines, or missing lines. To add a missing line, use the [▲] and [▼] keys until the line before the missing line is at the bottom of the screen. Then type the missing line or lines. If a line is wrong, move it to the lower line of the screen and use the [←] key to delete one or more lines, then type the correct line or lines.

Even after all typing errors have been corrected, a program can still be wrong if it was designed wrongly. The HP 35s manual provides advice on program testing and describes more programming tools.

To go to a line in a program, to see it or to change it, use the GTO command, followed by a dot and then the program name and the line number. For example to go to line 5 of program A type [GTO] [.] [A] [0] [0] [5].

The LBL and the RTN help to identify each program. If a program is executed by the user pressing [R/S] then the [RTN] goes back to the top of program memory, where the program stops. If both program B and program A are in the HP 35s, and program A is used, then the RTN at the end will go to label B at the top of program memory. Next time [R/S] is pressed, program B will begin, not program A. This means that only the program at the top of program memory will work like a function key when [R/S] is pressed. To execute program A if it is not at the top of memory, press [XEQ] [A] [ENTER].

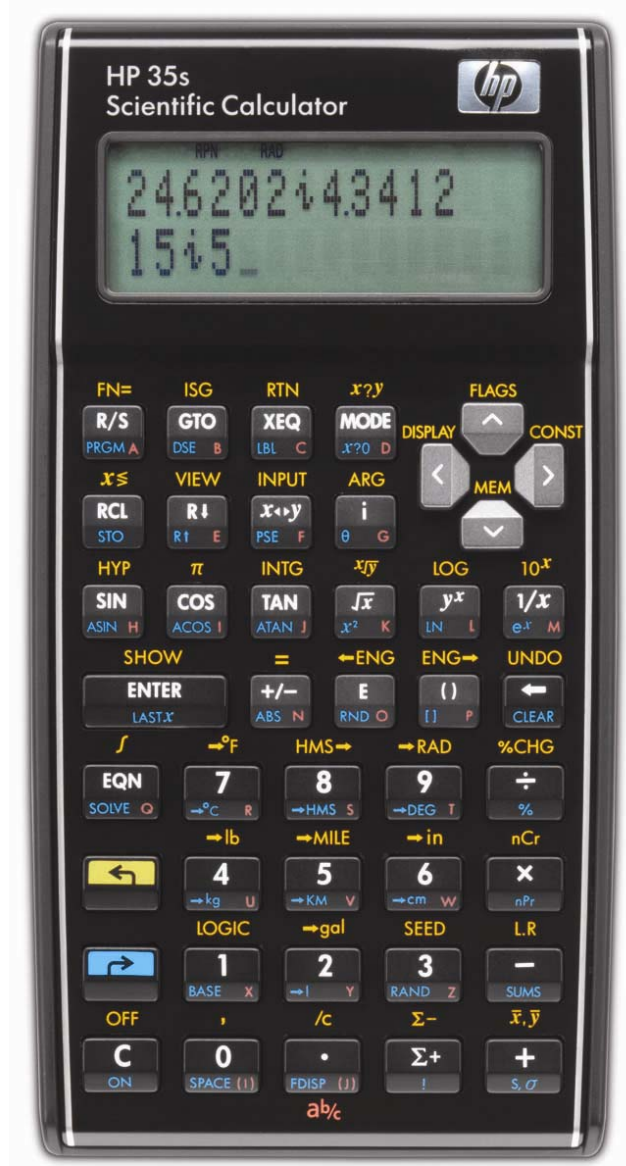
hp calculators

HP 35s Programming using line numbers

Programming the HP 35s

Using line numbers rather than labels

Example



Programming the HP 35s

Doing a simple calculation once on the HP 35s is easy. Doing the same calculation many times, or doing a complicated calculation, takes longer. It can be better to store all the steps needed for the calculation in a **program**. A program is a set of instructions, stored all together. Once it is written, it can be tested to see if it works correctly. Then it can be used many times, without the need to press every key of the calculation each time.

A simple program is just a set of keystrokes stored so that they can be carried out with one key. The HP 35s provides many commands to let programs do more, for example stop and ask for input, or show an intermediate result. This training aid concentrates on simple programming; it also shows a few of the more advanced programming commands.

Using line numbers rather than labels

The HP 35s has 26 labels for use to define programs or transfers to locations within programs. Unlike the HP 33s, the HP 35s also includes the ability to transfer execution to specific line numbers within one of the 26 labels. This allows for a much greater utilization of program memory without using labels excessively.

For example, the program line below illustrates how a goto instruction can now branch to a line number within a lettered label. Step B010 tests whether the value in the X register is less than the value in the Y register. If true, step B011 transfers execution to step 018 of label B. On the HP 33s, step B011 would have required a goto instruction pointing to a step with one of the 26 labels.

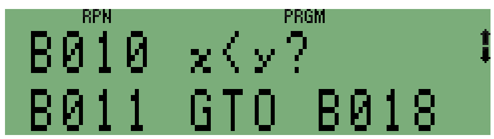


Figure 1

In the past, using line number GTO and XEQ instructions in programs was difficult if changes were made to the program after these instructions were entered, since the program steps would have changed but the transfer instructions would still have pointed at the old line numbers, making the program work incorrectly.

The HP 35s removes this constraint. When a program containing line number GTO or XEQ instructions has a step added or deleted, the HP 35s **dynamically** changes the lines referred to by these instructions to point at the correct location. For example, if in the program shown in figure 1 above, another step were added before step B010 such as an ABS instruction, steps B010 would become step B011 and step B011 would become step B012. More importantly, the HP 35s would change the new step B012's GTO instruction to continue pointing at the same location within the program – step B019 in this instance. This is shown in figure 2 below.

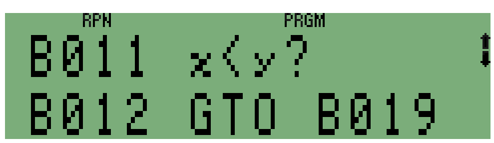


Figure 2

This dynamic renumbering allows for the use of line numbers in GTO or XEQ instructions without the drawbacks earlier, less-advanced calculators may have had.

In detail, the HP 35s handles changes in a program containing line number GTO and/or XEQ instructions as follows:

Edit performed	HP 35s program dynamically changed so that
A step is inserted before a GTO or XEQ instruction	All GTO and XEQ instructions are renumbered to point to the revised (higher step number) location
A step is deleted before a GTO or XEQ instruction	All GTO and XEQ instructions are renumbered to point to the revised (lower step number) location
The step pointed to by a GTO or XEQ instruction is deleted	Any GTO or XEQ instructions continue to point to the same instruction. The instruction that now fills the previous step number is the destination of the transfer instruction.

The HP 35s now offers the ability to take advantage of a large program memory capacity, limited only by a user's imagination.

<u>Example 1:</u> Rewrite the program from page 14-4 of the HP 35s User's Guide to use only one label. Use line numbers for all transfer instructions.

<u>Solution:</u> The program as presented on page 14-4 looks like this:

S001	LBL S	S008	RCL B	S015	RTN
S002	INPUT A	S009	RCL A	Q001	LBL Q
S003	INPUT B	S010	X^2	Q002	X <> Y
S004	INPUT C	S011	XEQ Q001	Q003	X^2
S005	INPUT D	S012	XEQ Q001	Q004	+
S006	RCL D	S013	XEQ Q001	Q005	RTN
S007	RCL C	S014	SQRT		

Steps S011 through S013 would need to be changed to point at the step after S015 RTN. Since we will be removing the LBL Q instruction, steps previously labeled Q002 through Q005 will now be right after step S015 RTN. They would now be labeled S016 through S019. The XEQ instructions found at steps S011 through S013 should now point to step S016. The revised program using only one label is shown below.

S001	LBL S	S008	RCL B	S015	RTN
S002	INPUT A	S009	RCL A	S016	X <> Y
S003	INPUT B	S010	X^2	S017	X^2
S004	INPUT C	S011	XEQ S016	S018	+
S005	INPUT D	S012	XEQ S016	S019	RTN
S006	RCL D	S013	XEQ S016		
S007	RCL C	S014	SQRT		

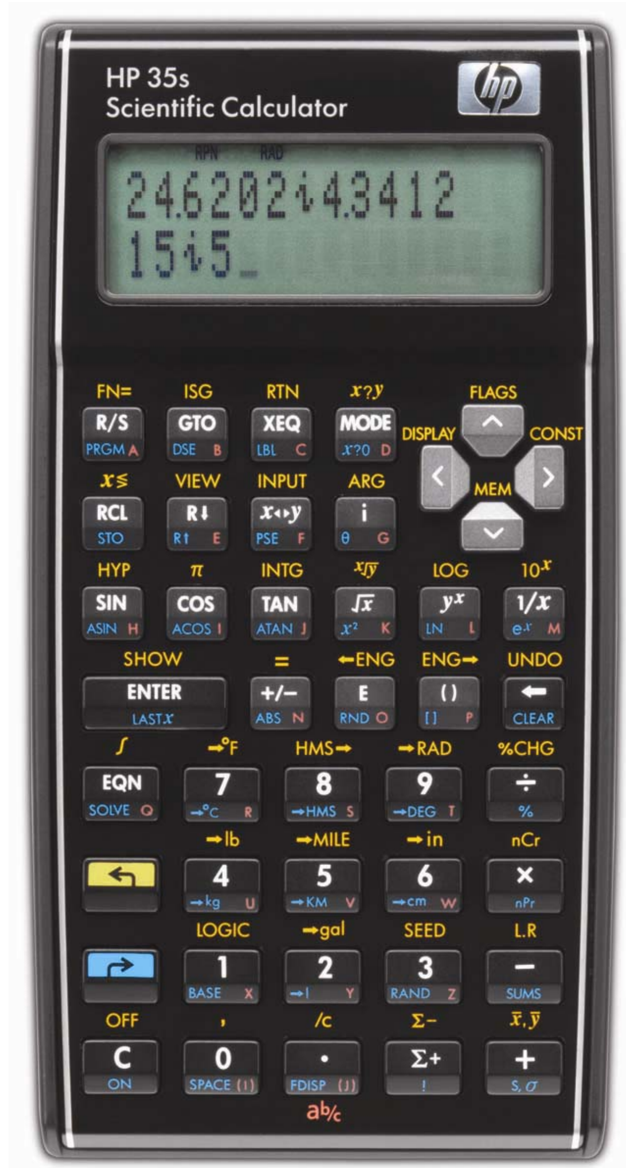
The program is not only one total line shorter but uses only one label. Consistent use of line number GTO and XEQ instructions allows for better utilization of the 26 letter labels.

hp calculators

HP 35s Accessing the stack registers

The stack registers

Examples



The stack registers

The HP 35s uses an operational stack of four registers, called X, Y, Z and T and LASTx. In RPN mode, these registers are used to hold values for computations. In algebraic mode, these registers hold results from previous calculations.

Chapter 2 of the HP 35s User’s Guide explains the RPN stack in detail. Many of these features work in algebraic mode as well.

In RPN mode, these stack registers are easily accessed using the [↱] [R↑], [R↓], [↱] [LASTx] and [x↔y] keys whether in a program or in normal computations. Access to these registers within algebraic mode is essentially the same, but the way the HP 35s presents these registers to the user is slightly different.

Examples

The examples shown below indicate some of the ways the stack registers can be accessed within algebraic mode as well as using this type of access in RPN mode within programs. Many efficiencies can be achieved in RPN mode using these approaches.

<u>Example 1:</u> Compute 1 + 2 then 3 + 4 and then divide 5 by the sum of the previous two results in algebraic mode.

<u>Solution:</u> [1] [+] [2] [ENTER]

Figure 1

[3] [+] [4] [ENTER]

Figure 2

[5] [÷] [↱] [( )] [R↓]

Figure 3

At this point, the HP 35s displays the four level stack with the cursor beneath the Y register. This register contains the first calculation we did above (the 1 + 2). Pressing [ENTER] will copy a reference to this register back to the calculation in progress as shown below. REGY stands for “register Y.”

Figure 4

+ R↓ < ENTER

Figure 5

+ R↓ < ENTER (REGX stands for “register X.”)

Figure 6

ENTER (This completes the calculation)

Figure 7

Answer: The answer is 0.5. The larger point is the ability to reference up to four previous results when in algebraic mode.

Example 2: In RPN mode within a program, fill the stack with 1, 2, 3, and 4. Then divide the 4 by (1+2x3), but do so without losing any of the stack register contents.

Solution: ↱ PRGM 1 ENTER ENTER 2 ENTER ENTER 3 ENTER ENTER 4

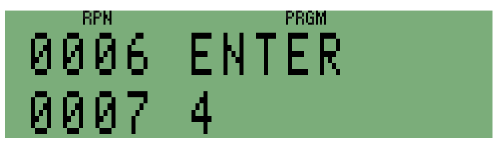


Figure 8

(Note: the ENTER key is pressed twice above in order to terminate digit entry upon the first press and then to actually place an ENTER into the program when pressed the second time). At this point, the four level stack is full of the four values. If you were to attempt to enter the 7 for the division, the 1 that was entered first would disappear off the top of the stack. However, the following technique can be used to operate upon a number located in the X register without losing any values from the stack.

The technique involves rolling the value in X down to the T register and then entering an equation that operates upon the T register to perform the calculation. This can be quite an involved expression. The result will be placed into the X register and the previous contents of Y, Z, and T are preserved.

R↓ EQN

Figure 9

[R↓]

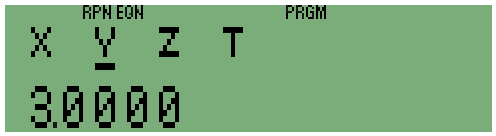


Figure 10

[>] [>] [ENTER]

Figure 11

[÷] [()] [1] [+] [2] [×] [3]

Figure 12

[ENTER]

Figure 13

Answer: The lines entered into this program would, when executed, take the value that was originally in X and divide it by (1 + 2 x 3) without disturbing the stack. While this is actually a mixing of algebraic features within the RPN mode, it provides HP 35s users with a tremendous ability to control the calculator.

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hp calculators

HP 35s Indirect register data packing program

The HP 35s and indirect registers

Saving program memory space

Saving indirect storage space

The program listing

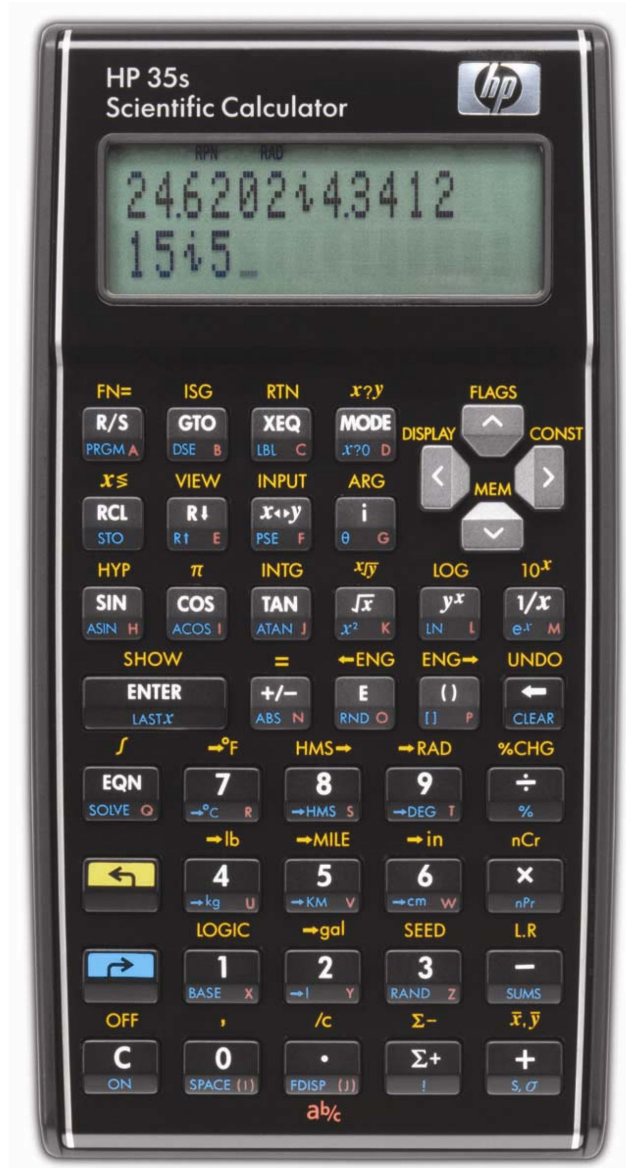
Usage instructions

Entering program lines

Line by line analysis of the program

Saving keystrokes

Usage examples



The HP 35s and indirect registers

The HP35s contains registers or variables that can be referenced directly or indirectly. Variables A through Z can be directly addressed, as in a [↱] [STO] [A] instruction. Indirect addressing uses two of these direct variables as indices that hold the location or address where an operation is to be performed. The two variables that are used this way are [I] and [J]. The indirect registers begin at address 0 and can go up to 800, if the user allocates that many. That is 801 additional storage registers compared to the earlier HP 33s calculator.

It is also possible to address the direct variables and the statistics variables indirectly using addresses of -1 through -32. Address -1 would refer to the direct variable [A], address -26 would refer to the direct variable [Z], and -27 trough -32 would refer to the statistical summation registers. This is shown in a table on page 14-22 of the HP 35s user's guide.

The way indirect addressing works is to store the number corresponding to the register you wish to use in either [I] or [J]. Then you perform a [↱] [STO] [(I)] or [↱] [STO] [(J)] (or any other allowed operation). For example, if you wish to recall a value stored in direct register [A], you can either press [RCL] [A] or store -1 into [I] by [↱] [STO] [(I)] and then perform a [RCL] [(I)]. Both will recall the value stored in A.

At first glance, that may not appear to be worth doing, since it takes more key presses to use the indirect method. However, where it becomes very useful is when you need to work with a lot of numbers, often within a program, or when you may not be able to know in advance where the number you wish to use is stored.

Saving program memory space

For example, suppose you have 20 numbers you wish to sum. A direct program might be written having these numbers stored in [A] through [T]. The program to sum them (which would take 41 lines of code and at least 120 bytes of memory), might look like:

```
A001  LBL A
A002  RCL A
A003  RCL B
A004  +
A005  RCL C
A006  +
A007  RCL D
A008  +
…
A039  RCL T
A040  +
A041  RTN
```

On the other hand, a program using the indirect registers might have the numbers stored in indirect locations 1 through 20. The program to sum the 20 values might look like this one. This program only takes 10 lines of code and only 32 bytes of code. Sure, developing the second program might take a little more time than the first, but it comes at a great reduction of program memory space used.

```
A001  LBL A
A002  20
A003  STO I
A004  RCL (I)
A005  DSE I
A006  RCL (I)
A007  +
A008  DSE I
A009  GTO A006
A010  RTN
```

Saving indirect storage space

To allocate a portion of the HP 35s memory to hold indirect registers, store a non-zero value into the highest register needed. If you need 100 registers to hold numbers and if locations 0 to 99 will work for your need, storing a non-zero value into indirect storage location 100 will allocate HP 35s calculator memory to create the block of indirect registers 0 through 100. Warning: If you store a zero into memory location 100, the HP 35s will dynamically reclaim all zero indirect storage registers starting with 100 and working down. This can cause quite a shock when you're not expecting it in a program or calculation.

Each indirect register, like each direct register and each stack register, can hold a variety of objects, such as a real number, a complex number, or a 2-D or 3-D vector. Since these take varying amounts of memory to hold them, the HP 35s allocates 37 bytes per register for each location, whether the register needs that many bytes or not (see page 14-24 of the HP 35s user's guide). This means that a group of indirect registers that are only going to hold a real number are only using 1/3 of the possible storage space per register.

To reclaim some of this space that might otherwise be unused, it is possible to pack three real numbers into a 3-D vector and store the group into a single indirect register. This can save a tremendous amount of calculator memory. Storing 100 real numbers using indirect registers normally would use 3700 bytes. Packing them using the program in this learning module will only use 1/3 of that memory, which will then be available for other uses.

This program originally appeared in Datafile, a publication of HPCC. HPCC is a voluntary, independent body run by and for users of handheld and portable computers and calculators. The club has been helping members for more than 20 years to get the most from their Hewlett Packard equipment and to further the exchange of information and ideas. You can find out more about HPCC at their website http://www.hpcc.org/ .

The program listing. Program length is 338 bytes. Checksum C4F6. RDN is [R↓] (Roll Down). All flag-related instructions (SF, CF, and FS?) are accessed through [⬏] [FLAGS]. The conditional tests (x=0?, x<0?) are accessed through [⬎] [x?0]. In several areas of this program, stack manipulations occur that look rather odd but manage to preserve the pre-existing stack contents. RPN mode is assumed in the program and throughout these instructions. The program uses one global label, variable register I, and flags 0, 1, 2, and 3.

Y001	LBL Y
Y002	CF 0
Y003	CF 1
Y004	CF 2
Y005	CF 3
Y006	x=0?
Y007	GTO Y062
Y008	x < 0?
Y009	SF 0
Y010	ABS
Y011	RDN
Y012	IDIV(REGT-1,3)
Y013	STO I
Y014	RDN
Y015	LASTx
Y016	ABS
Y017	RDN
Y018	RMDR(REGT-1,3)
Y019	x=0?
Y020	SF 1
Y021	FS? 1
Y022	GTO Y030
Y023	RDN
Y024	REGT-1
Y025	x=0?
Y026	SF 2
Y027	FS? 2
Y028	GTO Y030
Y029	SF 3
Y030	RDN
Y031	FS? 1
Y032	[1, 0, 0]
Y033	FS? 2
Y034	[0, 1, 0]
Y035	FS? 3
Y036	[0, 0, 1]
Y037	RCLx (I)
Y038	FS? 0
Y039	GTO Y058
Y040	+/-
Y041	RDN
Y042	XEQ Y063
Y043	RCL+ (I)
Y044	RDN
Y045	ABS
Y046	CLx
Y047	LASTx
Y048	RDN
Y049	XEQ Y063
Y050	RDN
Y051	REGZ+REGT
Y052	STO(I)
Y053	RDN
Y054	LASTx
Y055	LASTx
Y056	CLX
Y057	+
Y058	CF 0
Y059	CF 1
Y060	CF 2
Y061	CF 3
Y062	RTN
Y063	FS? 1
Y064	REGTx[1, 0, 0]
Y065	FS? 2
Y066	REGTx[0, 1, 0]
Y067	FS? 3
Y068	REGTx[0, 0, 1]
Y069	RTN
Y070	STO I
Y071	[0, 0, 0]
Y072	STO(I)
Y073	DSE I
Y074	GTO Y072
Y075	STO(I)
Y076	CLSTK
Y077	RTN

Usage Instructions:

1) Initialize the indirect registers to be used by providing the number of logical registers desired divided by 3 rounded up to the next highest integer. Then press XEQ Y070. For example, if you want 100 logical registers, give this routine 100 / 3, or 34 as an input. Note that you should probably keep at least 200-300 bytes free on the 35s.

2) To store a number, place the number to be stored in Y and the logical register location in X and press XEQ Y ENTER. Upon completion, the number just stored is in X. The original Z is now in Y and the original T is now in Z and T. LASTx is cleared.

3) To recall a number, place the logical register location to be recalled in X as a negative number and press XEQ Y ENTER. The recalled number is in X. The original contents of Y, Z, and T are undisturbed. LASTx contains the associated identity vector.

Entering program lines. How to enter some of the program lines might not appear obvious at first. Here are the key presses to place them into the program.

Line Y012: [EQN] [↰] [INTG] [2] [R↓] [>] [>] [ENTER] [−] [1] [>] [3] [ENTER]
Line Y018: [EQN] [↰] [INTG] [3] [R↓] [>] [>] [ENTER] [−] [1] [>] [3] [ENTER]
Line Y024: [EQN] [R↓] [>] [>] [ENTER] [−] [1] [ENTER]
Line Y037: [RCL] [×] [(I)]
Line Y043: [RCL] [+] [(I)]
Line Y046: [↱] [CLEAR] [1]
Line Y051: [EQN] [R↓] [>] [ENTER] [+] [R↓] [>] [>] [ENTER] [ENTER]
Line Y056: [↱] [CLEAR] [1]
Line Y064: [EQN] [R↓] [>] [>] [ENTER] [×] [↱] [[]] [1] [↰] [,] [0] [↰] [,] [0] [ENTER]
Line Y066: [EQN] [R↓] [>] [>] [ENTER] [×] [↱] [[]] [0] [↰] [,] [1] [↰] [,] [0] [ENTER]
Line Y068: [EQN] [R↓] [>] [>] [ENTER] [×] [↱] [[]] [0] [↰] [,] [0] [↰] [,] [1] [ENTER]
Line Y076: [↱] [CLEAR] [5]

Line by line analysis of the program. The description below explains what the program is doing in more detail. It may be of interest to see how the program operates.

Lines	What they do
Lines Y002 through Y005:	Reset flags.
Lines Y006 andY007:	Exits the program if an attempt is made to store into logical register zero, which is not supported. Lines Y008 and Y009 set flag zero if the logical register location is input as a negative, indicating a recall register input. Lines Y010 through Y013 store the indirect register number to be used into the I register.
Lines Y014 through Y018:	Determines the position in the 3-D vector where the value to be stored/recalled is found.
Lines Y019 through Y029:	Sets flag 1, 2, or 3, depending on the position within the 3-D vector for the value to be stored/recalled.
Lines Y033 through Y036:	Enters the appropriate identity vector.
Line Y037:	Extracts the proper value from the identity vector
Lines Y038 and Y039:	Exits the program if this is a recall entry.
Line Y040 and Y041:	Changes the sign of the extracted value and place it in stack register T.
Line Y042:	Calls a subroutine that creates an identity vector with the value of 1 in the vector replaced by the extracted value with its sign changed.

Line Y043:	Places in X the vector from the proper indirect register now with a zero in the location being replaced.
Lines Y044 through Y048:	These lines are stack manipulations to preserve the stack and store the previously extracted value into LASTx.
Line Y049:	Calls the subroutine that creates a vector with the proper position holding the value to be stored with the other locations holding a zero.
Line Y050:	Places this vector in T. At this point, register Z of the stack contains the original vector with a zero in the position where the value is to be stored, and register T of the stack contains a vector that has zeroes in the locations not being changed and the value being stored in the proper location within the vector.
Line Y051:	Adds these vectors in T and Z together and places the result in X.
Line Y052:	Stores this new vector back into the proper indirect register.
Lines Y053 through Y057:	Cleans up the stack so that the original value is in X, the original level Z is in Y, and the original level T is in Z and T.
Lines Y058 through Y062:	Cleans up the flags and exit the program.
Lines Y063 through Y069:	These lines are the subroutine called at lines Y042 and Y049.
Lines Y070 through Y077:	These lines are the initialization routine which stores vectors containing zeroes in the proper indirect registers.

Usage Examples. This program can be used in manual run mode or from within a program. The table below shows several examples of how it might be used. Since the program preserves the stack, usage does not require much special consideration, other than LASTx, as noted above. Program usage is the same as run mode usage – the routine is simply called as a subroutine.

Usage Examples	Keystrokes
1) Set aside 50 indirect registers. 50 divided by 3 is 17, rounded up to the next highest integer.	17 [XEQ] [Y] [0] [7] [0]
2) Store the following numbers:	
1.23456789 into logical register 10.	1.23456789 [ENTER] 10 [XEQ] [Y] [ENTER]
55 into logical register 7.	55 [ENTER] 7 [XEQ] [Y] [ENTER]
35.456565 into logical register 34.	35.455565 [ENTER] 34 [XEQ] [Y] [ENTER]
3) Compute the following:	
Logical register 34 divided by logical register 7.	34 [+/-] [XEQ] [Y] [ENTER] 7 [+/-] [XEQ] [Y] [ENTER] [÷]
Multiply logical register 7 by 3. Multiply logical register 34 by 5. Subtract the difference.	7 [+/-] [XEQ] [Y] [ENTER] 3 [×] 34 [+/-] [XEQ] [Y] [ENTER] 5 [×] [−]
Add logical register 10 to the result just computed.	10 [+/-] [XEQ] [Y] [ENTER] [+]

Saving keystrokes. Storing a number manually into an indirect register requires six key presses (⮫ STO I ⮫ STO (I)) while this program only requires four key presses, not counting the location and value to be stored which would be the same in both instances. In the example below, 15 is stored into indirect register 10. Manually, this requires 10 key presses. Using this program only requires 8 key presses.

Manually	Using this program
10 ⮫ STO I 15 ⮫ STO (I)	15 ENTER 10 XEQ Y ENTER

Recalling the same number from indirect register 10 takes 7 key presses manually and only 6 key presses using this program.

Manually	Using this program
10 ⮫ STO I RCL (I)	10 +/- XEQ Y ENTER

hp calculators

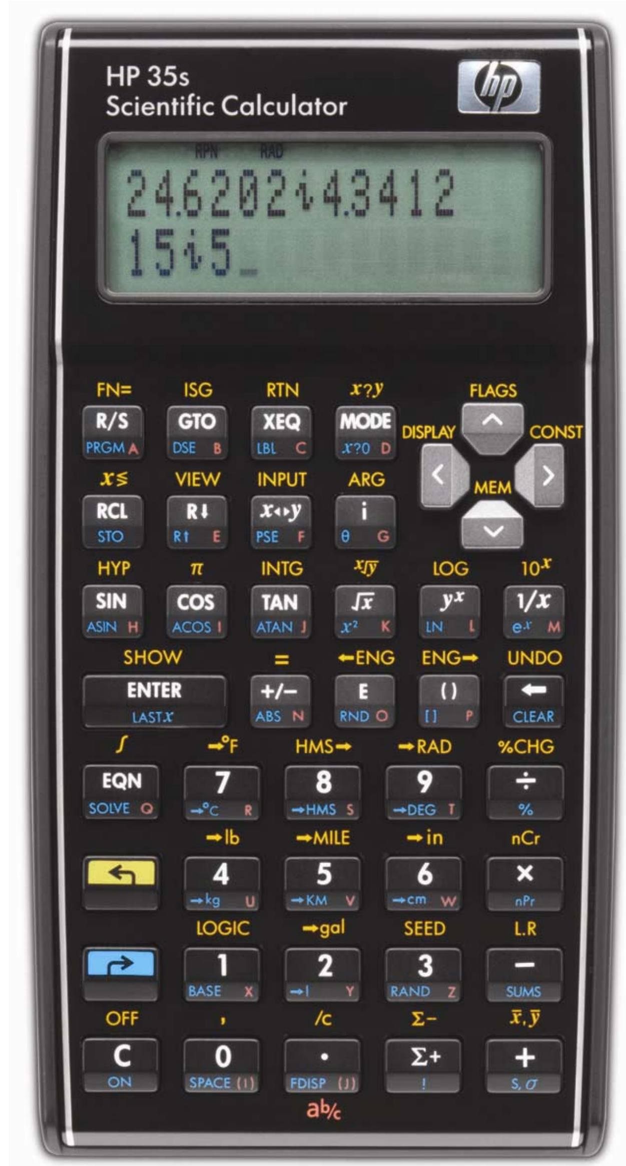
HP 35s Using HP 35s Flags

What are flags?

An example of using a flag to display a message

General-purpose flags and special flags

Using flags in programs



What are flags?

Ships use flags to signal special conditions. For example a ship might raise a flag as a distress signal, or to signal that an admiral is on board. Computers and calculators also use flags to signal special conditions. For example a flag could be used on the HP 35s to mark that financial calculations are being carried out in Canadian dollars, not in US dollars.

Flags can be raised (or set) or else they can be lowered (or cleared). They provide the answers to simple yes/no questions. Wherever a question like this needs to be asked, especially in a program or in the display, a flag can be used.

An Example of using a Flag to Display a Message

An easy example of flag use is to display some simple message, for example a reminder.

Example 1: A student who uses an HP 35s wants to display a reminder to complete Tuesday's assignment.

Solution: Set flag 1, which will show up in the display.

First the user must press ↰ FLAGS to display the flag operations menu.

Figure 1

Then the user must press 1 to select the SF (Set Flag) operation.

Figure 2

Now the user needs to press 1 again to make the SF operation act on flag 1.

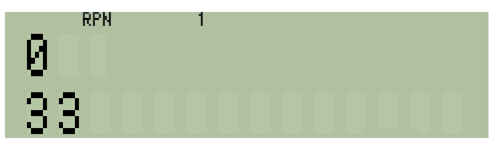


Figure 3

Answer: Flag 1 is now set, and a small number 1 is displayed at the top of the calculator screen. The small "1" looks like an exclamation point and reminds the student that something important needs to be done. Alternatively flag 2 could be used, as a reminder of Tuesday's assignment, as "two" sounds like "Tue".

Example 2: Once Tuesday's assignment has been completed, the student no longer needs to display the 1.

Solution: Clear flag 1, so it will no longer show up on the screen.

Again the user must press ↰ FLAGS to display the flag operations menu.

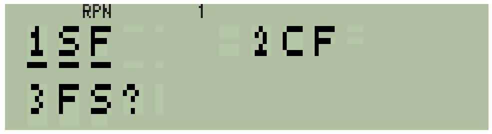


Figure 4

This time the user must press 2 to select the CF (Clear Flag) operation.

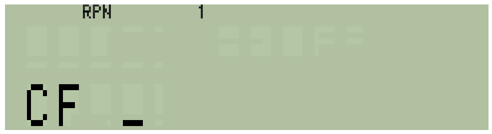


Figure 5

The little 1 is still shown. Now the user needs to press 1 to make the CF operation act on flag 1.

Figure 6

Answer: Flag 1 is now clear, so the small number 1 is no longer at the top of the calculator screen.

Example 3: Use the “Flag Set?” command to confirm that flag 1 is now clear.

Solution: Use the same steps, but this time choose the third command in the flags menu, to ask if flag 1 is set.

⬑ FLAGS 3 1

Figure 7

Answer: The display shows the message NO to tell the user that the answer to the question “is Flag 1 Set?” is “No”.

Note: If the flag is set, the message YES is shown. The messages YES and NO replace the normal display of numbers on the HP 35s screen, and the message symbol ⚠ is displayed. This does not mean that an error has been detected, instead it warns the user that a message is being shown, and must be cleared before normal operation can continue. To clear the message, press one of the two keys ← or C. C is the “Clear” key, at the lower left of the keyboard; it is also used as the ON key.

The examples above show how flags can be set, cleared and tested by commands carried out on the keyboard. Flags are also very useful in programs, as is described below.

General-purpose Flags and Special Flags

HP 35s users can set, clear, and test 12 different flags. When the HP 35s is turned on first, all these flags are clear.

Flags 0 through 4 are general-purpose flags, for use as signals and in programs. When one of these flags is set, its number is shown at the top of the HP 35s screen. The 0 looks like a degree sign and 1 like an exclamation point.

Flags 5 through 11 are special-purpose flags, and their state is not shown at the top of the screen. Each flag has a special meaning when it is set.

The user can set flag 5 to say that a program should stop if any calculation produces a result bigger than the largest number the HP 35s can handle. The number is replaced by the largest number the HP 35s can handle and the message OVERFLOW is displayed. If flag 5 is clear, the program continues to run, and OVERFLOW is displayed for a short time when the program finishes running.

The calculator automatically sets flag 6 if an overflow occurs, or if a number in a non-decimal base is larger than the calculator can handle. This can be very useful in programs – a program can test flag 6 to see if a calculation has produced an overflow, and if so then the program can deal with the problem. Flag 6 should be cleared after it has been set, so that it can be used to test if another error occurs later.

Flag 7 is set when fraction display mode is active. It becomes set when [↱] [FDISP] is first pressed, and it is cleared when [↱] [FDISP] is pressed again. It is also set when SF 7 is carried out on the keyboard or in a program. When flag 7 is cleared, fraction display is cancelled. This means that a program can set flag 7 to display a result as a fraction, and can later clear flag 7 so that further results can be displayed as usual.

When flag 8 is set, fractions are displayed with the denominator equal to the number stored by the [/c] command, but the fraction is simplified unless flag 9 is set too. For example, the number 0.5 is displayed as 5/10 if 10 is stored by the [/c] command and flag 8 is set. If flag 9 is clear, the 5/10 is simplified to 1/2 but if flag 9 is set, it is not simplified.

When flag 10 is clear (its normal state) any equation in a program is worked out and its result is put on the stack for use by the program. When flag 10 is clear an equation in a running program is displayed as a message and is not worked out. This means that an equation can be shown to the user, or that a message can be written as if it were an equation, and can then be displayed instead of being calculated; the message does not need to work as an equation, it could even say “HELLO, WORLD”. Flag 10 can be set before some equations, and cleared before others, so that a mixture of equations and messages can be used in a program.

When flag 11 is set, a working program stops and asks for the value of each variable in an equation when it comes to an equation and flag 10 is clear. If the equation is used in integration ([∫]) or in solving ([FN=] [SOLVE]), there is no prompt for the unknown variable, or the variable of integration. If flag 11 is clear, the value already stored in each variable, or 0 if no value has been stored, is used.

Flags 5 through 11 can also be used in programs as if they were general-purpose flags, as long as this does not interfere with their special uses. For example flag 9 can be used freely so long as flag 8 is not set. Any program that uses these flags for general purposes should leave them cleared when it is completed.

To use flags 10 and 11 with the flag commands, first press the decimal point key [.], then press [0] or [1].

Note: for details of equations, programs, fractions, solve and integrate, see the separate training aids on these topics.

Using Flags in Programs

The commands SF, CF and FS? can be very useful in programs. The examples below will show some of the ways in which flags can help in programs.

<u>Example 4:</u> A long program has three parts. To let the user see how far it has gone, it can set flag 1 in the first part, flag 2 in the second part, and flag 3 in the third part. How is this done?

<u>Solution:</u> At the beginning of the program, the user puts “SF 1” immediately after the first label.

[↱] [PRGM] [↱] [LBL] [A] [↰] [FLAGS] [1] [1]

```
A001 LBL A
A002 SF 1
```

Figure 8

At the end of the first part of the program, the user clears flag 1 and sets flag 2.

[↰] [FLAGS] [2] [1] [↰] [FLAGS] [1] [2]

```
A027 CF 1
A028 SF 2
```

Figure 9

At the end of the second part of the program, the user does the same, but clearing flag 2 and setting flag 3.

Finally at the end of the program, the user clears flag 3.

[↰] [FLAGS] [2] [3] [↰] [RTN]

```
A069 CF 3
A070 RTN
```

Figure 10

<u>Answer:</u> When the program runs, with the above steps in it, it will display flag 1 in the first part, flag 2 in the second part, and flag 3 in the third part. A long program will most likely have several labels in it, so the line numbers at the end might have a different letter in them, not A.

<u>Example 5:</u> A program calculates a factorial and then uses it. To make sure the program warns the user if the factorial of a number larger than 253 is calculated, and the result overflows, the program sets flag 5. How is this done?

<u>Solution:</u> “SF 5” is put in the program, just after the first label or just before the factorial is calculated.

[↱] [PRGM] [↱] [LBL] [F] [↰] [FLAGS] [1] [5] [↱] [!]

```
F002 SF 5
F003 !
```

Figure 11

If an overflow occurs, the program will stop at line F003 and will show the message OVERFLOW.

It is best to clear flag 5 at the end of the program, so the calculator will behave the usual way after the program is finished.

<u>Answer:</u> This example shows how flag 5 can be useful in a program.

<u>Example 6:</u> A program that uses temperatures must work with degrees Fahrenheit or degrees Celsius. Use flag 0 to make the program work with both temperature scales.

<u>Solution:</u> The program is written so that it checks flag 0. If flag 0 is set, it converts from Fahrenheit to Celsius, if flag 0 is clear, it assumes the temperature is already in Celsius. In the program, these steps are typed:

[←] [FLAGS] [3] [0] [→] [→°C]

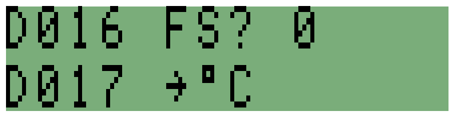


Figure 12

If flag 0 is set at step D016, then the answer to the test is YES, and step D017 is carried out. If flag 0 is clear then the answer to the test is NO and step D017 is skipped. The answer YES or NO is *not* displayed when a program is running. Instead, the rule "do the next step only if the answer is YES" is followed.

To use the program, the user sets flag 0 if measurements are in degrees Fahrenheit. The little 0 is displayed at the top of the screen, to remind the user that flag 0 is set and that measurements in degrees Fahrenheit are expected. The zero looks like a degrees symbol, which is a useful reminder at times when the user is working with temperatures. The user must clear flag 0 if measurements are in degrees Celsius, and the zero will disappear.

<u>Answer:</u> When the program is used with measurements in degrees Fahrenheit, the user must set flag 0. Step D017 of the program converts the measurement to degrees Celsius before the measurement is used. When the program is used with measurements in degrees Celsius, the user must clear flag 0. At step D016 the flag is not set, so step D017 is skipped, and the temperature is not converted to Celsius, as it already is in Celsius.

These examples show just some of the ways in which flags can be used in programs. Some of the other training aids show other uses of flags on the HP 35s.

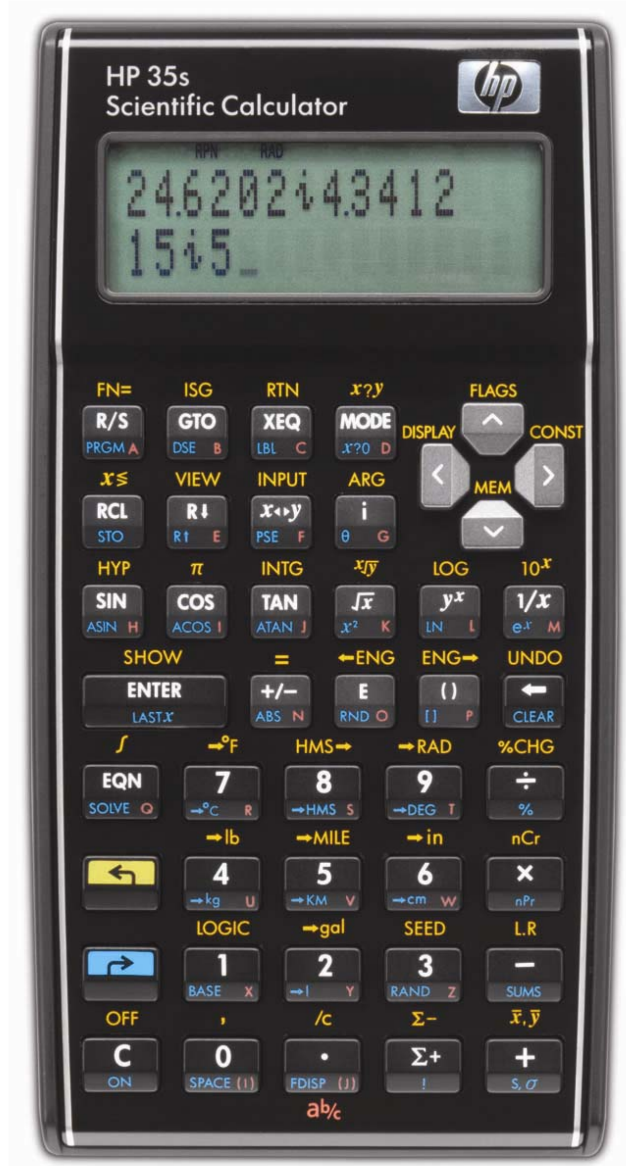
hp calculators

HP 35s Converting programs
to line number addressing

Programming the HP 35s

Using line numbers rather than labels

Example



Programming the HP 35s

Doing a simple calculation once on the HP 35s is easy. Doing the same calculation many times, or doing a complicated calculation, takes longer. It can be better to store all the steps needed for the calculation in a **program**. A program is a set of instructions, stored all together. Once it is written, it can be tested to see if it works correctly. Then it can be used many times, without the need to press every key of the calculation each time.

A simple program is just a set of keystrokes stored so that they can be carried out with one key. The HP 35s provides many commands to let programs do more, for example stop and ask for input, or show an intermediate result.

This training aid concentrates on converting programs originally written using labels, such as programs written for the HP33s, to using line number addressing, as is available on the HP 35s calculator.

Converting programs from labels to line numbers

The HP 35s has 26 labels for use to define programs or transfers to locations within programs. Unlike the HP 33s, the HP 35s also includes the ability to transfer execution to specific line numbers within one of the 26 labels. This allows for a much greater utilization of program memory without using labels excessively.

Suppose you have the program below and wish to convert it to the HP35s. This program will pause to display the intermediate values, given a whole number input, as it performs the steps involved in Ulam's Conjecture. Will the number eventually converge to one or not? (Note: There has been absolutely no attempt to optimize this program!)

	Label Version
A001	LBL A
A002	STO A
B001	LBL B
B002	PSE
B003	1
B004	x=y?
B005	RTN
B006	x<>y
B007	2
B008	RMDR
B009	x=0?
B010	GTO D

B011	RCL A
B012	3
B013	x
B014	1
B015	+
C001	LBL C
C002	STO A
C003	GTO B
D001	LBL D
D002	RCL A
D003	2
D004	INT÷
D005	GTO C

Converting on paper. Given the initial listing, the first suggestion is to make a note next to the first step following each LBL instruction after the initial label that starts the routine. These would be the PSE after LBL B, the STO A after LBL C, the RCL A after LBL D. Beside each of these steps, write B, C, and D. These will become the steps that line number GTOs and XEQs will reference. In the listing below, these steps are BOLD.

	Label Version
A001	LBL A
A002	STO A
B001	LBL B
B002	**PSE**
B003	1
B004	x=y?
B005	RTN
B006	x<>y
B007	2
B008	RMDR
B009	x=0?
B010	GTO D

B011	RCL A
B012	3
B013	x
B014	1
B015	+
C001	LBL C
C002	**STO A**
C003	GTO B
D001	LBL D
D002	**RCL A**
D003	2
D004	INT÷
D005	GTO C

Now, write the program down again, but this time leave out all LBL instructions – but put the LBL letter next to the instruction that follows the now deleted label. Also leave in the GTO (or XEQ) instructions with the labels originally referenced. This may make it easier to replace them with the proper line number addresses.

With	**Line Numbers**
	LBL A
	STO A
B	**PSE**
	1
	x=y?
	RTN
	X<>Y
	2
	RMDR
	x=0?
	GTO D

	RCL A
	3
	X
	1
	+
C	**STO A**
	GTO B
D	**RCL A**
	2
	INT÷
	GTO C

Now begin numbering the lines starting with A001. When you get to a line with a letter next to it, find the GTO or XEQ instruction with that same letter. Change that GTO or XEQ instruction to point to the line number of the instruction that had the letter next to it. Line A003 is the first one encountered.

With	**Line Numbers**
A001	LBL A
A002	STO A
B	**PSE**
	1
	x=y?
	RTN
	X<>Y
	2
	RMDR
	x=0?
	GTO D

	RCL A
	3
	X
	1
	+
C	**STO A**
	GTO A003 **Changed**
D	**RCL A**
	2
	INT÷
	GTO C

Continue working through the program in this manner. Line A017 is the next one. Then line A019.

With	**Line Numbers**
A001	LBL A
A002	STO A
A003	PSE
A004	1
A005	x=y?
A006	RTN
A007	X<>Y
A008	2
A009	RMDR
A010	x=0?
A011	GTO D

A012	RCL A
A013	3
A014	X
A015	1
A016	+
A017	**STO A**
	GTO A003
D	**RCL A**
	2
	INT÷
	GTO A017 **Changed**

With	**Line Numbers**
A001	LBL A
A002	STO A
A003	PSE
A004	1
A005	x=y?
A006	RTN
A007	X<>Y
A008	2
A009	RMDR
A010	x=0?
A011	GTO A019 **Changed**

A012	RCL A
A013	3
A014	X
A015	1
A016	+
A017	STO A
A018	GTO A003
A019	**RCL A**
	2
	INT÷
	GTO A017

The final version of the program would look like this:

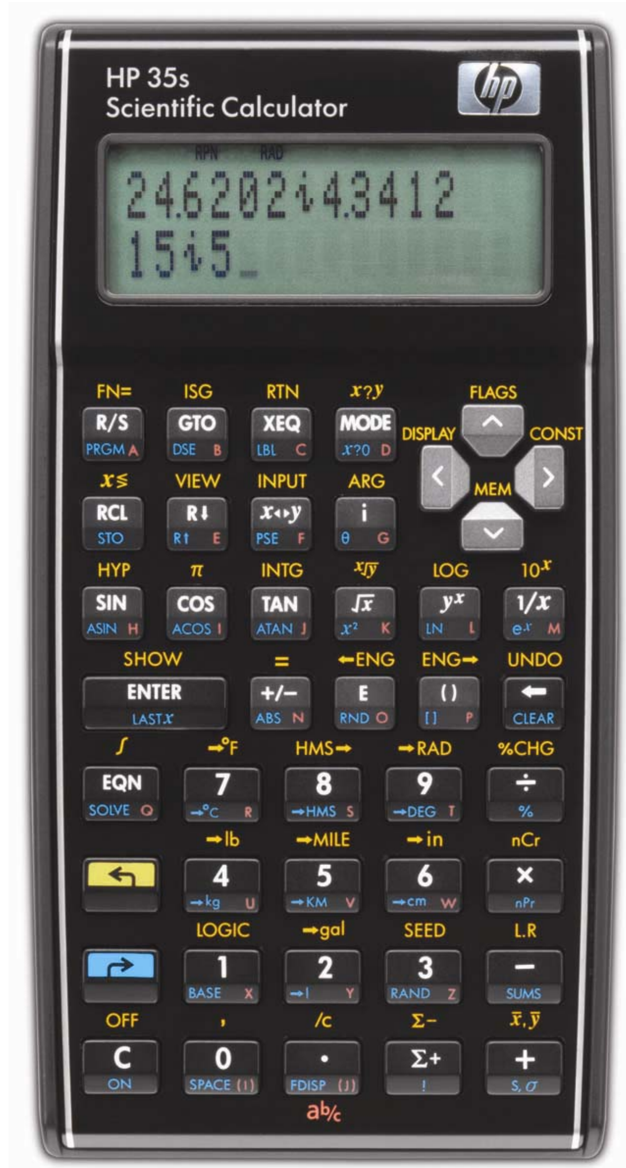
With	**Line Numbers**
A001	LBL A
A002	STO A
A003	PSE
A004	1
A005	x=y?
A006	RTN
A007	X<>Y
A008	2
A009	RMDR
A010	x=0?
A011	GTO A019

A012	RCL A
A013	3
A014	X
A015	1
A016	+
A017	STO A
A018	GTO A003
A019	RCL A
A020	2
A021	INT÷
A022	GTO A017

Conclusion. While there are many ways of converting programs containing labels to use line numbers, this is one example. Line number addressing provides many benefits on the HP 35s.

hp calculators

HP 35s General applications – Part 1



General applications

Practice solving problems

- Application 1: Shape Factor
- Application 2: Fluid Flow

General applications

This training aid will illustrate the application of the HP 35s calculator to several problems in other areas. These examples are far from exhaustive, but do indicate the incredible flexibility of the HP 35s calculator.

Practice solving problems

Application 1: Shape Factor

Example 1: What is the shape factor for heat transfer by radiation between two parallel disks 2 feet apart? The radii of the disks are 1.5 feet and 3.5 feet.

Solution: While the formula to solve this problem is not particularly complicated, it does involve a good amount of repetitive calculation, making it a very good candidate for the Equation Mode on the HP 35s. In the formula below, a is the radius of the first disk, b is the radius of the second disk, and L is the distance between the disks.

$$F = \frac{1}{2a^2}[L^2 + a^2 + b^2 - \sqrt{(L^2 + a^2 + b^2)^2 - 4a^2 * b^2}]$$

[EQN] [1] [÷] [( )] [2] [×] [↱] [x^2] [RCL] [A] [>] [>] [×]
[( )] [↱] [x^2] [RCL] [L] [>] [+] [↱] [x^2] [RCL] [A] [>] [+] [↱] [x^2] [RCL] [B] [>] [−]
[$\sqrt{x}$] [↱] [x^2] [↱] [x^2] [RCL] [L] [>] [+] [↱] [x^2] [RCL] [A] [>] [+] [↱] [x^2] [RCL] [B] [>] [>]
[−] [4] [×] [↱] [x^2] [RCL] [A] [>] [×] [↱] [x^2] [RCL] [B] [ENTER]

Figure 1

Figure 2

With the equation showing on the bottom line of the screen, press [ENTER]

Figure 3

[1] [·] [5] [R/S]

Figure 4

[2] [R/S]

Figure 5

[3] [·] [5] [R/S]

Figure 6

Answer: The shape factor is 0.7263.

Application 2: Fluid Flow

Example 1: What is the amount of flow of fluid across a weir with a V shaped notch? The angle of the notch is 30 degrees and the height of the liquid from the bottom edge of the weir is 6 feet.

Fluid flow = 2.505 x TAN (½ angle) x H $^{2.47}$

Solution: First, set the angle mode to degrees: [MODE] [1]

In RPN mode: [2] [·] [5] [0] [5] [ENTER] [3] [0] [ENTER] [2] [÷] [TAN] [×] [6] [ENTER] [2] [·] [4] [7] [y^x] [×]

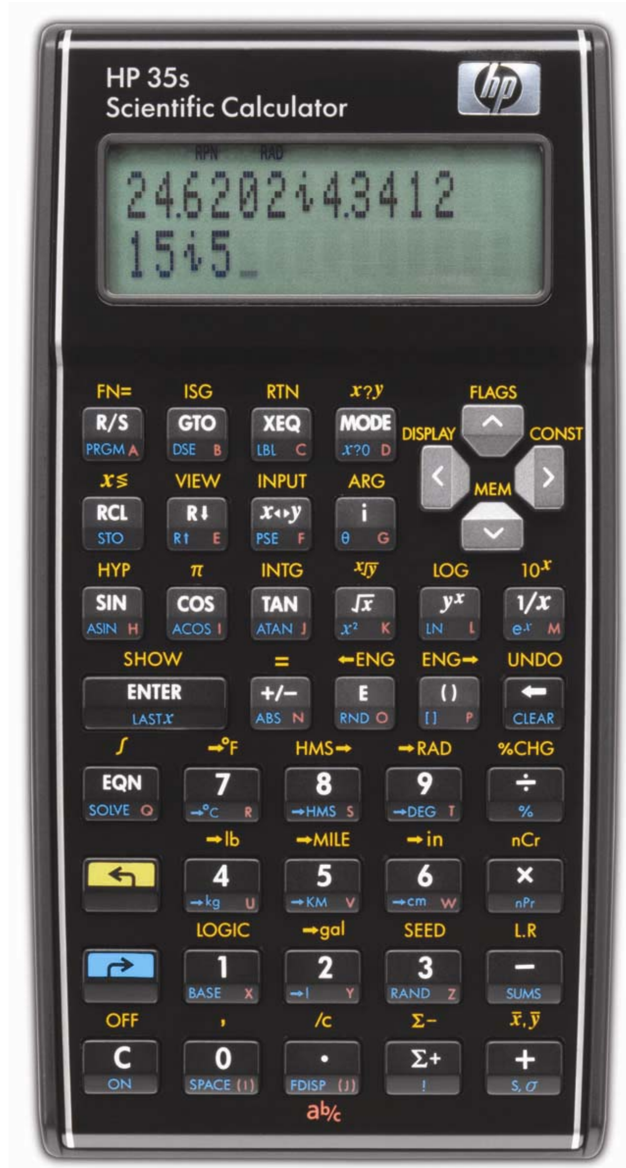
In algebraic mode: [2] [·] [5] [0] [5] [×] [TAN] [3] [0] [÷] [2] [>] [×] [6] [y^x] [2] [·] [4] [7] [ENTER]

Figure 7

Answer: The amount of fluid flow is 56.09 cubic feet per second.

hp calculators

HP 35s General applications – Part 2



Other applications

Practice solving problems

- Application 1: Aerodynamics

  Example 1: Turn radius and Turn rate

- Application 2: Electrical Engineering

  Example 1: Parallel Resistors

- Application 3: Civil Engineering

  Example 1: Rainfall runoff

General applications

This training aid will illustrate the application of the HP 35s calculator to several problems in other areas. These examples are far from exhaustive, but do indicate the incredible flexibility of the HP 35s calculator.

Practice solving problems

Application 1: Aerodynamics

Example 1: An airplane is in a steady coordinated turn with a true airspeed of 250 mph at a 40 degree bank angle. What is the turn radius in feet and the turn rate in degrees per second?

The equations are:

Turn Radius = Velocity ^{2} ÷ (g x TAN (angle))

Turn Rate = g x TAN (angle) ÷ Velocity

Where g is 32.2 feet per second per second

Solution: First, convert the speed to feet per second for unit consistency.

In RPN mode:

2 5 0 ENTER 5 2 8 0 ×
6 0 ÷ 6 0 ÷
ENTER (Save for next calculation)
↱ x^2 3 2 . 2 ENTER 4 0 TAN × ÷ (Radius in feet)

$x\leftrightarrow y$ 3 2 . 2 ENTER 4 0 TAN ×
$x\leftrightarrow y$ ÷ ↱ →DEG (Rate of turn in degrees per second)

In algebraic mode:

↱ x^2 2 5 0 × 5 2 8 0
÷ 6 0 ÷ 6 0 > ÷ ( )
3 2 . 2 × TAN 4 0 ENTER (Radius in feet)

↱ →DEG 3 2 . 2 × TAN 4 0 ÷
( ) 2 5 0 × 5 2 8 0
÷ 6 0 ÷ 6 0 ENTER (Rate of turn in degrees per second)

Figure 1

Answer: The turn radius is just under 4976 feet and the rate of turn is approximately 4.22 degrees per second. Figure 1 (RPN mode) shows the radius on the second level of the stack and the rate on the bottom level.

Application 2: Electrical Engineering

Example 1: Three resistors of 200 ohms, 500 ohms and 220 ohms are in parallel. What is the equivalent resistance?

Solution: In RPN mode: [2] [0] [0] [1/x] [5] [0] [0] [1/x] [+] [2] [2] [0] [1/x] [+] [1/x]

In algebraic mode: [1/x] [1/x] [2] [0] [0] [>] [+] [1/x] [5] [0] [0] [>] [+] [1/x] [2] [2] [0] [ENTER]

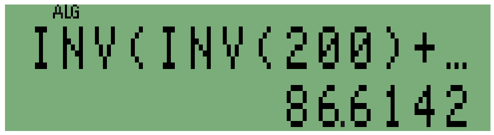


Figure 2

Answer: The equivalent resistance is 86.6 ohms

Application 3: Civil Engineering

Example 1: Runoff of rainfall from an area to an outlet will be at maximum when the water from the most remote point contributes to the flow. What is that time if the slope is 0.25 per foot per foot, the rain intensity is 0.8 inches per hour and the distance from the most remote area is 800 feet. Use a coefficient of 2.1 for grass.

The formula is: Time = C x (D ÷ (S x I ^{2})) $^{1/3}$

Where C is the grass coefficient, D is the distance from the most remote area, S is the slope, and I is the rainfall intensity.

Solution: In RPN mode: [2] [·] [1] [ENTER] [8] [0] [0] [ENTER] [0] [·] [2] [5] [ENTER] [0] [·] [8] [↱] [x^2] [×] [÷] [3] [↰] [$\sqrt[x]{y}$] [×]

In algebraic mode: [2] [·] [1] [×] [↰] [$\sqrt[x]{y}$] [3] [>] [8] [0] [0] [÷] [( )] [0] [·] [2] [5] [×] [↱] [x^2] [0] [·] [8] [ENTER]

Figure 3

Answer: The time until maximum is just under 36 minutes.

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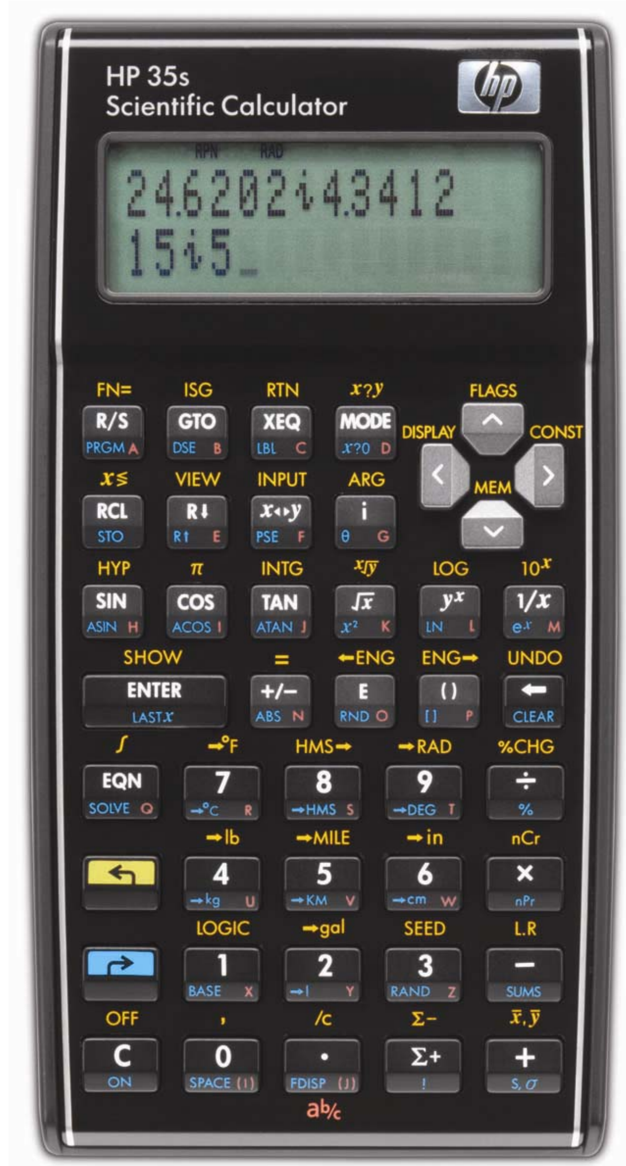
HP 35s General applications - Part 3

Other applications

Practice solving problems

- Application 1: True Heading
- Application 2: Thrown object
- Application 3: Gas Pressure



General applications

This training aid will illustrate the application of the HP 35s calculator to several problems in other areas. These examples are far from exhaustive, but do indicate the incredible flexibility of the HP 35s calculator.

Practice solving problems

Application 1: True Heading

Example 1: Before a plane takes off, a preflight plan must be filed indicating the proposed trip. In these plans, the known data are true course (TC), wind direction (WD), wind velocity (WV) and true air speed (TAS). Find the true heading of a planned flight, if TC = 80 degrees, WV = 55 mph, TAS = 180 mph, and the WD is toward 95 degrees.

The true heading = TC – ASIN (WV x SIN (WD – TC) / TAS)

Solution: Place the 35s into degrees mode by pressing [MODE] [1]

In RPN mode: [8] [0] [ENTER] [5] [5] [ENTER] [9] [5] [ENTER] [8] [0] [–] [SIN] [1] [8] [0] [÷] [×] [↰] [ASIN] [–]

In algebraic mode: [8] [0] [–] [↰] [ASIN] [5] [5] [×] [SIN] [9] [5] [–] [8] [0] [>] [÷] [1] [8] [0] [ENTER]

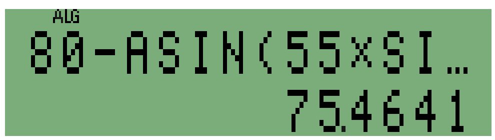


Figure 1

Answer: 75.46 degrees.

Application 2: Thrown object

Example 1: If a ball is thrown straight upward with a velocity of 95 feet per second, what is the velocity and height of the object after 2 seconds? Use a value of 32.2 feet per second per second for g.

Velocity = Original Velocity – g x time

Height = Original Velocity x time – ½ x g x t^2

Solution: In RPN mode: [9] [5] [ENTER] [3] [2] [·] [2] [ENTER] [2] [×] [–] (Velocity at t = 2 seconds)

[9] [5] [ENTER] [2] [×] [0] [·] [5] [ENTER] [3] [2] [·] [2] [×] [2] [↰] [x^2] [–] (Height at t = 2 seconds)

In algebraic mode: [9] [5] [–] [3] [2] [·] [2] [×] [2] [ENTER] (Velocity at t = 2 seconds)

[9] [5] [×] [2] [–] [0] [·] [5] [×] [3] [2] [·] [2] [×] [↰] [x^2] [2] [ENTER] (Height at t = 2 seconds)

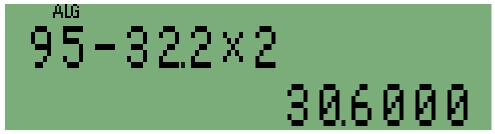


Figure 2

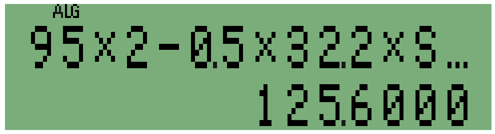


Figure 3

Answer: After 2 seconds, the object is at a height of 125.6 feet and traveling at a velocity of 30.6 feet per second.

Application 3: Gas pressure

Example 1: The internal pressure of a tank of gas is 1100 psi at room temperature (298 degrees Kelvin). What is the internal pressure if the temperature rises by 35 degrees Celsius?

New Pressure = Old Pressure x New Temperature ÷ Old Temperature

Solution: In RPN mode: [1] [1] [0] [0] [ENTER] [2] [9] [8] [ENTER] [3] [5] [+] [×] [2] [9] [8]

In algebraic mode: [1] [1] [0] [0] [×] [()] [2] [9] [8] [+] [3] [5] [>] [÷] [2] [9] [8] [ENTER]

Figure 4

Answer: The new pressure is 1229 psi.

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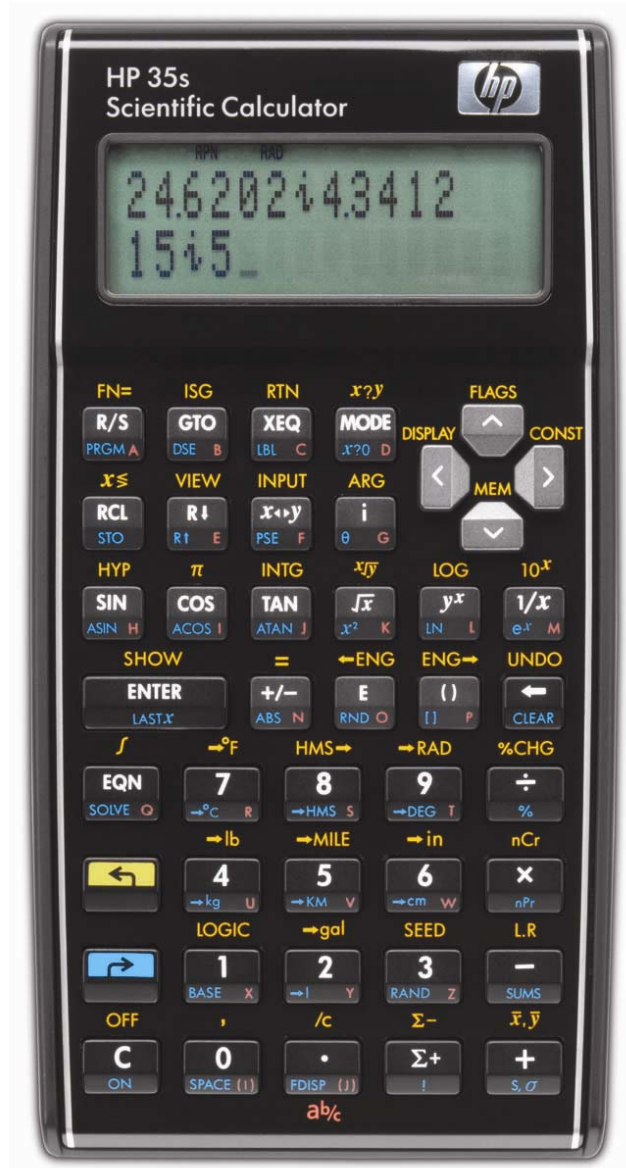
HP 35s Applications in Electrical Engineering

Applications in electrical engineering

Practice solving problems in electrical engineering

- Application 1: Transmission line impedance



Applications in electrical engineering

This training aid will illustrate the application of the HP 35s calculator to several problems arising in electrical engineering. These examples are far from exhaustive, but do indicate the incredible flexibility of the HP 35s calculator.

Practice solving problems in electrical engineering

Application 1: Transmission line impedance

The formulas below allow for the computation of the high frequency characteristic impedance for three types of transmission lines, where D is the input wire spacing, d is the wire diameter, ε is the relative permittivity, and h is the wire height.

Open two wire line $$Z_0 = \frac{120}{\sqrt{\varepsilon}} \mathrm{LN}\left(\frac{2D}{d}\right)$$ Figure 1

Single wire near ground $$Z_0 = \frac{138}{\sqrt{\varepsilon}} \mathrm{LOG}\left(\frac{4h}{d}\right)$$ Figure 2

Coaxial line $$Z_0 = \frac{60}{\sqrt{\varepsilon}} \mathrm{LN}\left(\frac{D}{d}\right)$$ Figure 3

In the examples that follow, the HP 35s will be used to solve problems involving these equations. If repetitive calculations with these equations is foreseen, they could be entered into the HP 35s as equations and solved in that manner.

Example 1: Compute Z_0 for RG-218/U coaxial cable with D = 0.68 inches, d = 0.195 inches, and ε = 2.3 (polyethylene).

Solution: In RPN mode: [6] [0] [ENTER] [2] [.] [3] [√x] [÷] [0] [.] [6] [8] [ENTER] [0] [.] [1] [9] [5] [÷] [↱] [LN] [×]

In algebraic mode: [6] [0] [÷] [√x] [2] [.] [3] [>] [×] [↱] [LN] [0] [.] [6] [8] [÷] [0] [.] [1] [9] [5] [ENTER]

Figure 4

Answer: 49.42 ohms.

Example 2: Compute Z_0 for an open 2-wire line with D = 6 inches, d = 0.0808 inches, and ε = 1 (air).

Solution: Note that the division by the square root of 1 in the solutions below is unnecessary, but included for clarity.

In RPN mode: [1] [2] [0] [ENTER] [1] [√x] [÷] [6] [ENTER] [2] [×] [0] [.] [0] [8] [0] [8] [÷] [↱] [LN] [×]

In algebraic mode: [1] [2] [0] [÷] [√x] [1] [>] [×] [↱] [LN] [6] [×] [2] [÷] [0] [.] [0] [8] [0] [8] [ENTER]

Figure 5

Answer: 600.08 ohms.

Example 3: Compute Z_0 for an air line consisting of a single 0.1285 inch wire six inches from a ground plane.

Solution: Note that $\varepsilon = 1$, since this is an air line.

In RPN mode: [1] [3] [8] [ENTER] [1] [$\sqrt{x}$] [÷] [4] [ENTER] [6] [×] [0] [.] [1] [2] [8] [5] [÷] [↰] [LOG] [×]

In algebraic mode: [1] [3] [8] [÷] [$\sqrt{x}$] [1] [>] [×] [↰] [LOG] [4] [×] [6] [÷] [0] [.] [1] [2] [8] [5] [ENTER]

Figure 6

Answer: 313.44 ohms.

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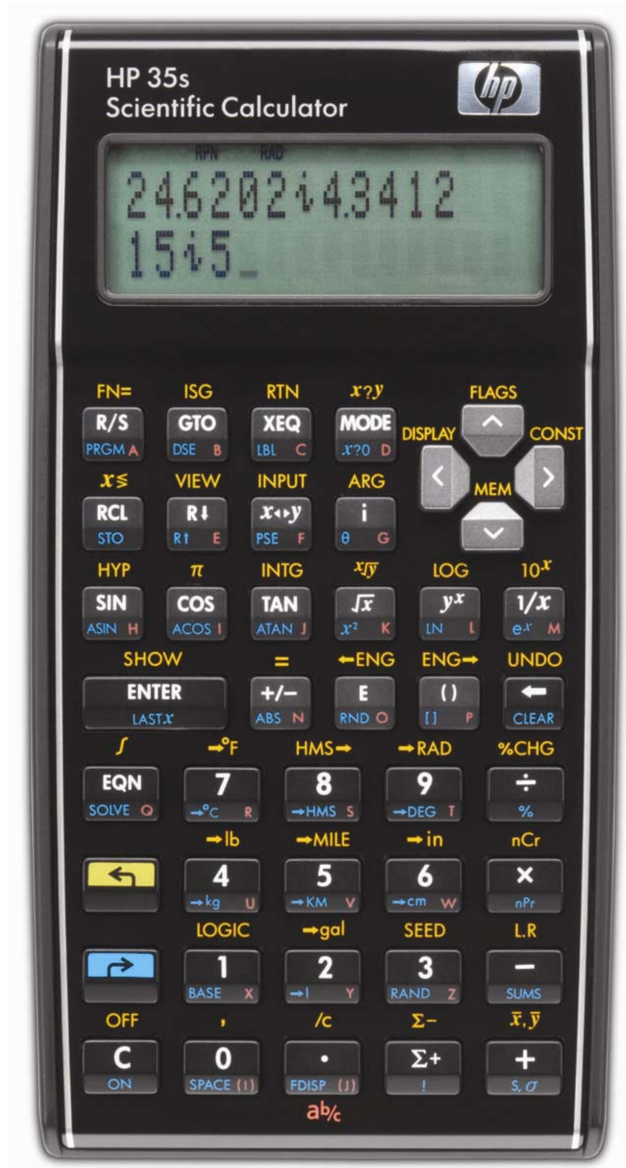

HP 35s Applications in Mechanical Engineering

Applications in mechanical engineering

Practice solving problems in mechanical engineering

- Application 1: Stress on an element (Mohr circle)

Applications in mechanical engineering

This training aid will illustrate the application of the HP 35s calculator to several problems arising in mechanical engineering. These examples are far from exhaustive, but do indicate the incredible flexibility of the HP 35s calculator.

Practice solving problems in mechanical engineering

Application 1: Stress on an element (Mohr circle)

The Mohr circle equations convert an arbitrary stress configuration to principal stresses, maximum shear stress, and rotation angle. It is then possible to calculate the state of stress for an arbitrary orientation θ'.

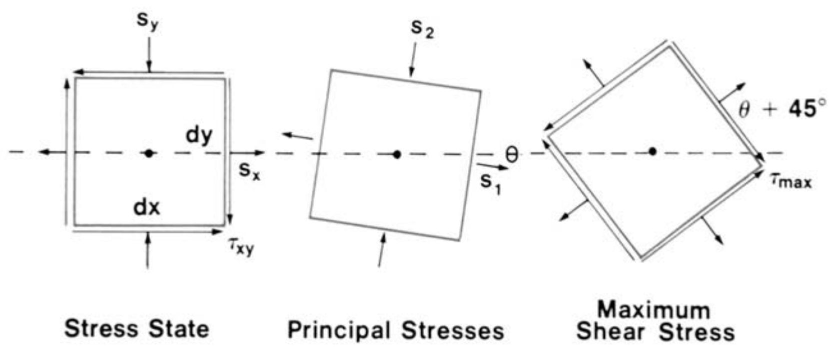

Figure 1

The Mohr circle formulas are shown below, where s is the normal stress, τ is the shear stress, s_x is the stress in the x direction for Mohr circle input, s_y is the stress in the y direction for Mohr circle input, τ_{xy} is the shear stress on the element for the Mohr circle input, s_1 and s_2 are the principal stresses, θ is the rotation angle, and τ_{max} is the maximum shear stress. Note that θ is the angle of rotation from the specified axis to the principal axis, and so should be thought of as a negative angle. This is opposite to the normal Mohr circle convention.

Maximum shear stress $$\tau_{max} = \sqrt{\left(\frac{s_x - s_y}{2}\right)^2 + \tau_{xy}^{\ 2}}$$ Figure 2

Principal stress $$s_1 = \frac{s_x + s_y}{2} + \tau_{max}$$ Figure 3

Principal stress $$s_2 = \frac{s_x + s_y}{2} - \tau_{max}$$ Figure 4

Rotation angle $$\theta = \frac{1}{2}\tan^{-1}\left(\frac{2\tau_{xy}}{s_x - s_y}\right)$$ Figure 5

<u>Example:</u> If s_x = 25,000 psi, s_y = -5,000 psi, and τ_{xy} = 4,000 psi, compute the principal stresses, the angle of rotation θ, and the maximum shear stress.

<u>Solution:</u> Solve for the maximum shear stress, τ_{max}.

In RPN mode: [2] [5] [0] [0] [0] [ENTER] [5] [0] [0] [0] [+/-] [−] [2] [÷] [↱] [x^2] [4] [0] [0] [0] [↱] [x^2] [+] [$\sqrt{x}$] [↱] [STO] [T]

In algebraic mode: [$\sqrt{x}$] [↱] [x^2] [( )] [2] [5] [0] [0] [0] [−] [5] [0] [0] [0] [+/-] [>] [÷] [2] [>] [+] [↱] [x^2] [4] [0] [0] [0] [ENTER] [↱] [STO] [T]

Figure 6

Solve for the principal stress, s_1.

In RPN mode: [2] [5] [0] [0] [0] [ENTER] [5] [0] [0] [0] [+/-] [+] [2] [÷] [RCL] [T] [+]

In algebraic mode: [( )] [2] [5] [0] [0] [0] [+] [5] [0] [0] [0] [+/-] [>] [÷] [2] [+] [RCL] [T] [ENTER]

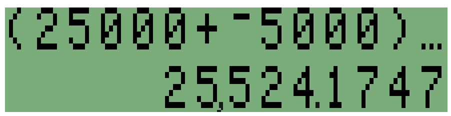

Figure 7

Solve for the principal stress, s_2.

In RPN mode: [2] [5] [0] [0] [0] [ENTER] [5] [0] [0] [0] [+/-] [+] [2] [÷] [RCL] [T] [−]

In algebraic mode: [( )] [2] [5] [0] [0] [0] [+] [5] [0] [0] [0] [+/-] [>] [÷] [2] [−] [RCL] [T] [ENTER]

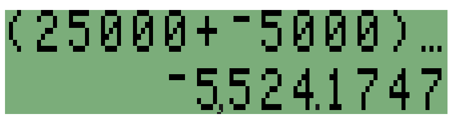

Figure 8

Solve for the rotation angle, θ.

In RPN mode: [2] [ENTER] [4] [0] [0] [0] [×] [2] [5] [0] [0] [0] [ENTER] [5] [0] [0] [0] [+/-] [−] [÷] [↱] [ATAN] [2] [÷]

In algebraic mode: [↱] [ATAN] [2] [×] [4] [0] [0] [0] [÷] [( )] [2] [5] [0] [0] [0] [−] [5] [0] [0] [0] [+/-] [>] [>] [÷] [2] [ENTER]

Figure 9

Answer: The principal stresses, s_1 and s_2, are 25,524 psi and -5,524 psi. The angle of rotation, θ, is 7.4657 degrees. The maximum shear stress is 15,524 psi.

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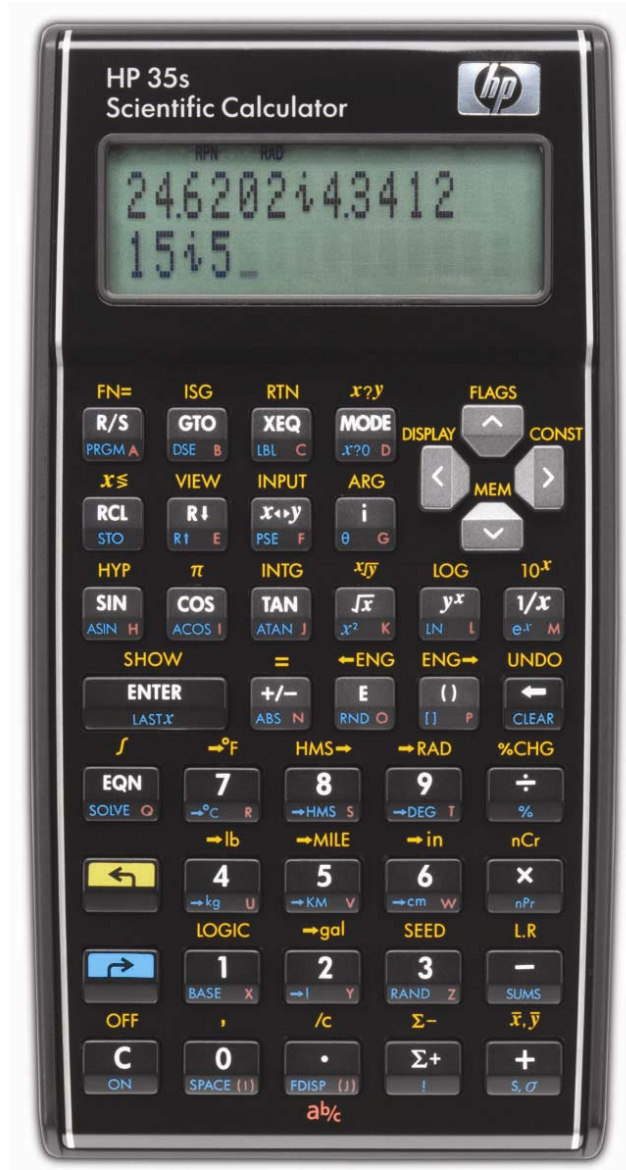
HP 35s Applications in Medicine



Applications in Medicine

Practice solving problems in medicine

- Application 1: Beer's Law
- Application 2: Body Surface Area (BSA)
- Application 3: Schilling Test for Vitamin B_{12} Absorption

Applications in Medicine

This training aid will illustrate the application of the HP 35s calculator to several problems arising in medicine. These examples are far from exhaustive, but do indicate the incredible flexibility of the HP 35s calculator.

Practice solving problems in medicine

Application 1: Beer's Law

Beer's law is a physical law which states that the quantity of light absorbed by a substance dissolved in a non-absorbing solvent is directly related to the concentration of the substance and the path length of the light through the solution. Beer's Law describes how the intensity of light diminishes as it passes through an absorbing media. For many colored materials there is a linear relationship between a property of the materials called optical density and the concentration of the colored species. The linear relationship is called Beer's Law. The formulas needed to solve Beer's Law are shown below.

$$A=2-LOG(T)$$

Figure 1

$$Cu=Cs\cdot\frac{Au}{As}$$

Figure 2

$$T=10^{(2-A)}$$

Figure 3

In these formulas, T is the percent transmittance, A is the absorbance (optical density) of the substance, Au is the absorbance of the unknown, As is the absorbance of the standard, Cu is the concentration of the unknown substance, and Cs is the concentration of the standard.

Example: A standard solution with a solute concentration of 2 mg/ml is found to have an absorbance of 0.41 at 550 nm. An unknown from a patient is found to show 46% transmittance at the same wavelength. Convert this percent transmission to absorbance. Also find the solute concentration in the unknown.

Solution: Solve for the absorbance of the unknown. Note that T is entered as the percent multiplied by 100.

In RPN mode: 2 ENTER 4 6 ↰ LOG −

In algebraic mode: 2 − ↰ LOG 4 6 ENTER

0.0000
0.3372

Figure 4

Then solve for the solute concentration of the unknown. Note that the absorbance of the unknown is available in the calculator's display to continue the calculation.

In RPN mode: 0 · 4 1 ÷ 2 ×

In algebraic mode: ÷ 0 · 4 1 × 2 ENTER

Figure 5

Answer: The absorbance of the unknown is 34% and the solute concentration of the unknown is 1.65 mg/ml. Figures 4 and 5 indicate the display in RPN mode.

Application 2: Body Surface Area (BSA)

There are two primary methods used to estimate body surface area, the Dubois method and the Boyd Method. Each method uses inputs of a patient's height and weight in metric units and estimates the patient's BSA.

Dubois' formula is shown below in Figure 6 and requires input of the height in centimeters and the weight in kilograms. Note that Dubois' formula is undefined for children with a BSA less than 0.6 m^2. Boyd's formula should be used in these situations.

$$BSA(m^2) = Ht^{0.725} \times Wt^{0.425} \times 0.007184$$

Figure 6

Boyd's formula is shown below in Figure 7 and requires input of the height in centimeters and the weight in grams.

$$BSA(m^2) = Wt^{(0.7285 - 0.0188 \times LOG(Wt))} \times Ht^{0.3} \times 0.0003207$$

Figure 7

Example 1: A patient is 176 centimeters tall and has a weight of 63.5 kilograms. What is the patient's BSA using the Dubios formula? What is the patient's BSA using Boyd's formula?

Solution: Solve for the BSA using Dubios' formula. Figure 8 shows the answer in algebraic mode.

In RPN mode: 1 7 6 ENTER 0 · 7 2 5 y^x
6 3 · 5 ENTER 0 · 4 2 5 y^x ×
0 · 0 0 7 1 8 4 ×

In algebraic mode: 1 7 6 y^x 0 · 7 2 5 ×
6 3 · 5 y^x 0 · 4 2 5 ×
0 · 0 0 7 1 8 4 ENTER

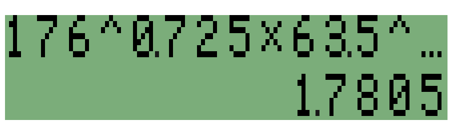


Figure 8

Now solve for the BSA using Boyd's formula. Note that Boyd's formula requires the weight to be input in grams. Figure 9 shows the answer in RPN mode.

In RPN mode: [0][.][7][2][8][5][ENTER][0][.][0][1][8][8][ENTER]
[6][3][5][0][0][◄][LOG][►][LAST x][R↓][×][−][y^x]
[1][7][6][ENTER][0][.][3][y^x][×][0][.][0][0][0][3][2][0][7][×]

In algebraic mode: [6][3][5][0][0][y^x][()][0][.][7][2][8][5][−]
[0][.][0][1][8][8][×][◄][LOG][6][3][5][0][0][>][>][×]
[1][7][6][y^x][0][.][3][×][0][.][0][0][0][3][2][0][7][ENTER]

Figure 9

<u>Answer:</u> Dubois' method estimates a BSA of 1.78 m^2, while Boyd's method estimates a BSA of 1.76m^2.

<u>Example 2:</u> A patient is 176 centimeters tall and has a weight of 63.5 kilograms. What is the patient's BSA using Boyd's formula? Solve the problem by entering Boyd's formula as an *equation*.

<u>Solution:</u> To enter Boyd's formula into the calculator as an equation, press the following keys on the HP 35s:

[EQN][RCL][B][◄][=][RCL][W][y^x][()][0][.][7][2][8][5][−][0][.][0][1][8][8][×][◄][LOG]
[RCL][W][>][>][×][RCL][H][y^x][0][.][3][×][0][.][0][0][0][3][2][0][7][ENTER]

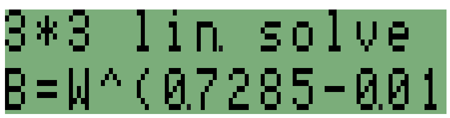


Figure 10

To verify proper entry of the equation, press

[◄][SHOW]

and hold down the [SHOW] key. This will display the equation's checksum and length. The values displayed should be a checksum of 30D6 and a length of 42, as indicated in Figure 11.

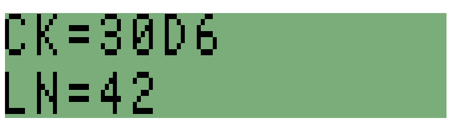


Figure 11

Release the [SHOW] key and the display will return to the one shown in Figure 10. Now press:

[SOLVE][B]

The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution, in this case the variable W. The value of 0.0000 is displayed below if this is the first time the equation has been solved on the HP 35s calculator. If any previous equations have used this variable, it will display the value presently held in the variable. Enter the value of W.

```
W?
0.0000
```

Figure 12

In either RPN or algebraic mode, press: [6] [3] [5] [0] [0] [R/S]

```
H?
0.0000
```

Figure 13

In either RPN or algebraic mode, press: [1] [7] [6] [R/S]

```
B=
            1.7576
```

Figure 14

Answer: Boyd's method estimates a BSA of 1.76m^2. Additional problems can be solved using this equation, if desired. Figure 14 displays the result.

Application 3: Schilling Test for Vitamin B_{12} Absorption

The Schilling Test determines the amount of a radioactive vitamin B_{12} intake that is absorbed. The equation for this calculation is shown in Figure 10.

$$E=\frac{V}{DIL}\cdot\left(\frac{UCPM-BCPM}{SCPM-BCPM}\right)\cdot 100$$

Figure 15

where V is equal to 1 if the urine volume is less than or equal to 1 liter, or equal to the actual urine volume if greater than one liter. If the urine volume is less than 1 liter, it is assumed to have been brought up to 1 liter by the addition of water (and is indicated by DIL, the dilution of the standard). The background (BCPM), standard (SCPM) and urine (UCPM) counts per minute should be of equal volumes counted over equal time intervals (which need not be one minute). The patient being tested should not have received recent prior radioactivity.

Example 1: A capsule of radioactive vitamin B12 is administered orally to a patient. Over the following 24 hours, a volume of 2.54 liters of urine is collected. A 20 milliliter sample of the urine is counted for 10 minutes to give 1923 counts. A 1 milliliter of standard is diluted to 20 milliliters and counted for 10 minutes, giving 1757 counts. 20 milliliters of tap water is used for a background count and over a 10 minute time interval produces 127 counts. Find the percent of the dose excreted.

Solution: V is 2.54 liters, DIL is 20, the Urine CPM is 1923, the standard CPM is 1757, and the background CPM is 127.

In RPN mode: [2] [.] [5] [4] [ENTER] [2] [0] [÷] [1] [9] [2] [3] [ENTER] [1] [2] [7] [−] [1] [7] [5] [7] [ENTER] [1] [2] [7] [−] [÷] [×] [1] [0] [0] [×]

In algebraic mode: [2] [.] [5] [4] [÷] [2] [0] [×]
[( )] [( )] [1] [9] [2] [3] [−] [1] [2] [7] [>] [÷]
[( )] [1] [7] [5] [7] [−] [1] [2] [7] [>] [>] [×] [1] [0] [0] [ENTER]

```
2.54÷20×((1923…
        13.9934
```

Figure 16

Answer: The amount excreted is 13.99%. The amount absorbed is 86.01%. Figure 16 shows the answer in algebraic mode.

Example 2: A capsule of radioactive vitamin B12 is administered orally to a patient. Over the following 24 hours, a volume of 2.54 liters of urine is collected. A 20 milliliter sample of the urine is counted for 10 minutes to give 1923 counts. A 1 milliliter of standard is diluted to 20 milliliters and counted for 10 minutes, giving 1757 counts. 20 milliliters of tap water is used for a background count and over a 10 minute time interval produces 127 counts. Find the percent of the dose excreted. Solve the problem by entering the formula as an equation.

Solution: V is 2.54 liters, DIL is 20, the Urine CPM is 1923, the standard CPM is 1757, and the background CPM is 127.

To enter the formula into the calculator as an equation, press the following keys on the HP 35s:

[EQN] [RCL] [E] [↰] [=] [RCL] [V] [÷] [RCL] [V] [×] [( )] [( )] [RCL] [U] [−] [RCL] [B] [>] [÷] [( )] [RCL] [S] [−] [RCL] [B] [>] [>] [×] [1] [0] [0] [ENTER]

```
B=W^(0.7285-0.0…
E=V÷D×((U-B)÷(
```

Figure 17

To verify proper entry of the equation, press

[↰] [SHOW]

and hold down the [SHOW] key. This will display the equation's checksum and length. The values displayed should be a checksum of BF1C and a length of 23, as indicated in Figure 18.

```
CK=BF1C
LN=23
```

Figure 18

Release the [SHOW] key and the display will return to the one shown in Figure 17. Now press:

[↪] [SOLVE] [E]

The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution, in this case the variable V. The value of 0.0000 is displayed below if this is the first time the equation has been solved on the HP 35s calculator. If any previous equations have used this variable, it will display the value presently held in the variable. Enter the value of V.

Figure 19

In either RPN or algebraic mode, press: [2] [·] [5] [4] [R/S]

Figure 20

In either RPN or algebraic mode, press: [2] [0] [R/S]

Figure 21

In either RPN or algebraic mode, press: [1] [9] [2] [3] [R/S]

Figure 22

Note that the value displayed for B results from the reuse of variable B from the earlier example in this training aid.

In either RPN or algebraic mode, press: [1] [2] [7] [R/S]

Figure 23

In either RPN or algebraic mode, press: [1] [7] [5] [7] [R/S]

Figure 24

Answer: The amount excreted is 13.99%.

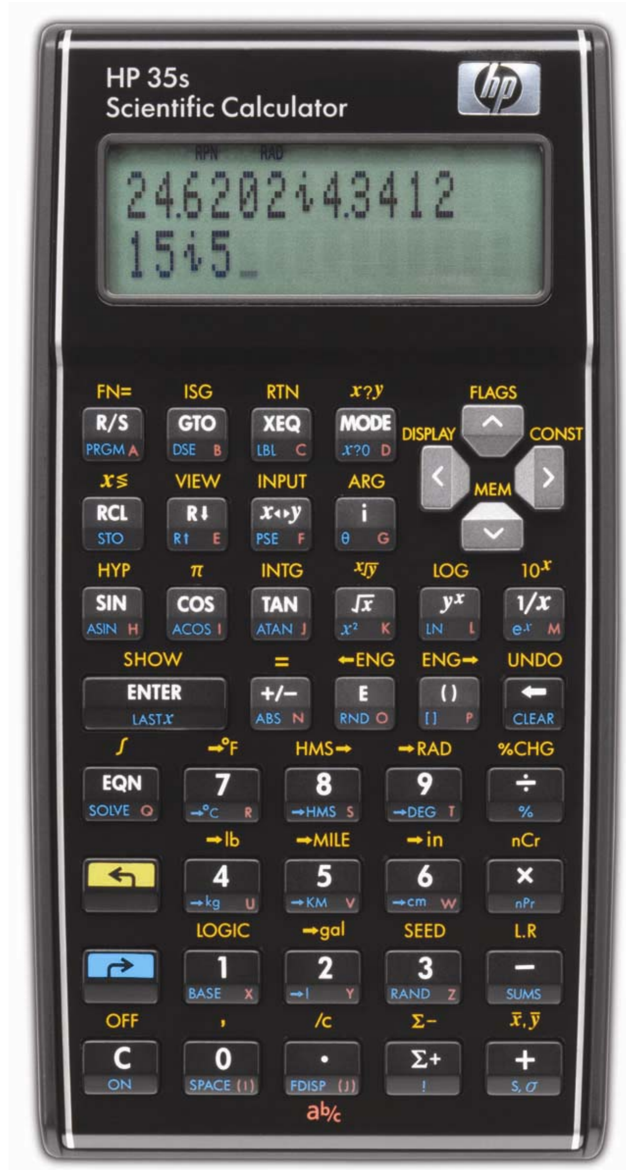
hp calculators

HP 35s Using random numbers for simulations

Random numbers

Simulation

Practice using random numbers for simulations



Random numbers

Random numbers have uses as varied as games and stock market simulations. On the HP 35s, generating random numbers involves providing a starting decimal seed to the calculator using the [↰] [SEED] function. Random numbers between 0 and 1 are then generated sequentially using the [↱] [RAND] function.

A different series of random numbers will be generated from each decimal number used as an initial seed. Using the same initial seed will result in the same series of random numbers.

Simulation

A useful application of random numbers is to simulate complex processes that involve the element of chance. These simulations can be as easy as simulating the flip of a coin or can be quite elaborate. The examples below are far from exhaustive, but provide an illustration of how random numbers can be used on the HP 35s.

Practice solving problems angles and times

Example 1: Simulate flipping a coin four times. Use a starting seed of 0.123456.

Solution: When a coin is flipped, the probability of heads is 0.5 and of tails also 0.5. Let the decimal range of 0 < random number < 0.5 equate to observing a "heads." The decimal range of 0.5 <= random number <1 will equate to a tails. Store the initial seed and then generate the four random numbers.

In RPN mode: [0] [.] [1] [2] [3] [4] [5] [6] [↰] [SEED]
In algebraic mode: [↰] [SEED] [0] [.] [1] [2] [3] [4] [5] [6] [ENTER]

In RPN mode, press [↱] [RAND]. In algebraic mode: [↱] [RAND] [ENTER]

Figure 1

In RPN mode, press [↱] [RAND]. In algebraic mode: [↱] [RAND] [ENTER]

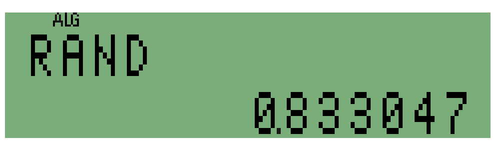


Figure 2

In RPN mode, press [↱] [RAND]. In algebraic mode: [↱] [RAND] [ENTER]

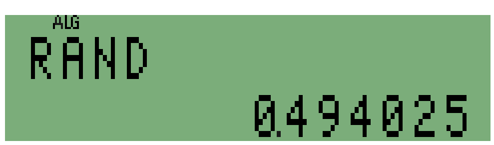


Figure 3

In RPN mode, press [↱] [RAND]. In algebraic mode: [↱] [RAND] [ENTER]

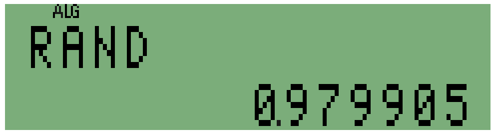


Figure 4

Answer: The first three random numbers are in the range 0.5 <= random number <1, and therefore equate to the result "heads." The fourth random number is in the range 0 <= random number < 0.5, and is therefore a result of "tails." Figures 1 through 4 show the display assuming algebraic mode.

Example 2: Nelson's Newstand sells newspapers and has experienced demand for newspapers as follows over the last 50 days: 10 newspapers on 5 of the days; 15 newspapers on 20 of the days; 20 newspapers on 15 of the days; and 25 newspapers on 10 of the days. Using random numbers and an initial seed of 0.234567, simulate demand for the next 4 days.

Solution: The first step will be to translate the past demand into ranges for our random numbers for the simulation. Out of past 50 days, demand was 10 on 5 of these days, or 10% of the time. Out of the past 50 days, demand was 15 on 20 of these days, or 40% of the time. Out of the past 50 days, demand was 20 on 15 of these days, or 30% of the time. Finally, out of the past 50 days, demand was 25 on 10 of the days, or 20% of the time. This information can be summarized in a table as shown below.

Demand	Probability
10	0.1
15	0.4
20	0.3
25	0.2

Next, we need to assign a range for each level of demand that corresponds to the relative probability for that demand. It is this range that will be used to classify each random number as a specific simulated demand.

Demand	Probability	Range
10	0.1	0.0 < random number <= 0.1
15	0.4	0.1 < random number <= 0.5
20	0.3	0.5 < random number <= 0.8
25	0.2	0.8 < random number < 1.0

Note that each range corresponds to the probability of each outcome (the range between 0.1 and 0.5 is 40% of the possible outcomes of the random numbers and therefore reflects the 40% chance that a demand of 15 will occur). Store the initial seed and then generate the five random numbers. Evaluate each random number as it is generated.

In RPN mode: [0] [·] [2] [3] [4] [5] [6] [7] [shift] [SEED]
In algebraic mode: [shift] [SEED] [0] [·] [2] [3] [4] [5] [6] [7] [ENTER]

In RPN or algebraic mode: ↱ RAND

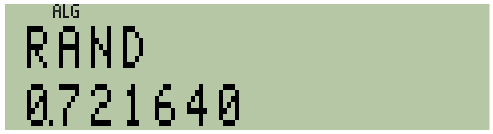


Figure 5

This corresponds to a demand of 20 newspapers. In RPN mode, press ↱ RAND. In algebraic mode: ↱ RAND ENTER

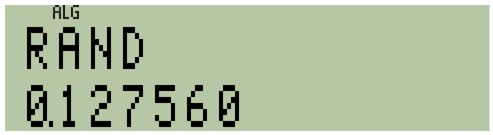


Figure 6

This corresponds to a demand of 15 newspapers. In RPN mode, press ↱ RAND. In algebraic mode: ↱ RAND ENTER

Figure 7

This corresponds to a demand of 20 newspapers. In RPN mode, press ↱ RAND. In algebraic mode: ↱ RAND ENTER

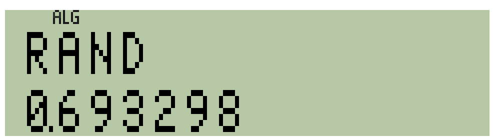


Figure 8

This corresponds to a demand of 20 newspapers. In RPN mode, press ↱ RAND. In algebraic mode: ↱ RAND ENTER

Figure 9

This corresponds to a demand of 20 newspapers.

Answer: The results were demands of 20, 15, 20, and 20 newspapers. If the simulation were carried out for a longer period (which could be done by writing a program), other levels of demand would be generated. Figures 5 through 9 show the display assuming algebraic mode.

Example 3: Simulate rolling 2 dice. Use a starting seed of 0.345678

Solution: When a die is rolled, the result is equally likely to be a 1, 2, 3, 4, 5, or 6. Since the HP 35s random numbers are decimal numbers, it will be necessary to transform them into integers between 1 and 6. Since the lowest possible valid value of rolling a die is 1, the process to transform a decimal random number into a value between 1 and 6 will be:

Result = The integer value of (the random number x 6 plus 1)

It is necessary to multiply the decimal random number generated by 6, add 1 and take the integer value of the result. Since two die are to be rolled, this will be done two times. Store the initial seed and then generate the first random number.

In RPN mode: [0] [.] [3] [4] [5] [6] [7] [8] [↰] [SEED]
In algebraic mode: [↰] [SEED] [0] [.] [3] [4] [5] [6] [7] [8] [ENTER]

Figure 10

In RPN mode: [↱] [RAND] [6] [×] [1] [+] [↰] [INTG] [4]
In algebraic mode: [↰] [INTG] [4] [↱] [RAND] [×] [6] [+] [1] [ENTER]

Figure 11

In RPN mode: [↱] [RAND] [6] [×] [1] [+] [↰] [INTG] [4]
In algebraic mode: [↰] [INTG] [4] [↱] [RAND] [×] [6] [+] [1] [ENTER]

Figure 12

Answer: The value of the first die was a 4 and the second was a 3, for a total on the two dice of 7. Figures 10 through 12 show the display assuming algebraic mode. Note: In algebraic mode, to generate another random dice roll, it is much quicker to press [<] and then [ENTER]. This will re-evaluate the previous command line.

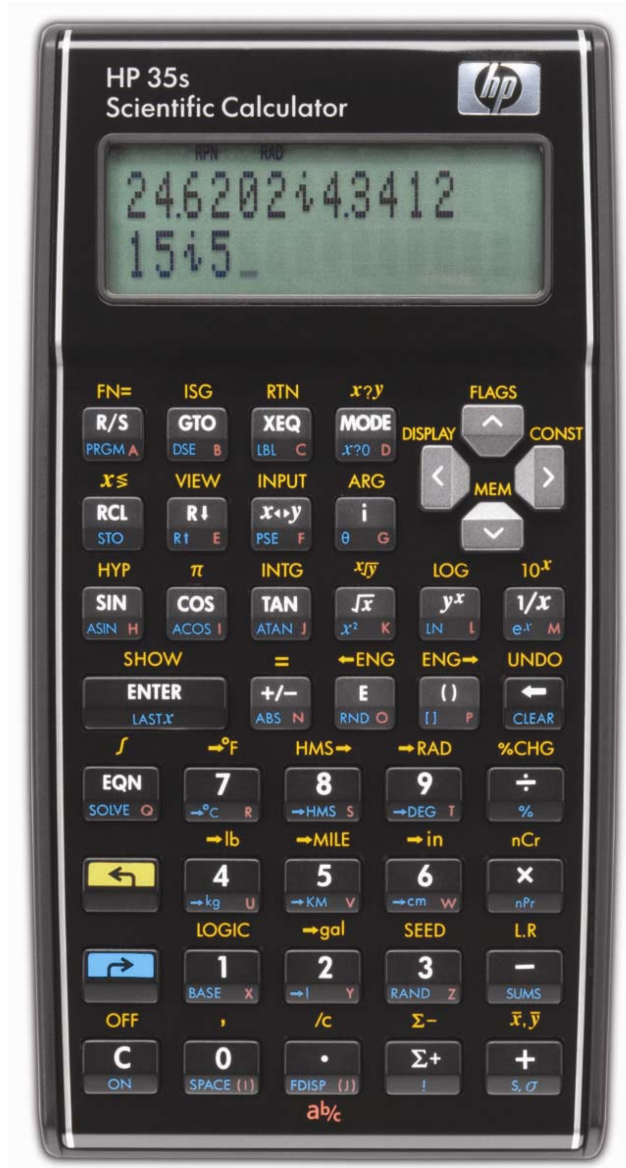
hp calculators

HP 35s Sinking Funds

Sinking Funds

The Time Value of Money on the HP 35s

Practice solving for payment required to achieve a goal



Sinking Funds

A sinking fund is an annuity where a specific value in the future is needed, which is accumulated through a series of regular payments. These types of problems often occur when saving for a goal, such as retirement or college tuition.

The Time Value of Money on the HP 35s

To solve time value of money problems on the HP 35s, the formula below is entered into the flexible equation solver built into the calculator. This equation expresses the standard relationship between the variables in the time value of money formula. The formula uses these variables: ***N*** is the number of compounding periods; ***I*** is the ***periodic*** interest rate as a percentage (for example, if the ***annual*** interest rate is 15% and there are 12 payments per year, the ***periodic*** interest rate, ***i***, is 15÷12=1.25%); ***B*** is the initial balance of loan or savings account; ***P*** is the periodic payment; ***F*** is the future value of a savings account or balance of a loan.

Equation: P x 100 x (1 - (1 + I ÷ 100)^ -N) ÷ I + F x (1 + I ÷ 100) ^ -N + B

To enter this equation into the calculator, press the following keys on the HP 35s:

[EQN] [RCL] [P] [×] [1] [0] [0] [×] [( )] [1] [−] [( )] [1] [+] [RCL] [I] [÷] [1] [0] [0] [>] [y^x]
[+/-] [RCL] [N] [>] [÷] [RCL] [I] [+] [RCL] [F] [×] [( )] [1] [+] [RCL] [I] [÷] [1] [0] [0] [>] [y^x] [+/-]
[RCL] [N] [+] [RCL] [B] [ENTER]

To verify proper entry of the equation, press

[←] [SHOW]

and hold down the [SHOW] key. This will display the equation's checksum and length. The values displayed should be a checksum of CEFA and a length of 41.

To solve for the different variables within this equation, the [→] [SOLVE] button is used. This key is the right shift of the [EQN] key.

Notes for using the SOLVE function with this equation:

1) If your first calculation using this formula is to solve for the interest rate I, press [1] [→] [STO] [I] before beginning.
2) Press [EQN]. If the time value of money equation is not at the top of the list, press [▲] or [▼] to scroll through the list until the equation is displayed.
3) Determine the variable for which you wish to solve and press:
    a) [→] [SOLVE] [N] to calculate the number of compounding periods.
    b) [→] [SOLVE] [I] to calculate the periodic interest rate. Note: this will need to be multiplied by the number of compounding periods per year to get the annual rate. If the compounding is monthly, multiply by 12.
    c) [→] [SOLVE] [B] to calculate the initial balance (or Present Value) of a loan or savings account.
    d) [→] [SOLVE] [P] to calculate the periodic payment.
    e) [→] [SOLVE] [F] to calculate the future value of a loan or savings account.
4) When prompted, enter a value for each of the variables in the equation as you are prompted and press [R/S]. The solver will display the variables' existing value. If this is to be kept, do not enter any value but press [R/S] to continue. If the value is to be changed, enter the changed value and press [R/S]. If a variable had a value in a previous calculation but is not involved in this calculation (as might happen to the variable P (payment) when solving a compound interest problem right after solving an annuity problem), enter a zero for the value and press [R/S].

5) After you press R/S for the last time, the value of the unknown variable will be calculated and displayed.
6) To do another calculation with the same or changed values, go back to step 2 above.

The SOLVE feature will work effectively without any initial guesses being supplied for the unknown variable with the exception noted above about the variable I in this equation. This equation follows the standard convention that money in is considered positive and money out is negative.

The practice problems below illustrate using this equation to solve a variety of sinking fund problems.

Practice solving for payment required to achieve a goal

Example 1: How much would you need to save at the end of every month to accumulate $10,000 in 6 years? Assume the funds would earn 6%, compounded monthly, and that you begin with nothing in the account.

Solution: First, enter the time value of money equation into the HP 35s solver as described earlier in this document.

Then press EQN and press ▲ or ▼ to scroll through the equation list until the time value of money equation is displayed. Then press:

⮫ SOLVE P

The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution. The value of 0.0000 is displayed below if this is the first time the time value of money equation has been solved on the HP 35s calculator. If any previous equations have used a variable used in the time value of money equation, they may already have been assigned a value that would be displayed on your HP 35s display. Follow the keystrokes shown below and the solution should be found as described.

Figure 1

In RPN mode, press: 6 ENTER 1 2 ÷ R/S
In algebraic mode, press: 6 ÷ 1 2 ENTER R/S

Figure 2

In RPN mode, press: 6 ENTER 1 2 × R/S
In algebraic mode, press: 6 × 1 2 ENTER R/S

Figure 3

In either RPN or algebraic mode, press: 1 0 0 0 0 R/S

Figure 4

In either RPN or algebraic mode, press: [0] [R/S]

Figure 5

Answer: The required monthly deposit is $115.73.

Example 2: John wants to retire as a millionaire. He is 25 years old. How much would he need to deposit each month beginning one month from now and continuing until his 65th birthday in order to achieve his goal? Assume the funds would earn 5%, compounded monthly, and that John begins with nothing in the account.

Solution: First, enter the time value of money equation into the HP 35s solver as described earlier in this document.

Then press [EQN] and press [⌃] or [⌄] to scroll through the equation list until the time value of money equation is displayed. Then press:

[↱] [SOLVE] [P]

The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution. The value of 0.5000 is leftover from the immediately preceding example. If your HP 35s has been used to make changes to the value stored in any of the time value of money equation variables, the initial values displayed may vary from what is shown below. If this example is worked immediately after the preceding example, the displays below will be shown on an HP 35s. Follow the keystrokes shown below and the solution should be found as described.

Figure 6

In RPN mode, press: [5] [ENTER] [1] [2] [÷] [R/S]
In algebraic mode, press: [5] [÷] [1] [2] [ENTER] [R/S]

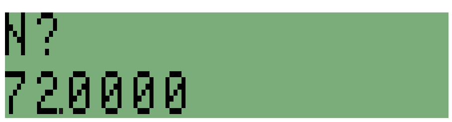


Figure 7

In RPN mode, press: [6] [5] [ENTER] [2] [5] [−] [1] [2] [×] [R/S]
In algebraic mode, press: [()] [6] [5] [−] [2] [5] [>] [×] [1] [2] [ENTER] [R/S]
(Since John is 25, he has (65 – 25) x 12, or 480 months until his 65th birthday)

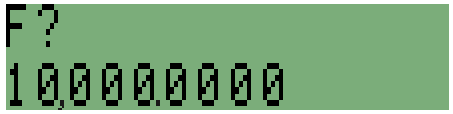


Figure 8

In either RPN or algebraic mode, press: [1] [0] [0] [0] [0] [0] [0] [R/S]

Figure 9

In either RPN or algebraic mode, press: [0] [R/S]

Figure 10

Answer: $655.30

Example 3: How much money should you deposit each year into an account, beginning one year from today, to have $30,000 in the account after 15 years? Assume the funds would earn 6%, compounded annually, and that the account begins with a balance of $1,000.

Solution: First, enter the time value of money equation into the HP 35s solver as described earlier in this document.

Then press [EQN] and press [⌃] or [⌄] to scroll through the equation list until the time value of money equation is displayed. Then press:

[↱] [SOLVE] [P]

The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution. The initial values shown in the figures below assume this example is worked immediately after the preceding example. Follow the keystrokes shown below and the solution should be found as described.

Figure 11

In either RPN or algebraic mode, press: [6] [R/S]

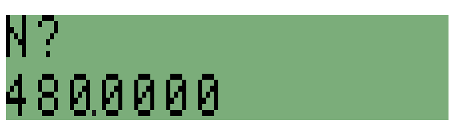


Figure 12

In either RPN or algebraic mode, press: [1] [5] [R/S]

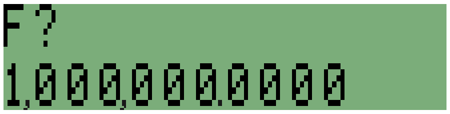


Figure 13

In either RPN or algebraic mode, press: 3 0 0 0 0 R/S

Figure 14

In either RPN or algebraic mode, press: 1 0 0 0 +/- R/S

Figure 15

Answer: $1,185.92

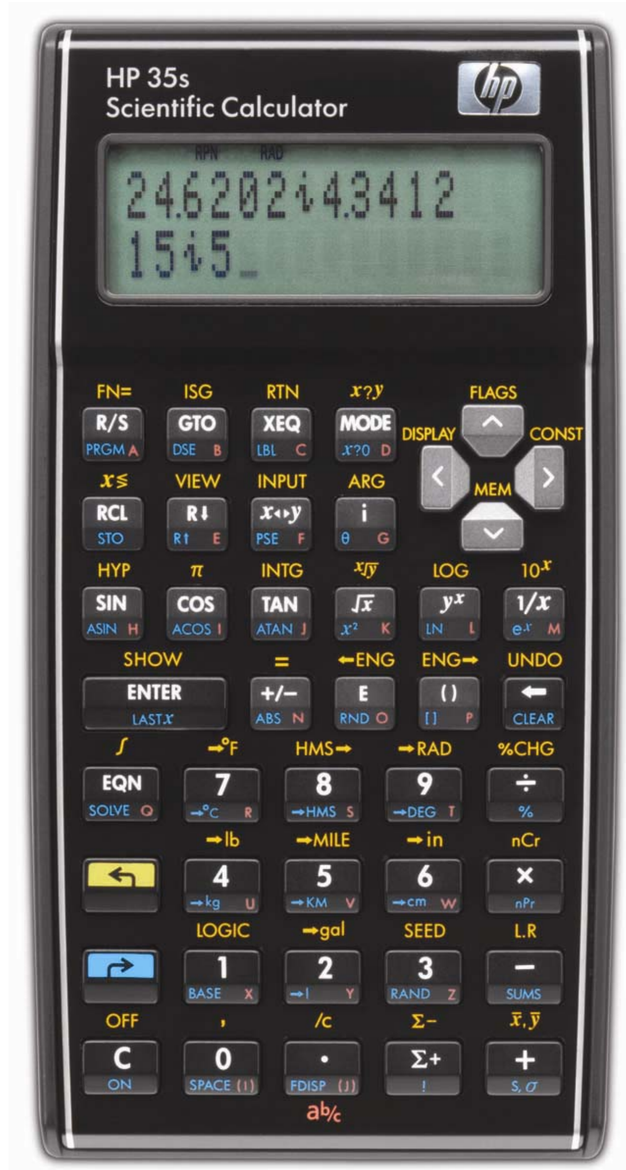
hp calculators

HP 35s Present value

Present value

The Time Value of Money on the HP 35s

Practice solving for the present value of future cash flows



Present value

Many problems involving the time value of money require the conversion of monies to be received in the future into the equivalent monies today. This conversion is the computing of the present value of the monies being received in the future. There are many benefits from this conversion to a present value, including the ability to better visualize the real magnitude of future expenditures or receipts as well as the direct comparison using values today of alternative future receipts or expenditures.

The Time Value of Money on the HP 35s

To solve time value of money problems on the HP 35s, the formula below is entered into the flexible equation solver built into the calculator. This equation expresses the standard relationship between the variables in the time value of money formula. The formula uses these variables: ***N*** is the number of compounding periods; ***I*** is the ***periodic*** interest rate as a percentage (for example, if the ***annual*** interest rate is 15% and there are 12 payments per year, the ***periodic*** interest rate, ***i***, is 15÷12=1.25%); ***B*** is the initial balance of loan or savings account; ***P*** is the periodic payment; ***F*** is the future value of a savings account or balance of a loan.

Equation: P x 100 x (1 - (1 + I ÷ 100)^ -N) ÷ I + F x (1 + I ÷ 100) ^ -N + B

To enter this equation into the calculator, press the following keys on the HP 35s:

[EQN] [RCL] [P] [×] [1] [0] [0] [×] [()] [1] [−] [()] [1] [+] [RCL] [I] [÷] [1] [0] [0] [>] [y^x]
[+/−] [RCL] [N] [>] [÷] [RCL] [I] [+] [RCL] [F] [×] [()] [1] [+] [RCL] [I] [÷] [1] [0] [0] [>] [y^x] [+/−]
[RCL] [N] [+] [RCL] [B] [ENTER]

To verify proper entry of the equation, press

[⬑] [SHOW]

and hold down the [SHOW] key. This will display the equation's checksum and length. The values displayed should be a checksum of CEFA and a length of 41.

To solve for the different variables within this equation, the [⬏] [SOLVE] button is used. This key is the right shift of the [EQN] key.

Notes for using the SOLVE function with this equation:

1) If your first calculation using this formula is to solve for the interest rate I, press [1] [⬏] [STO] [I] before beginning.
2) Press [EQN]. If the time value of money equation is not at the top of the list, press [▲] or [▼] to scroll through the list until the equation is displayed.
3) Determine the variable for which you wish to solve and press:
   a) [⬏] [SOLVE] [N] to calculate the number of compounding periods.
   b) [⬏] [SOLVE] [I] to calculate the periodic interest rate. Note: this will need to be multiplied by the number of compounding periods per year to get the annual rate. If the compounding is monthly, multiply by 12.
   c) [⬏] [SOLVE] [B] to calculate the initial balance (or Present Value) of a loan or savings account.
   d) [⬏] [SOLVE] [P] to calculate the periodic payment.
   e) [⬏] [SOLVE] [F] to calculate the future value of a loan or savings account.
4) When prompted, enter a value for each of the variables in the equation as you are prompted and press [R/S]. The solver will display the variables' existing value. If this is to be kept, do not enter any value but press [R/S] to

continue. If the value is to be changed, enter the changed value and press [R/S]. If a variable had a value in a previous calculation but is not involved in this calculation (as might happen to the variable P (payment) when solving a compound interest problem right after solving an annuity problem), enter a zero for the value and press [R/S].

5) After you press [R/S] for the last time, the value of the unknown variable will be calculated and displayed.
6) To do another calculation with the same or changed values, go back to step 2 above.

The SOLVE feature will work effectively without any initial guesses being supplied for the unknown variable with the exception noted above about the variable I in this equation. This equation follows the standard convention that money in is considered positive and money out is negative.

The practice problems below illustrate using this equation to solve a variety of problems involving present values.

Practice solving for the present value of future cash flows

Example 1: If you are to pay $50,000 in 6 years, what is this worth in today's dollars, assuming interest is applied at 8%, compounded quarterly?

Solution: First, enter the time value of money equation into the HP 35s solver as described earlier in this document.

Then press [EQN] and press [▲] or [▼] to scroll through the equation list until the time value of money equation is displayed. Then press:

[↱] [SOLVE] [B]

The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution. The value of 0.0000 is displayed below if this is the first time the time value of money equation has been solved on the HP 35s calculator. If any previous equations have used a variable used in the time value of money equation, they may already have been assigned a value that would be displayed on your HP 35s display. Follow the keystrokes shown below and the solution should be found as described.

Figure 1

Since this is a compound interest example and does not have a series of equal-sized, equal-spaced payments, the value or P is zero.

In either RPN or algebraic mode, press: [0] [R/S]

Figure 2

In RPN mode, press: [8] [ENTER] [4] [÷] [R/S]
In algebraic mode, press: [8] [÷] [4] [ENTER] [R/S]

Figure 3

In RPN mode, press: 6 ENTER 4 × R/S
In algebraic mode, press: 6 × 4 ENTER R/S

Figure 4

In either RPN or algebraic mode, press: 5 0 0 0 0 +/- R/S
(Since the money is being paid out in the future, it is entered as a negative number)

Figure 5

Answer: The equivalent amount this is equal to in today's dollars is $31,086.07.

Example 2: Darryl has won a contest that will pay him $500 per month for the next 20 years. If interest is 6%, compounded monthly, what is the amount today this prize is worth?

Solution: First, enter the time value of money equation into the HP 35s solver as described earlier in this document.

Then press EQN and press ⌃ or ⌄ to scroll through the equation list until the time value of money equation is displayed. Then press:

↱ SOLVE B

The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution. The displays shown in the figures below assume the preceding example has just been worked. Follow the keystrokes shown below and the solution should be found as described.

Figure 6

In either RPN or algebraic mode, press: 5 0 0 +/- R/S

Figure 7

In RPN mode, press: [6] [ENTER] [1] [2] [÷] [R/S]
In algebraic mode, press: [6] [÷] [1] [2] [ENTER] [R/S]

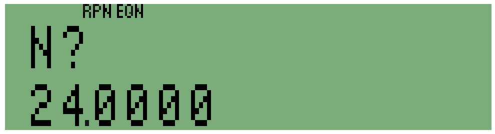


Figure 8

In RPN mode, press: [2] [0] [ENTER] [1] [2] [×] [R/S]
In algebraic mode, press: [2] [0] [×] [1] [2] [ENTER] [R/S]

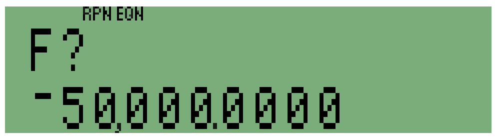


Figure 9

In either RPN or algebraic mode, press: [0] [R/S]

Figure 10

<u>Answer:</u> The equivalent amount in today's dollars is $69,790.39.

<u>Example 3:</u> Dan will receive $40 per month for the next five years and a single payment 60 months from today of $2,000. If interest is 5.5%, compounded monthly, what is the present value of these cash flows?

<u>Solution:</u> First, enter the time value of money equation into the HP 35s solver as described earlier in this document.

Then press [EQN] and press [▲] or [▼] to scroll through the equation list until the time value of money equation is displayed. Then press:

[↱] [SOLVE] [B]

The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution. The displays for these prompts are not shown in this example. Follow the keystrokes shown below and the solution should be found as described.

In RPN mode, press:

In RPN mode, press:	4 0 R/S	(Enters P)
	5 · 5 ENTER 1 2 ÷ R/S	(Enters I)
	5 ENTER 1 2 × R/S	(Enters N)
	2 0 0 0 R/S	(Enters F)
In algebraic mode, press:	4 0 R/S	(Enters P)
	5 · 5 ÷ 1 2 ENTER R/S	(Enters I)
	5 × 1 2 ENTER R/S	(Enters N)
	2 0 0 0 R/S	(Enters F)

Figure 11

Answer: The equivalent amount in today's dollars is $3,614.21.

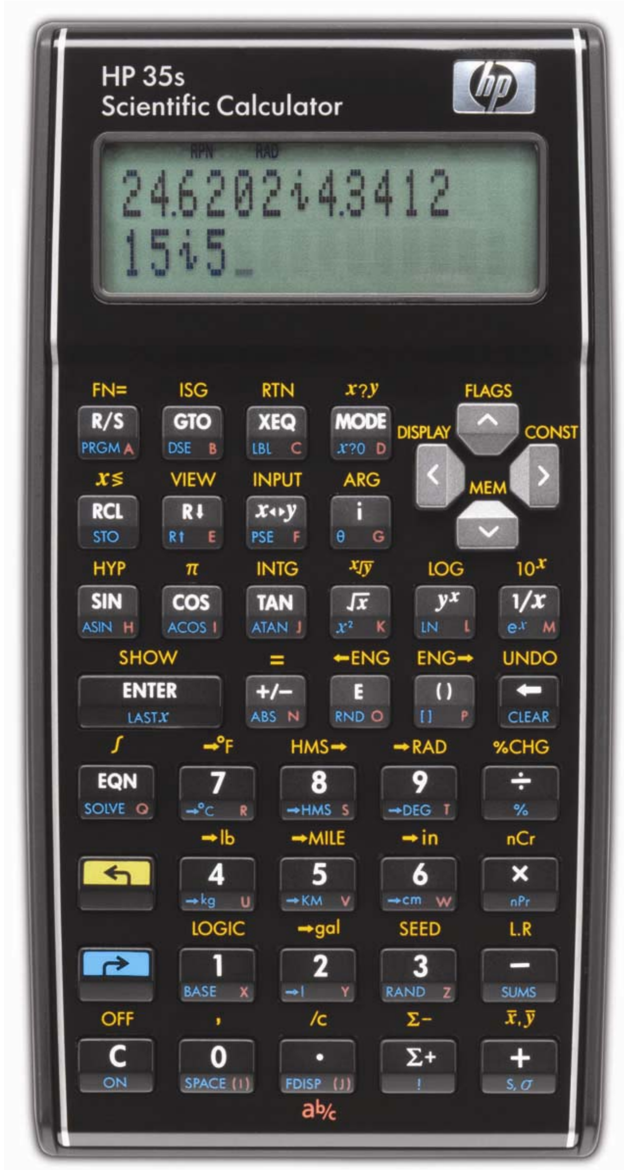
hp calculators

HP 35s Bond Prices

Bond Prices

The Time Value of Money on the HP 35s

Practice solving for the price of a bond



Bond Prices

A bond is a financial instrument where a company, government entity, or individual borrow money with the promise to pay interest periodically and to repay the initial amount borrowed at a specified future date. Bonds will usually have a specified interest rate (called the coupon rate) and are most often in denominations of $1,000. Bonds also usually pay interest every six months. The interest rate the bond pays is fixed when the bond is first sold or issued, but changes in the market interest rate will change the price of the bond over its lifetime. If market interest rates have gone up since the bond was purchased, the price of the bond will have gone down. If, however, market interest rates have gone down since the bond was purchased, the price of the bond will have gone up. The HP 35s can directly solve for bond prices using the time value of money formula below in simple situations where a bond interest payment is exactly one period away. For other situations, the answers will be approximations.

The Time Value of Money on the HP 35s

To solve time value of money problems on the HP 35s, the formula below is entered into the flexible equation solver built into the calculator. This equation expresses the standard relationship between the variables in the time value of money formula. The formula uses these variables: ***N*** is the number of compounding periods; ***I*** is the ***periodic*** interest rate as a percentage (for example, if the ***annual*** interest rate is 15% and there are 12 payments per year, the ***periodic*** interest rate, ***i***, is 15÷12=1.25%); ***B*** is the initial balance of loan or savings account; ***P*** is the periodic payment; ***F*** is the future value of a savings account or balance of a loan.

Equation: P x 100 x (1 - (1 + I ÷ 100)^ -N) ÷ I + F x (1 + I ÷ 100) ^ -N + B

To enter this equation into the calculator, press the following keys on the HP 35s:

EQN RCL P × 1 0 0 × ( ) 1 − ( ) 1 + RCL I ÷ 1 0 0 > y^x
+/− RCL N > ÷ RCL I + RCL F × ( ) 1 + RCL I ÷ 1 0 0 > y^x +/−
RCL N + RCL B ENTER

To verify proper entry of the equation, press

⬅ SHOW

and hold down the SHOW key. This will display the equation's checksum and length. The values displayed should be a checksum of CEFA and a length of 41.

To solve for the different variables within this equation, the ➡ SOLVE button is used. This key is the right shift of the EQN key.

Notes for using the SOLVE function with this equation:

1) If your first calculation using this formula is to solve for the interest rate I, press 1 ➡ STO I before beginning.
2) Press EQN. If the time value of money equation is not at the top of the list, press ⌃ or ⌄ to scroll through the list until the equation is displayed.
3) Determine the variable for which you wish to solve and press:
   a) ➡ SOLVE N to calculate the number of compounding periods.
   b) ➡ SOLVE I to calculate the periodic interest rate. Note: this will need to be multiplied by the number of compounding periods per year to get the annual rate. If the compounding is monthly, multiply by 12.
   c) ➡ SOLVE B to calculate the initial balance (or Present Value) of a loan or savings account.

   d) [↱] [SOLVE] [P] to calculate the periodic payment.
   e) [↱] [SOLVE] [F] to calculate the future value of a loan or savings account.

4) When prompted, enter a value for each of the variables in the equation as you are prompted and press [R/S]. The solver will display the variables' existing value. If this is to be kept, do not enter any value but press [R/S] to continue. If the value is to be changed, enter the changed value and press [R/S]. If a variable had a value in a previous calculation but is not involved in this calculation (as might happen to the variable P (payment) when solving a compound interest problem right after solving an annuity problem), enter a zero for the value and press [R/S].
5) After you press [R/S] for the last time, the value of the unknown variable will be calculated and displayed.
6) To do another calculation with the same or changed values, go back to step 2 above.

The SOLVE feature will work effectively without any initial guesses being supplied for the unknown variable with the exception noted above about the variable I in this equation. This equation follows the standard convention that money in is considered positive and money out is negative.

The practice problems below illustrate using this equation to solve a variety of problems involving bond prices.

Practice solving for the price of a bond

<u>Example 1:</u> A bond with 20 years left has a 5% coupon rate and pays interest semiannually. If the market interest rate is now 6%, compounded semiannually, for what price should this bond be selling?

<u>Solution:</u> First, enter the time value of money equation into the HP 35s solver as described earlier in this document.

Then press [EQN] and press [⌃] or [⌄] to scroll through the equation list until the time value of money equation is displayed. Then press:

[↱] [SOLVE] [B]

The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution. The value of 0.0000 is displayed below if this is the first time the time value of money equation has been solved on the HP 35s calculator. If any previous equations have used a variable used in the time value of money equation, they may already have been assigned a value that would be displayed on your HP 35s display. Follow the keystrokes shown below and the solution should be found as described.

Figure 1

The payment is found by multiplying the coupon interest rate, 5%, by the face value of the bond, $1,000, then dividing the result by 2 for the semiannual interest payment amount, $25.

In RPN mode, press: [.] [0] [5] [ENTER] [1] [0] [0] [0] [×] [2] [÷] [R/S]
In algebraic mode, press: [.] [0] [5] [×] [1] [0] [0] [0] [÷] [2] [ENTER] [R/S]

Figure 2

In RPN mode, press: [6] [ENTER] [2] [÷] [R/S]
In algebraic mode, press: [6] [÷] [2] [ENTER] [R/S]

Figure 3

In RPN mode, press: [2] [0] [ENTER] [2] [×] [R/S]
In algebraic mode, press: [2] [0] [×] [2] [ENTER] [R/S]

Figure 4

In either RPN or algebraic mode, press: [1] [0] [0] [0] [R/S]

Figure 5

<u>Answer:</u> The price of the bond is $884.43.

<u>Example 2:</u> A bond with 10 years left until it matures has a 6% coupon rate and pays interest semiannually. What is the price of this bond, if the market interest rate is 5%, compounded semiannually?

<u>Solution:</u> First, enter the time value of money equation into the HP 35s solver as described earlier in this document.

Then press [EQN] and press [⌃] or [⌄] to scroll through the equation list until the time value of money equation is displayed. Then press:

[↱] [SOLVE] [B]

The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution. The displays shown in the figures below assume the preceding example has just been worked. Follow the keystrokes shown below and the solution should be found as described.

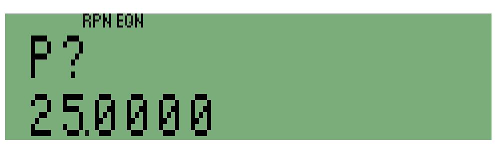


Figure 6

The payment is found by multiplying the coupon interest rate, 6%, by the face value of the bond, $1,000, then dividing the result by 2 for the semiannual interest payment amount.

In RPN mode, press: [.] [0] [6] [ENTER] [1] [0] [0] [0] [×] [2] [÷] [R/S]
In algebraic mode, press: [.] [0] [6] [×] [1] [0] [0] [0] [÷] [2] [ENTER] [R/S]

Figure 7

In RPN mode, press: [5] [ENTER] [2] [÷] [R/S]
In algebraic mode, press: [5] [÷] [2] [ENTER] [R/S]

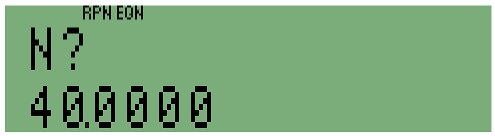


Figure 8

In RPN mode, press: [1] [0] [ENTER] [2] [×] [R/S]
In algebraic mode, press: [1] [0] [×] [2] [ENTER] [R/S]

Figure 9

In either RPN or algebraic mode, press: [1] [0] [0] [0] [R/S]

Figure 10

Answer: The price of the bond is $1,077.95.

Example 3: A bond with 13 years left until it matures has a 5.5% coupon rate and pays interest semiannually. What is the price of this bond, if the market interest rate is 6.15%?

Solution: First, enter the time value of money equation into the HP 35s solver as described earlier in this document.

Then press [EQN] and press [▲] or [▼] to scroll throu7gh the equation list until the time value of money equation is displayed. Then press:

[↱] [SOLVE] [B]

The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution. The displays for these prompts are not shown in this example. Follow the keystrokes shown below and the solution should be found as described.

In RPN mode, press:	[.] [0] [5] [5] [ENTER] [1] [0] [0] [0] [×] [2] [÷] [R/S]	(Enters P)
	[6] [.] [1] [5] [ENTER] [2] [÷] [R/S]	(Enters I)
	[1] [3] [ENTER] [2] [×] [R/S]	(Enters N)
	[1] [0] [0] [0] [R/S]	(Enters F)
In algebraic mode, press:	[.] [0] [5] [5] [×] [1] [0] [0] [0] [÷] [2] [ENTER] [R/S]	(Enters P)
	[6] [.] [1] [5] [÷] [2] [ENTER] [R/S]	(Enters I)
	[1] [3] [×] [2] [ENTER] [R/S]	(Enters N)
	[1] [0] [0] [0] [R/S]	(Enters F)

Figure 11

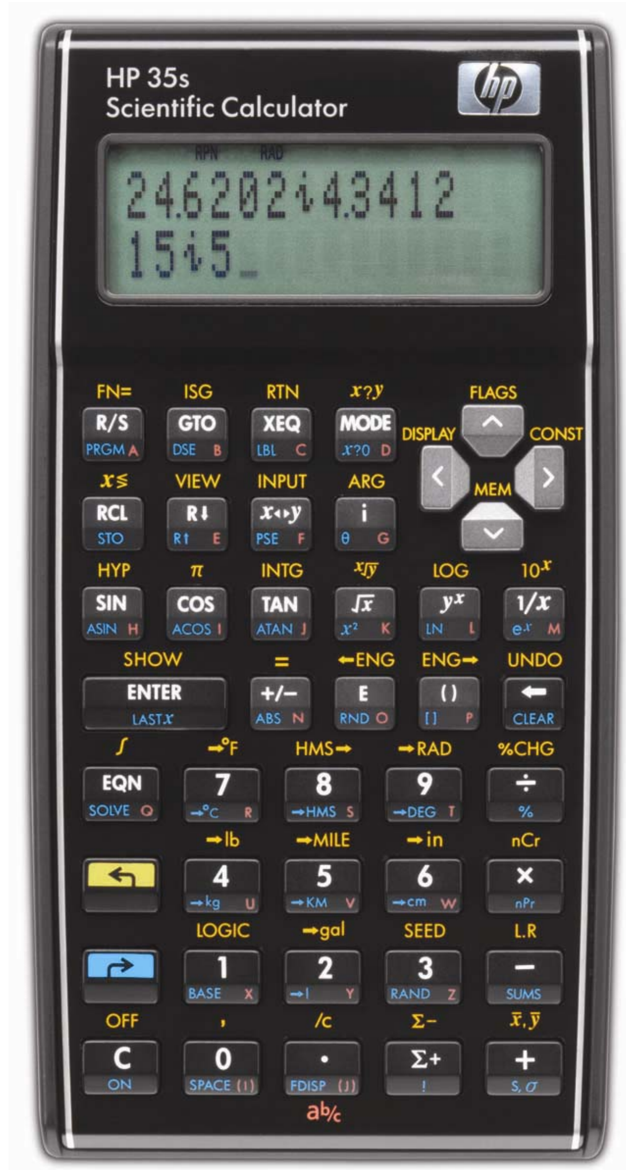
Answer: The price of the bond is $942.40.

hp calculators

HP 35s Trend Lines

Trend Lines

Practice predicting the future using trend lines



Trend Lines

A trend line is actually an equation of a line in the form Y = mX + b, where m is the slope of the line and b is the Y-intercept. Linear regression calculates the equation for this line by minimizing the sum of the squared residuals between the actual data points and the predicted data points using the estimated line’s slope and intercept. Once the slope and intercept have been calculated, it is fairly easy to substitute other values for X and predict a corresponding value for Y, or to substitute a value for Y and predict a value for X. When the X value is a measure of time (months or years, for example), the equation is specifically referred to as a trend line. These are often used to predict future sales growth given past sales data. Be aware, however, that it is rarely a good idea to use such an equation to predict too far into the future from the actual data used, since circumstances can change rather quickly. Also be aware that these predictions are linear in nature and make no adjustment for any seasonality that may exist.

On the HP 35s, values are entered into the statistical / summation registers by keying in the number (or pair of numbers) desired and pressing [Σ+]. This process is repeated for all numbers or pair of numbers. When entering a pair of numbers in RPN or algebraic mode, key the Y value, press [ENTER], then key the X value and press [Σ+].

To view the linear regression results, press [↰] [L.R.]. The HP 35s displays a menu of relevant values. Items on this menu are viewed by pressing the [<] or [>] cursor keys of the HP 35s.

This menu allows you to predict a value for X given a Y value, or predict a value for Y given an X value. It also displays the linear regression line's correlation, slope, and y-intercept. The correlation will always be between –1 and +1, where values closer to –1 and +1 indicating a good “fit” of the line to the data. Values nearer to zero indicate little to no “fit.” Little reliance should be placed upon predictions made where the correlation is not near –1 or +1. Exactly how far away from these values the correlation can be and the equation still be considered a good predictor is a matter of debate. To use a value displayed on the menu, press the [ENTER] button and the value will be copied for further use. This is illustrated in the problems below.

Practice predicting the future using trend lines

<u>Example 1:</u> John’s store has had sales for the last 5 months of $150, $165, $160, $175, and $170. Use a trend line to predict sales for months 6 and 7 and also predict when estimated sales would reach $200. What is the correlation of the regression line?

<u>Solution:</u> Be sure to clear the statistics / summation memories before starting the problem.

[↱] [CLEAR] [4]

In RPN or algebraic mode, press:

[1] [5] [0] [ENTER] [1] [Σ+] [1] [6] [5] [ENTER] [2] [Σ+] [1] [6] [0] [ENTER] [3] [Σ+]
[1] [7] [5] [ENTER] [4] [Σ+] [1] [7] [0] [ENTER] [5] [Σ+]

To view the linear regression results, press [↰] [L.R.]. Figure 2 displays the menu shown.

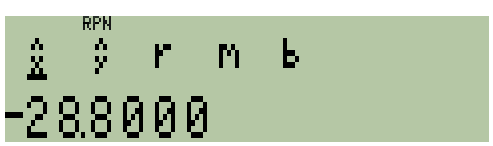


Figure 2

In either RPN or algebraic mode, press: [>] [>] to view the correlation.

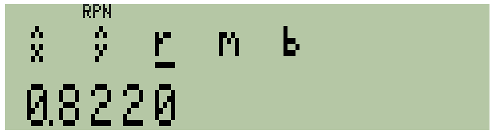


Figure 3

In either RPN or algebraic mode, press: [>] to view the slope of the linear regression / trend line.

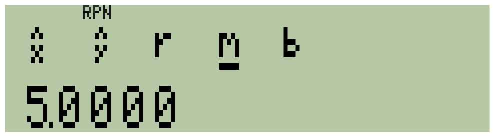


Figure 4

In either RPN or algebraic mode, press [>] to view the y-intercept of the linear regression / trend line.

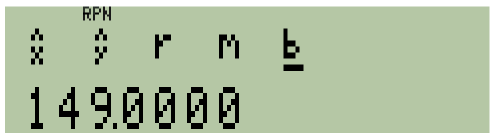


Figure 5

To estimate sales for month 6, do the following: In either RPN or algebraic mode, press:
[C] [6] [↰] [L.R.] [>]

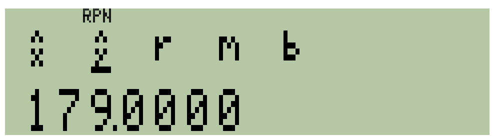


Figure 6

To estimate sales for month 7, do the following: In either RPN or algebraic mode, press:
[C] [7] [↰] [L.R.] [>]

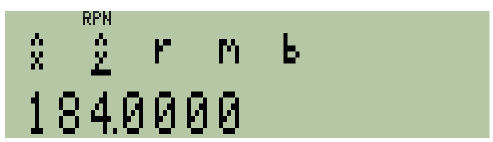


Figure 7

To estimate the month during which sales would reach $200, do the following: In either RPN or algebraic mode, press: [C] [2] [0] [0] [↰] [L.R.]

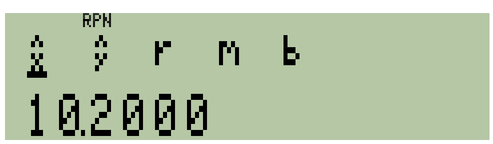


Figure 8

Answer: Sales in month 6 are predicted to be $179 and in month 7 $184. Sales are predicted to reach $200 between months 10 and 11. The correlation is 0.82, which indicates a fairly strong relationship and predictive ability.

<u>Example 2:</u> A store's quarterly sales for the last 2 years have been $30,000, $31,200, $30,500, $32,400, $32,200, $33,100, $32,600 and $33,250. Use a trend line to predict sales for the next year and also predict when estimated sales would reach $38,000. What is the correlation of the linear regression line?

<u>Solution:</u> The X values will be the quarters of 1 through 8. The Y values will be the existing sales numbers. Predictions will be made for quarters 9, 10, 11, and 12. Be sure to clear the statistics / summation memories before starting the problem.

[↱] [CLEAR] [4]

In RPN or algebraic mode, press:

[3] [0] [0] [0] [0] [ENTER] [1] [Σ+] [3] [1] [2] [0] [0] [ENTER] [2] [Σ+]
[3] [0] [5] [0] [0] [ENTER] [3] [Σ+] [3] [2] [4] [0] [0] [ENTER] [4] [Σ+]
[3] [2] [2] [0] [0] [ENTER] [5] [Σ+] [3] [3] [1] [0] [0] [ENTER] [6] [Σ+]
[3] [2] [6] [0] [0] [ENTER] [7] [Σ+] [3] [3] [2] [5] [0] [ENTER] [8] [Σ+]

To view the linear regression results, press [↰] [L.R.]. Figure 9 displays the menu shown.

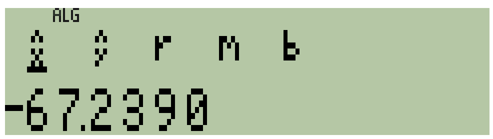


Figure 9

In either RPN or algebraic mode, press: [>] [>] to view the correlation.

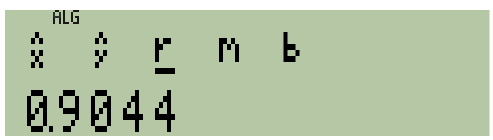


Figure 10

In either RPN or algebraic mode, press: [>] to view the slope of the linear regression / trend line.

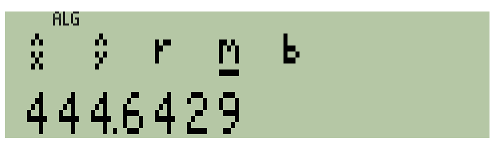


Figure 11

In either RPN or algebraic mode, press [>] to view the y-intercept of the linear regression / trend line.

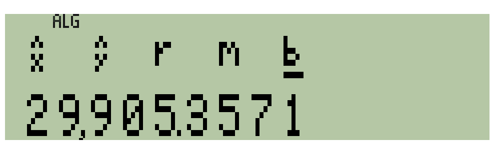


Figure 12

To estimate sales for the first quarter of the next year (quarter 9), do the following:

In either RPN or algebraic mode, press: [C] [9] [↰] [L.R.] [>]

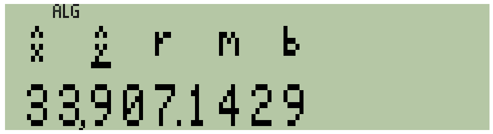


Figure 13

To estimate sales for the second quarter of next year (quarter 10), do the following:

In either RPN or algebraic mode, press: C 1 0 ↰ L.R. >

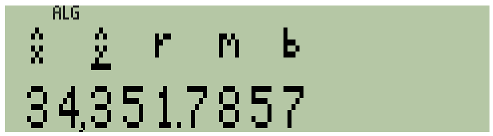


Figure 14

To estimate sales for the third quarter of the next year (quarter 11), do the following:

In either RPN or algebraic mode, press: C 1 1 ↰ L.R. >

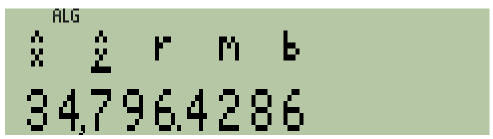


Figure 15

To estimate sales for the fourth quarter of next year (quarter 12), do the following:

In either RPN or algebraic mode, press: [C] [1] [2] [↱] [L.R.] [>]

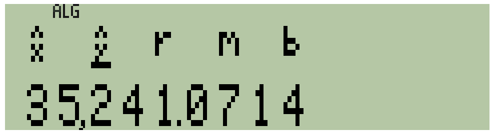


Figure 16

To estimate the month during which sales would reach $38,000, do the following:

In either RPN or algebraic mode, press: [C] [3] [8] [0] [0] [0] [↱] [L.R.]

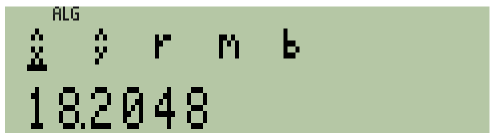
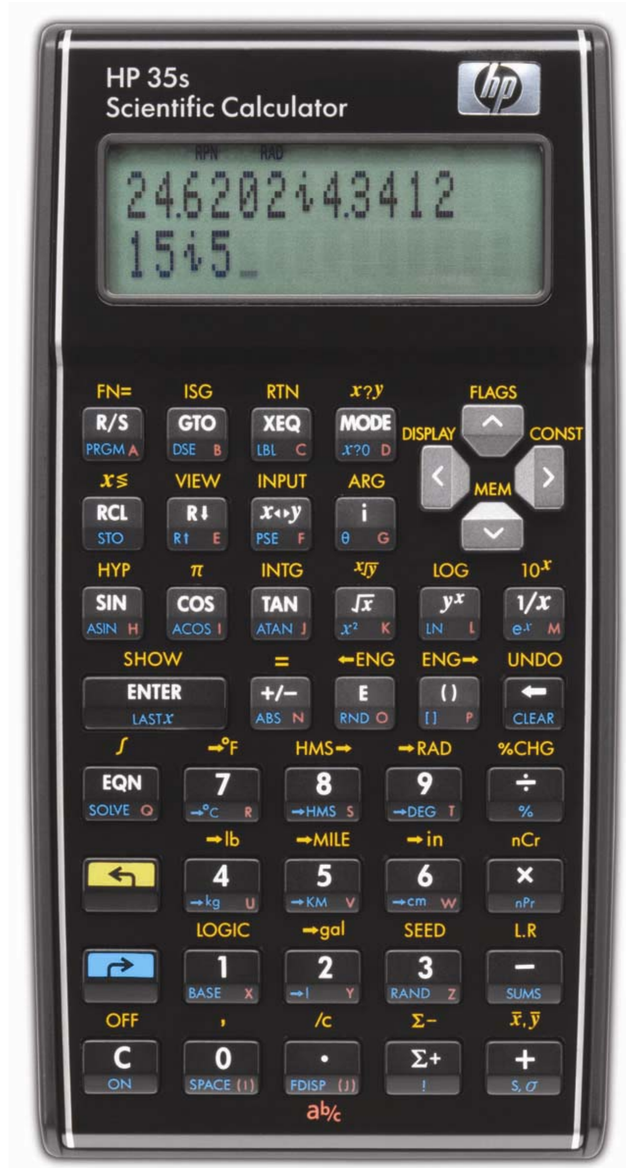


Figure 17

<u>Answer:</u> Sales for quarters 9 through 12 are predicted to be $33,907, $34,351, $34,796 and $35,241. Sales are predicted to reach $38,000 between months 18 and 19. The correlation is 0.90, which indicates a fairly strong relationship and predictive ability.

hp calculators



HP 35s Cost Estimation using Linear Regression

Cost estimation using Linear Regression

Practice estimating costs using linear regression

Cost estimation using Linear Regression

Linear regression calculates the equation for a line that "best fits" a set of ordered pairs by minimizing the sum of the squared residuals between the actual data points and the predicted data points using the estimated line's slope and intercept. The equation of the line produced by linear regression is in the form Y = mX + b, where m is the slope of the line and b is the Y-intercept. Once the slope and intercept have been calculated, it is fairly easy to substitute other values for X and predict a corresponding value for Y, or to substitute a value for Y and predict a value for X. When the X value is a measure of time (months or years, for example), the equation is specifically referred to as a trend line.

Linear regression is often used to estimate the fixed and variable components from a company's or department's total costs. In these circumstances, the values for X are usually the cost driver for the organization or department. Examples might include units produced, hours worked, hours of machine time, and others. The values for Y are the total cost for that level of X input. The computed slope of the linear regression line will indicate the variable cost per unit of X, while the computed Y-intercept will indicate the fixed cost.

In many or most circumstances, this type of cost analysis will generate slopes and Y-intercepts that make sense in the real world. It is sometimes possible, though, that the fixed cost component in particular may not make any sense. The generated Y-intercept (fixed cost) might be negative, for example, to make the linear regression line fit the observed cost data as closely as possible. Be aware, as well, that it is rarely a good idea to use such an equation to predict too far away from the range of the actual data used, since circumstances can change rather quickly. In other words, if you fit a line using cost data for units produced from 500 to 1,500 a month, making cost predictions using forecasted production levels of 5,000 units a month may generate unreliable results. Also, since time is not a variable in these calculations, the order in which the costs are input as data points does not matter – you may enter the data points in any order desired.

On the HP 35s, values are entered into the statistical / summation registers by keying in the number (or pair of numbers) desired and pressing Σ+. This process is repeated for all numbers or pair of numbers. When entering a pair of numbers in RPN or algebraic mode, key the Y value, press ENTER, then key the X value and press Σ+.

To view the linear regression results, press ↰ L.R.. The HP 35s displays a menu of relevant values. Items on this menu are viewed by pressing the ◁ or ▷ cursor keys of the HP 35s.

This menu allows you to predict a value for X given a Y value, or predict a value for Y given an X value. It also displays the linear regression line's correlation, slope, and y-intercept. The correlation will always be between –1 and +1, where values closer to –1 and +1 indicating a good "fit" of the line to the data. Values nearer to zero indicate little to no "fit." Little reliance should be placed upon predictions made where the correlation is not near –1 or +1. Exactly how far away from these values the correlation can be and the equation still be considered a good predictor is a matter of debate. To use a value displayed on the menu, press the ENTER button and the value will be copied for further use. This is illustrated in the problems below.

Practice estimating costs using linear regression

Example 1: Johnson's Chair Company has experienced the following costs for the first 6 months of the year:

# Chairs Made	Total Costs
5,000	$120,000
5,500	$122,100
4,800	$118,540
5,300	$122,400
4,950	$119,100
5,150	$124,200

What estimate would a linear regression equation produce for Johnson's fixed and variable cost? How good is the fit of the linear regression line generated (What is the correlation)? What are the total costs predicted if 5,400 chairs were to be made? If the total costs were $125,000, how many chairs would you estimate had been produced?

Solution: The X values will be the number of chairs produced. The Y values will be the total costs. Be sure to clear the statistics / summation memories before starting the problem.

[↱] [CLEAR] [4]

In RPN or algebraic mode, press:

[1] [2] [0] [0] [0] [0] [ENTER] [5] [0] [0] [0] [Σ+]
[1] [2] [2] [1] [0] [0] [ENTER] [5] [5] [0] [0] [Σ+]
[1] [1] [8] [5] [4] [0] [ENTER] [4] [8] [0] [0] [Σ+]
[1] [2] [2] [4] [0] [0] [ENTER] [5] [3] [0] [0] [Σ+]
[1] [1] [9] [1] [0] [0] [ENTER] [4] [9] [5] [0] [Σ+]
[1] [2] [4] [2] [0] [0] [ENTER] [5] [1] [5] [0] [Σ+]

To view the linear regression results, press [↰] [L.R.]. Figure 2 displays the menu shown.

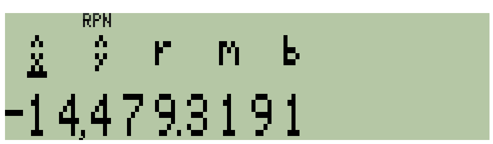


Figure 2

In either RPN or algebraic mode, press: [>] [>] [>] to view the slope.

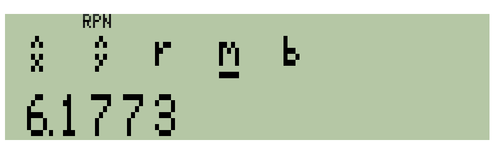


Figure 3

In either RPN or algebraic mode, press: [>] to view the y-intercept.

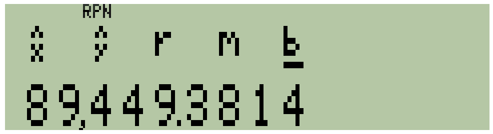


Figure 4

In either RPN or algebraic mode, press: [<][<] to view the correlation.

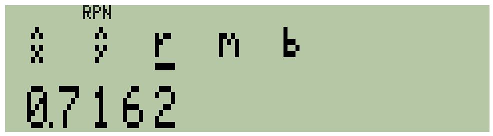


Figure 5

To estimate costs if 5,400 chairs are made, do the following:

In either RPN or algebraic mode, press: [C] [5] [4] [0] [0] [↰] [L.R.] [>]

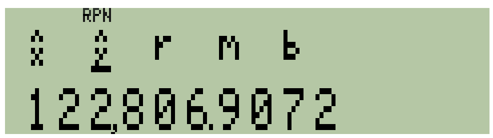


Figure 6

To estimate the number of chairs made if the costs were $125,000, do the following:

In either RPN or algebraic mode, press: [C] [1] [2] [5] [0] [0] [0] [↰] [L.R.]

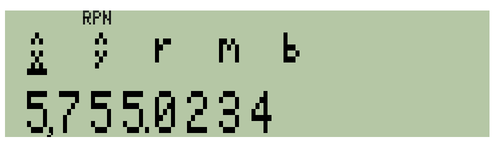


Figure 7

Answer: The linear regression equation generated is of the form: Y = 6.18X + 89449.38. The slope of 6.18 is the estimate for the variable cost and the Y-intercept of 89,449.38 is the estimate for the fixed cost. The correlation value of 0.72 is not as close to +1 as might be hoped, but still indicates a moderate fit. The total cost estimate if 5,400 chairs were made is $122,806. The estimated number of chairs made if the total costs were $125,000 is 5,755 chairs.

Example 2: The stamping department cost analyst is reviewing the total cost compared with the number of machine hours used for the last 4 weeks.

# Machine Hours	Total Costs
350	$55,000
375	$57,300
400	$58,100
360	$56,250

What estimate would a linear regression equation produce for the stamping department's fixed and variable cost? How good is the fit of the linear regression line generated (What is the correlation)? What are the total costs predicted if 380 machine hours are used next week? If the total costs were $60,000, how many machine hours would you estimate had been used?

Solution: The X values will be the number of machine hours used. The Y values will be the total costs. Be sure to clear the statistics / summation memories before starting the problem.

[↱] [CLEAR] [4]

In RPN or algebraic mode, press:

[5] [5] [0] [0] [0] [ENTER] [3] [5] [0] [Σ+]
[5] [7] [3] [0] [0] [ENTER] [3] [7] [5] [Σ+]
[5] [8] [1] [0] [0] [ENTER] [4] [0] [0] [Σ+]
[5] [6] [2] [5] [0] [ENTER] [3] [6] [0] [Σ+]

To view the linear regression results, press [↰] [L.R.]. Figure 8 displays the menu shown.

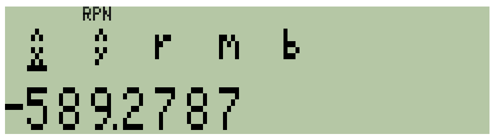


Figure 8

In either RPN or algebraic mode, press: [>] [>] [>] to view the slope.

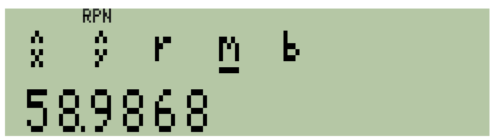


Figure 9

In either RPN or algebraic mode, press: [>] to view the y-intercept.

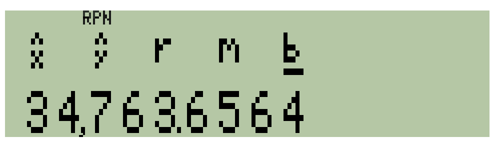


Figure 10

In either RPN or algebraic mode, press: [<] [<] to view the correlation.

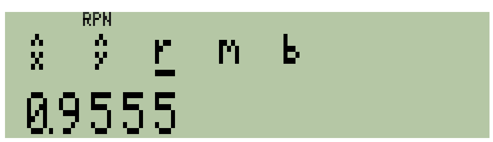


Figure 11

To estimate costs if 380 machine hours are used, do the following:

In either RPN or algebraic mode, press: [C] [3] [8] [0] [↰] [L.R.] [>]

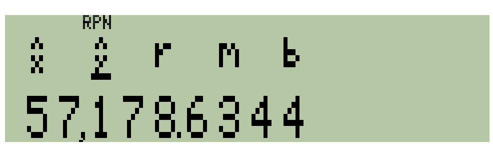


Figure 12

To estimate the number of number of machine hours used if costs were $60,000, do the following:

In either RPN or algebraic mode, press: [C] [6] [0] [0] [0] [0] [⬑] [L.R.]

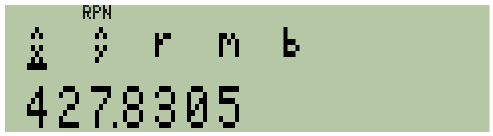


Figure 13

Answer: The linear regression equation generated is of the form: Y = 58.99X + 34,763.66. The slope of 58.99 is the estimate for the variable cost per machine hour and the Y-intercept of 34,763.66 is the estimate for the fixed cost. The correlation value of 0.96 is quite close to +1 and indicates a very good fit. The total cost estimate if 380 machine hours are used is $57,178. The estimated number of machine hours used if the total costs were $60,000 is 427.8 machine hours.

i n v e n t

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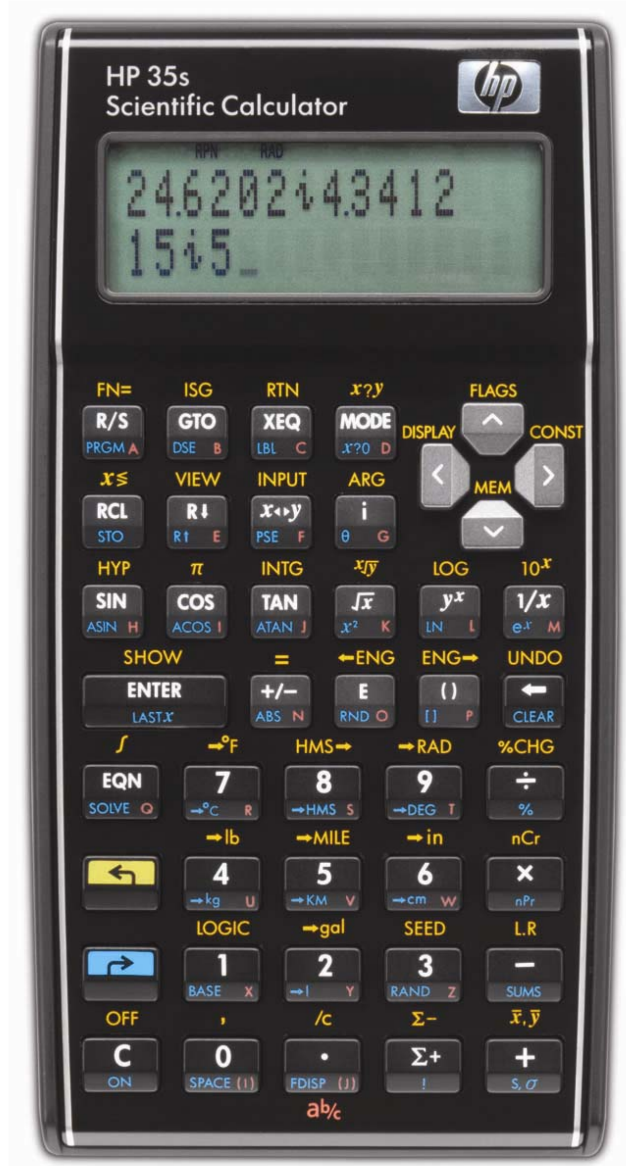
HP 35s Percentages and Percentage Changes

Percentages

Practice working problems involving percentages

Practice working problems involving percentage changes



Percentages

A percentage is a fraction multiplied by 100. For example, 25 percent is written 25%, and is 0.25 (one quarter) multiplied by 100.

Percentages are used very widely in business, for example to specify bank rate, interest rates, tax rates, or discounts. Percentages and percent changes are also used outside business – scientific or engineering measurements, results, and uncertainties are stated as percentages.

The HP 35s provides a % key for use in calculating percentages, and adding or subtracting percentages. It also provides a percent change key for the calculation of changes as percentages.

Practice working problems involving percentages

Most business calculations are made to the nearest cent or penny, so it is useful to set the display mode of the HP 35s to FIX 2 before doing these practice problems, to have two digits displayed after the decimal point. Press [DISPLAY] [1] [2] to set FIX 2 mode.

Example 1: What is 12% of $1,235.17?

Solution: In RPN mode, the number 1,235.17 is typed and then [ENTER] is pressed. Then 12 is typed and the [%] key is pressed.

[1] [2] [3] [5] [.] [1] [7] [ENTER] [1] [2] [%]

Figure 1

The number 1,235.17 is still displayed in the upper line (it is left in register Y) and the result, 12% of 1,235.17, is displayed in the lower line (in register X). Unlike other RPN commands such as [+] or [×], the [%] command leaves the number in the Y register unchanged. This makes it possible to continue a calculation, using that number. This will be shown in the next example.

In algebraic mode, press:

[%] [1] [2] [3] [5] [.] [1] [7] [>] [1] [2] [ENTER]

Figure 2

Note that in algebraic mode "n" percent *of* something is obtained by multiplying by the percentage.

Answer: 12% of $1,235.17 is $148.22 when written to the nearest cent.

Example 2: What is 12% added to $1,235.17?

Solution: In RPN mode, the calculation shown in Figure 1 has left the original number in register Y, and 12% of it in register X. Pressing [+] adds the 12 percent to the original number, giving the answer.

Figure 3

In algebraic mode, press:

[1] [2] [3] [5] [.] [1] [7] [+] [↱] [%] [1] [2] [3] [5] [.] [1] [7] [>] [1] [2] [ENTER]

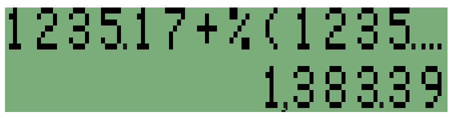


Figure 4

Note that in algebraic mode “n” percent *added to* something is obtained by adding the percentage to the original value.

Answer: 12% added to $1,235.17 is $1,383.39 to the nearest cent.

Example 3: The local grocery store is offering 8% off all tinned foods this week. What will be the cost of buying 5 tins that normally cost $1.85 each?

Solution: In RPN mode, the usual cost of 5 tins is first calculated by multiplying 1.85 by 5. Then 8% is calculated as in Example 1. Finally, the [−] key is used to subtract the percentage from the original.

[1] [.] [8] [5] [ENTER] [5] [×] [8] [↱] [%] [−]

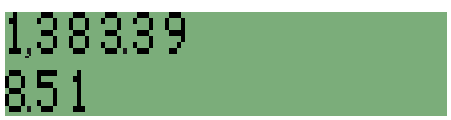


Figure 5

In algebraic mode, the price of 5 tins is also calculated first, then the percent discount is computed

[1] [.] [8] [5] [×] [5] [ENTER]

Figure 6

[↱] [LAST x] [−] [↱] [%] [↱] [LAST x] [>] [8] [ENTER]

Figure 7

<u>Answer:</u> 8% subtracted from 5 times $1.85 gives a price of $8.51 for the 5 tins, to the nearest cent.

Practice working problems involving percentage changes

The examples so far have shown how percentages are calculated, and how they are added or subtracted, by use of the [%] key. Calculating a percent change is carried out using [%CHG] above the [÷] key.

<u>Example 5:</u> An investor began the day with $28,758.91 as the value of her investment only to find that when the market closes in the afternoon, the investment is worth $28,701. By how much did the market change during the day?

<u>Solution:</u> In RPN mode, enter the old value, the new value, and then the [%CHG] key is pressed.

[2] [8] [7] [5] [8] [·] [9] [1] [ENTER] [2] [8] [7] [0] [1] [↰] [%CHG]

Figure 8

As with the [%] key, the original value stays in register Y so that it can be used again.

In algebraic mode, press:

[↰] [%CHG] [2] [8] [7] [5] [8] [·] [9] [1] [>] [2] [8] [7] [0] [1] [ENTER]

Figure 9

<u>Answer:</u> The market changed by -0.20 during the day, in other words it fell by 0.2%.

Note: It is important to remember that the change is calculated as a percentage of the *first* number. If you have 100 apples and give 20 to your neighbor, then you have 80 apples left and the percentage change is -20/100 or -20%. If you have 80 apples and your neighbor gives you 20 then you have 100 again, but this time the change is 20/80 or +25%. This means that a percent change down, followed by exactly the same percent change up, does not bring you back to the original number.

Finally, if FIX 2 mode was set before these practice problems were done, it may be useful to set a different mode now they are finished.

Press: [↰] [DISPLAY] [4] to set “All” mode.

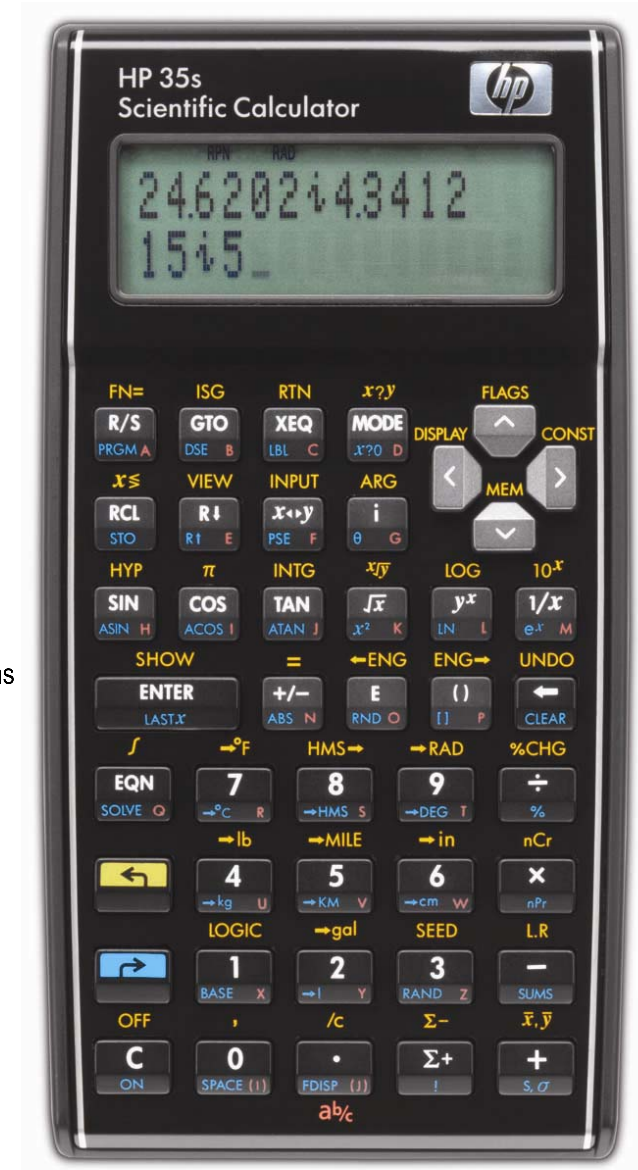
hp calculators

HP 35s House Payment Calculations

House payments

The Time Value of Money on the HP 35s

Practice solving house payment calculation problems



House payments

The payment required to pay off a house over time involves the solution of an ordinary annuity with the value of the payment as the unknown variable.

The Time Value of Money on the HP 35s

To solve time value of money problems on the HP 35s, the formula below is entered into the flexible equation solver built into the calculator. This equation expresses the standard relationship between the variables in the time value of money formula. The formula uses these variables: ***N*** is the number of compounding periods; ***I*** is the ***periodic*** interest rate as a percentage (for example, if the ***annual*** interest rate is 15% and there are 12 payments per year, the ***periodic*** interest rate, ***i***, is 15÷12=1.25%); ***B*** is the initial balance of loan or savings account; ***P*** is the periodic payment; ***F*** is the future value of a savings account or balance of a loan.

Equation: P x 100 x (1 - (1 + I ÷ 100)^ -N) ÷ I + F x (1 + I ÷ 100) ^ -N + B

To enter this equation into the calculator, press the following keys on the HP 35s:

EQN RCL P × 1 0 0 × ( ) 1 − ( ) 1 + RCL I ÷ 1 0 0 > y^x
+/− RCL N > ÷ RCL I + RCL F × ( ) 1 + RCL I ÷ 1 0 0 > y^x +/−
RCL N + RCL B ENTER

To verify proper entry of the equation, press

↰ SHOW

and hold down the SHOW key. This will display the equation's checksum and length. The values displayed should be a checksum of CEFA and a length of 41.

To solve for the different variables within this equation, the ↱ SOLVE button is used. This key is the right shift of the EQN key.

Notes for using the SOLVE function with this equation:

1) If your first calculation using this formula is to solve for the interest rate I, press 1 ↱ STO I before beginning.
2) Press EQN. If the time value of money equation is not at the top of the list, press ⌃ or ⌄ to scroll through the list until the equation is displayed.
3) Determine the variable for which you wish to solve and press:
   a) ↱ SOLVE N to calculate the number of compounding periods.
   b) ↱ SOLVE I to calculate the periodic interest rate. Note: this will need to be multiplied by the number of compounding periods per year to get the annual rate. If the compounding is monthly, multiply by 12.
   c) ↱ SOLVE B to calculate the initial balance (or Present Value) of a loan or savings account.
   d) ↱ SOLVE P to calculate the periodic payment.
   e) ↱ SOLVE F to calculate the future value of a loan or savings account.
4) When prompted, enter a value for each of the variables in the equation as you are prompted and press R/S. The solver will display the variables' existing value. If this is to be kept, do not enter any value but press R/S to continue. If the value is to be changed, enter the changed value and press R/S. If a variable had a value in a previous calculation but is not involved in this calculation (as might happen to the variable P (payment) when solving a compound interest problem right after solving an annuity problem), enter a zero for the value and press R/S.

5) After you press [R/S] for the last time, the value of the unknown variable will be calculated and displayed.
6) To do another calculation with the same or changed values, go back to step 2 above.

The SOLVE feature will work effectively without any initial guesses being supplied for the unknown variable with the exception noted above about the variable I in this equation. This equation follows the standard convention that money in is considered positive and money out is negative.

The practice problems below illustrate using this equation to solve a variety of problems involving house payment calculations.

Practice solving house payment calculation problems

Example 1: Jill bought a house for $210,000. Her 30-year loan will have an interest rate of 6%, compounded monthly. What is the size of her monthly house payment?

Solution: First, enter the time value of money equation into the HP 35s solver as described earlier in this document.

Then press [EQN] and press [⌃] or [⌄] to scroll through the equation list until the time value of money equation is displayed. Then press:

[↱] [SOLVE] [P]

The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution. The value of 0.0000 is displayed below if this is the first time the time value of money equation has been solved on the HP 35s calculator. If any previous equations have used a variable used in the time value of money equation, they may already have been assigned a value that would be displayed on your HP 35s display. Follow the keystrokes shown below and the solution should be found as described.

Figure 1

In RPN mode, press: [6] [ENTER] [1] [2] [÷] [R/S]
In algebraic mode, press: [6] [÷] [1] [2] [ENTER] [R/S]

Figure 2

In RPN mode, press: [3] [0] [ENTER] [1] [2] [×] [R/S]
In algebraic mode, press: [3] [0] [×] [1] [2] [ENTER] [R/S]

Figure 3

In either RPN or algebraic mode, press: 0 R/S

Figure 4

In either RPN or algebraic mode, press: 2 1 0 0 0 0 R/S

Figure 5

Answer: The required monthly deposit is $1,259.06.

Example 2: Samantha bought a house for $165,000. Her 15-year loan will have an interest rate of 5%, compounded monthly. What is the size of her monthly house payment?

Solution: First, enter the time value of money equation into the HP 35s solver as described earlier in this document.

Then press EQN and press ⌃ or ⌄ to scroll through the equation list until the time value of money equation is displayed. Then press:

↱ SOLVE P

The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution. These displays are not shown in the rest of this example. Follow the keystrokes shown below and the solution should be found as described.

In RPN mode, press:

5 ENTER 1 2 ÷ R/S	(Enters I)
1 5 ENTER 1 2 × R/S	(Enters N)
0 R/S	(Enters F)
1 6 5 0 0 0 +/_ R/S	(Enters B)

In algebraic mode, press:

5 ÷ 1 2 ENTER R/S	(Enters I)
1 5 × 1 2 ENTER R/S	(Enters N)
0 R/S	(Enters F)
1 6 5 0 0 0 +/_ R/S	(Enters B)

Figure 6

Answer: $1,304.81 (Note that the loan amount was entered as a negative number)

Example 3: Jeff bought a house for $125,000 and financed it with a 20-year loan at a rate of 5.25%, compounded monthly. What is the size of Jeff's monthly house payment?

Solution: First, enter the time value of money equation into the HP 35s solver as described earlier in this document.

Then press EQN and press ▲ or ▼ to scroll through the equation list until the time value of money equation is displayed. Then press:

SOLVE P

The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution. These displays are not shown in the rest of this example. Follow the keystrokes shown below and the solution should be found as described.

In RPN mode, press:	5 · 2 5 ENTER 1 2 ÷ R/S	(Enters I)
	2 0 ENTER 1 2 × R/S	(Enters N)
	0 R/S	(Enters F)
	1 2 5 0 0 0 +/- R/S	(Enters B)
In algebraic mode, press:	5 · 2 5 ÷ 1 2 ENTER R/S	(Enters I)
	2 0 × 1 2 ENTER R/S	(Enters N)
	0 R/S	(Enters F)
	1 2 5 0 0 0 +/- R/S	(Enters B)

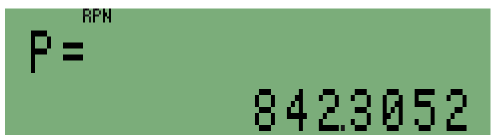


Figure 7

Answer: $842.31 (Note that the loan amount was entered as a negative number)

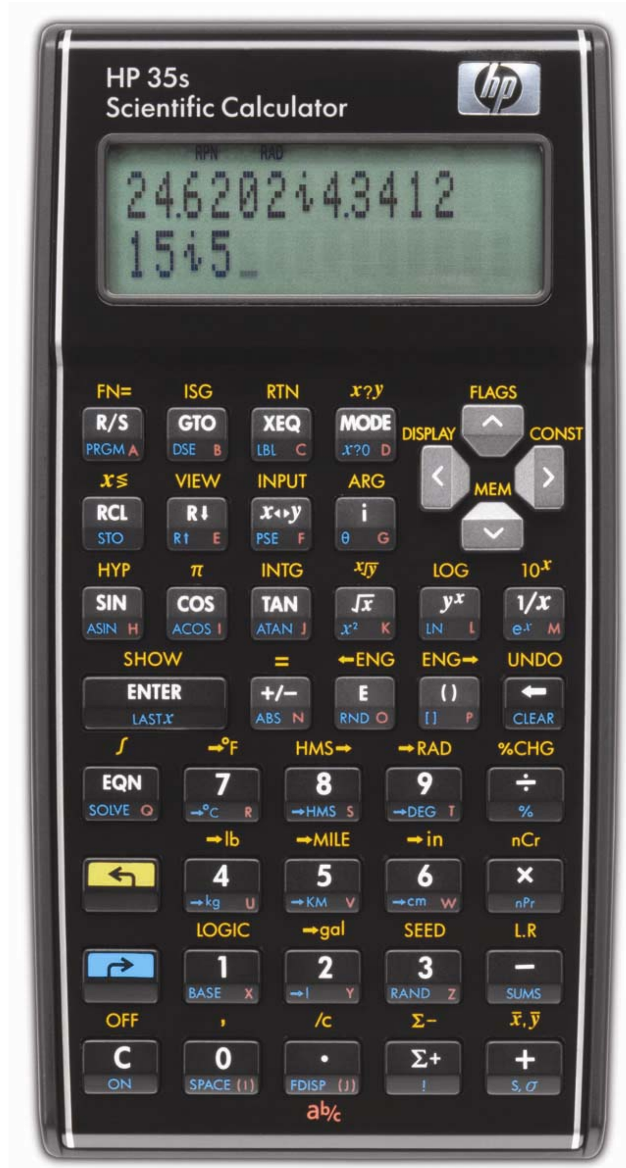
hp calculators

HP 35s Property Appreciation

Property Appreciation

The Time Value of Money on the HP 35s

Practice solving property appreciation problems



Property Appreciation

When the value of a piece of property increases over time, it has appreciated in value. If a value in the past is known, it is possible to solve the resulting compound interest problem to determine the rate of this appreciation.

The Time Value of Money on the HP 35s

To solve time value of money problems on the HP 35s, the formula below is entered into the flexible equation solver built into the calculator. This equation expresses the standard relationship between the variables in the time value of money formula. The formula uses these variables: ***N*** is the number of compounding periods; ***I*** is the ***periodic*** interest rate as a percentage (for example, if the ***annual*** interest rate is 15% and there are 12 payments per year, the ***periodic*** interest rate, ***i***, is 15÷12=1.25%); ***B*** is the initial balance of loan or savings account; ***P*** is the periodic payment; ***F*** is the future value of a savings account or balance of a loan.

Equation: P x 100 x (1 - (1 + I ÷ 100)^ -N) ÷ I + F x (1 + I ÷ 100) ^ -N + B

To enter this equation into the calculator, press the following keys on the HP 35s:

[EQN] [RCL] [P] [×] [1] [0] [0] [×] [()] [1] [−] [()] [1] [+] [RCL] [I] [÷] [1] [0] [0] [>] [y^x]
[+/−] [RCL] [N] [>] [÷] [RCL] [I] [+] [RCL] [F] [×] [()] [1] [+] [RCL] [I] [÷] [1] [0] [0] [>] [y^x] [+/−]
[RCL] [N] [+] [RCL] [B] [ENTER]

To verify proper entry of the equation, press

[↰] [SHOW]

and hold down the [SHOW] key. This will display the equation's checksum and length. The values displayed should be a checksum of CEFA and a length of 41.

To solve for the different variables within this equation, the [↱] [SOLVE] button is used. This key is the right shift of the [EQN] key.

Notes for using the SOLVE function with this equation:

1) If your first calculation using this formula is to solve for the interest rate I, press [1] [↱] [STO] [I] before beginning.
2) Press [EQN]. If the time value of money equation is not at the top of the list, press [▲] or [▼] to scroll through the list until the equation is displayed.
3) Determine the variable for which you wish to solve and press:
   a) [↱] [SOLVE] [N] to calculate the number of compounding periods.
   b) [↱] [SOLVE] [I] to calculate the periodic interest rate. Note: this will need to be multiplied by the number of compounding periods per year to get the annual rate. If the compounding is monthly, multiply by 12.
   c) [↱] [SOLVE] [B] to calculate the initial balance (or Present Value) of a loan or savings account.
   d) [↱] [SOLVE] [P] to calculate the periodic payment.
   e) [↱] [SOLVE] [F] to calculate the future value of a loan or savings account.
4) When prompted, enter a value for each of the variables in the equation as you are prompted and press [R/S]. The solver will display the variables' existing value. If this is to be kept, do not enter any value but press [R/S] to continue. If the value is to be changed, enter the changed value and press [R/S]. If a variable had a value in a previous calculation but is not involved in this calculation (as might happen to the variable P (payment) when solving a compound interest problem right after solving an annuity problem), enter a zero for the value and press [R/S].

5) After you press [R/S] for the last time, the value of the unknown variable will be calculated and displayed.
6) To do another calculation with the same or changed values, go back to step 2 above.

The SOLVE feature will work effectively without any initial guesses being supplied for the unknown variable with the exception noted above about the variable I in this equation. This equation follows the standard convention that money in is considered positive and money out is negative.

The practice problems below illustrate using this equation to solve a variety of property appreciation problems.

Practice solving property appreciation problems

Example 1: Greg bought a house 10 years ago for $120,000. He sold it last week for $180,000. On an annual basis, what was the compound rate of increase or appreciation?

Solution: First, enter the time value of money equation into the HP 35s solver as described earlier in this document.

Then press [EQN] and press [▲] or [▼] to scroll through the equation list until the time value of money equation is displayed. Then press:

[↱] [SOLVE] [I]

The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution. The value of 0.0000 is displayed below if this is the first time the time value of money equation has been solved on the HP 35s calculator. If any previous equations have used a variable used in the time value of money equation, they may already have been assigned a value that would be displayed on your HP 35s display. If this is the first time a solution for I has been attempted, press [↱] [1] [STO] [I], then follow the keystrokes shown below and the solution should be found as described. If previous solutions for I have been found, follow the instructions below.

Figure 1

In either RPN or algebraic mode, press: [0] [R/S]

Figure 2

In either RPN or algebraic mode, press: [1] [0] [R/S]

Figure 3

In either RPN or algebraic mode, press: [1] [8] [0] [0] [0] [0] [+/-] [R/S]

Figure 4

In either RPN or algebraic mode, press: [1] [2] [0] [0] [0] [0] [R/S]

Figure 5

Answer: An annual appreciation rate of 4.138%

Example 2: Johanna bought a house 5 years ago for $310,000. She sold it today for $400,000. At what rate, compounded monthly, did Johanna's house appreciate over this period?

Solution: First, enter the time value of money equation into the HP 35s solver as described earlier in this document.

Then press [EQN] and press [▲] or [▼] to scroll through the equation list until the time value of money equation is displayed. Then press:

[↱] [SOLVE] [I]

The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution. These displays are not shown in the rest of this example. Follow the keystrokes shown below and the solution should be found as described.

In either RPN or algebraic mode, press:

[0] [R/S]	(Enters P)
[6] [0] [R/S]	(Enters N)
[4] [0] [0] [0] [0] [0] [+/-] [R/S]	(Enters F)
[3] [1] [0] [0] [0] [0] [R/S]	(Enters B)

Figure 6

Answer: When multiplied by 12 to convert to the annual appreciation rate, the answer is 5.108%

Example 3: Howard bought some land 8 years ago for $800,000. He has an offer to sell it today for $1,400,000. What is the annual appreciation rate reflected by this offer?

Solution: First, enter the time value of money equation into the HP 35s solver as described earlier in this document.

Then press [EQN] and press [▲] or [▼] to scroll through the equation list until the time value of money equation is displayed. Then press:

[↱] [SOLVE] [I]

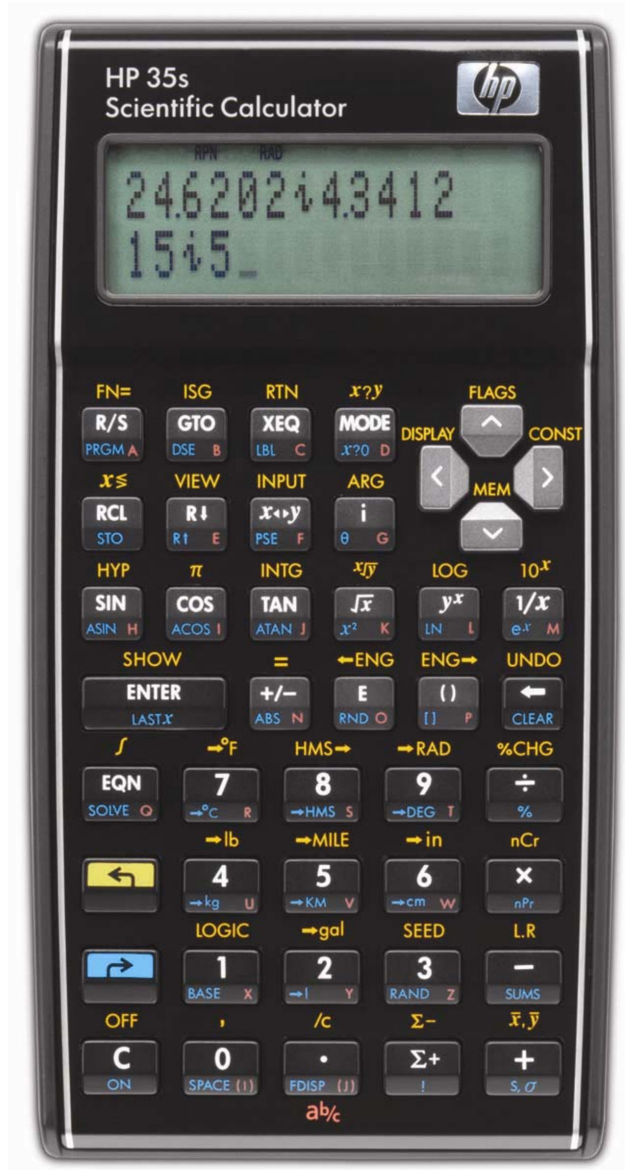
The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution. These displays are not shown in the rest of this example. Follow the keystrokes shown below and the solution should be found as described.

In either RPN or algebraic mode, press:	0 R/S	(Enters P)
	8 R/S	(Enters N)
	1 4 0 0 0 0 0 +/- R/S	(Enters F)
	8 0 0 0 0 0 R/S	(Enters B)

Figure 7

Answer: The property appreciated at a rate of 7.25%, compounded annually.

hp calculators



HP 35s House payment qualification

House payment qualification

The Time Value of Money on the HP 35s

Practice solving house payment qualification problems

House payment qualification

The payment required to pay off a house over time involves the solution of an ordinary annuity with the value of the payment as the unknown variable. When applying for a house loan, the lender takes the applicant's overall debt burden into account. A general guideline applied is that the total debt-to-income ratio should be below 34% and that the house payment plus taxes and insurance should be below 27% of total income. This will determine the maximum house payment for which an applicant may qualify as well as the corresponding maximum loan amount.

The Time Value of Money on the HP 35s

To solve time value of money problems on the HP 35s, the formula below is entered into the flexible equation solver built into the calculator. This equation expresses the standard relationship between the variables in the time value of money formula. The formula uses these variables: ***N*** is the number of compounding periods; ***I*** is the ***periodic*** interest rate as a percentage (for example, if the ***annual*** interest rate is 15% and there are 12 payments per year, the ***periodic*** interest rate, ***i***, is 15÷12=1.25%); ***B*** is the initial balance of loan or savings account; ***P*** is the periodic payment; ***F*** is the future value of a savings account or balance of a loan.

Equation: P x 100 x (1 - (1 + I ÷ 100)^ -N) ÷ I + F x (1 + I ÷ 100) ^ -N + B

To enter this equation into the calculator, press the following keys on the HP 35s:

[EQN] [RCL] [P] [×] [1] [0] [0] [×] [( )] [1] [−] [( )] [1] [+] [RCL] [I] [÷] [1] [0] [0] [>] [y^x]
[+/−] [RCL] [N] [>] [÷] [RCL] [I] [+] [RCL] [F] [×] [( )] [1] [+] [RCL] [I] [÷] [1] [0] [0] [>] [y^x] [+/−]
[RCL] [N] [+] [RCL] [B] [ENTER]

To verify proper entry of the equation, press

[↰] [SHOW]

and hold down the [SHOW] key. This will display the equation's checksum and length. The values displayed should be a checksum of CEFA and a length of 41.

To solve for the different variables within this equation, the [↱] [SOLVE] button is used. This key is the right shift of the [EQN] key.

Notes for using the SOLVE function with this equation:

1) If your first calculation using this formula is to solve for the interest rate I, press [1] [↱] [STO] [I] before beginning.
2) Press [EQN]. If the time value of money equation is not at the top of the list, press [▲] or [▼] to scroll through the list until the equation is displayed.
3) Determine the variable for which you wish to solve and press:
   a) [↱] [SOLVE] [N] to calculate the number of compounding periods.
   b) [↱] [SOLVE] [I] to calculate the periodic interest rate. Note: this will need to be multiplied by the number of compounding periods per year to get the annual rate. If the compounding is monthly, multiply by 12.
   c) [↱] [SOLVE] [B] to calculate the initial balance (or Present Value) of a loan or savings account.
   d) [↱] [SOLVE] [P] to calculate the periodic payment.
   e) [↱] [SOLVE] [F] to calculate the future value of a loan or savings account.
4) When prompted, enter a value for each of the variables in the equation as you are prompted and press [R/S]. The solver will display the variables' existing value. If this is to be kept, do not enter any value but press [R/S] to

continue. If the value is to be changed, enter the changed value and press [R/S]. If a variable had a value in a previous calculation but is not involved in this calculation (as might happen to the variable P (payment) when solving a compound interest problem right after solving an annuity problem), enter a zero for the value and press [R/S].

5) After you press [R/S] for the last time, the value of the unknown variable will be calculated and displayed.
6) To do another calculation with the same or changed values, go back to step 2 above.

The SOLVE feature will work effectively without any initial guesses being supplied for the unknown variable with the exception noted above about the variable I in this equation. This equation follows the standard convention that money in is considered positive and money out is negative.

The practice problems below illustrate using this equation to solve a variety of problems involving qualifying for a specific house payment.

Practice solving house payment qualification problems

Example 1: Richard wants to buy a house that costs $170,000 using a 30 year loan at 6% compounded monthly. His annual income is $55,000. His existing monthly debt includes a car payment of $295 per month and a minimum payment on his credit card of $25 per month. Property taxes are estimated at $1,300 per year and the annual insurance premium is estimated at $450 per year. Can Richard qualify for this house loan if the lender applies the 27%/34% guidelines?

Solution: First, enter the time value of money equation into the HP 35s solver as described earlier in this document.

Richard's monthly income is $55,000 divided by 12, or $4,583.33. The maximum house payment (including taxes and insurance) Richard can qualify for is 27% of his monthly income, or $1,237.50.

In RPN mode, press: [5] [5] [0] [0] [0] [ENTER] [1] [2] [÷] [0] [.] [2] [7] [×]

In algebraic mode, press: [5] [5] [0] [0] [0] [÷] [1] [2] [×] [0] [.] [2] [7] [ENTER]

Then, find the monthly payment needed to buy the house by pressing [EQN] and press [▲] or [▼] to scroll through the equation list until the time value of money equation is displayed. Then press:

[↱] [SOLVE] [P]

The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution. The value of 0.0000 is displayed below if this is the first time the time value of money equation has been solved on the HP 35s calculator. If any previous equations have used a variable used in the time value of money equation, they may already have been assigned a value that would be displayed on your HP 35s display. Follow the keystrokes shown below and the solution should be found as described.

Figure 1

In RPN mode, press: [6] [ENTER] [1] [2] [÷] [R/S]
In algebraic mode, press: [6] [÷] [1] [2] [ENTER] [R/S]

Figure 2

In RPN mode, press: [3] [0] [ENTER] [1] [2] [×] [R/S]
In algebraic mode, press: [3] [0] [×] [1] [2] [ENTER] [R/S]

Figure 3

In either RPN or algebraic mode, press: [0] [R/S]

Figure 4

In either RPN or algebraic mode, press: [1] [7] [0] [0] [0] [0] [R/S]

Figure 5

The house payment is $1,019.24 a month. With taxes and insurance, this increases to $1,165.07.

In RPN mode, press: [1] [3] [0] [0] [ENTER] [4] [5] [0] [+] [1] [2] [÷] [−]

In algebraic mode, press: [−] [( )] [( )] [1] [3] [0] [0] [+] [4] [5] [0] [)] [÷] [1] [2] [)] [ENTER]

The $1,165.07 is the total monthly house payment plus taxes and insurance. This is lower than the 27% limit earlier computed of $1,237.50, so Richard meets the 27% guideline.

Richard's total monthly debt is to be less than 34% of his monthly income. The maximum monthly debt Richard can have is 34% of his monthly income, or $1,558.33

In RPN mode, press: [5] [5] [0] [0] [0] [ENTER] [1] [2] [÷] [0] [.] [3] [4] [×]

In algebraic mode, press: [5] [5] [0] [0] [0] [÷] [1] [2] [×] [0] [.] [3] [4] [ENTER]

Richard's total debt would be the $1,165.07 house payment, the $295 car payment and the $25 per month credit card payment. This is a total of $1,485.07, which is less than the maximum monthly debt limit set by the 34% guideline.

In RPN mode, press: [1][1][6][5][.][0][7][ENTER][2][9][5][+][2][5][+]

In algebraic mode, press: [1][1][6][5][.][0][7][+][2][9][5][+][2][5][ENTER]

Answer: Richard can qualify for this house loan because he meets the 27%/34% guidelines.

Example 2: Caroline wants to buy a house that costs $208,000 using a 15-year loan at 5% compounded monthly. Her annual income is $75,000. Her existing monthly debt includes a car payment of $365 per month and minimum payments on her credit card of $96.50 per month. Property taxes are estimated at $1,900 per year and the annual insurance premium is estimated at $1,150 per year. Can Caroline qualify for this house loan if the lender applies the 27%/34% guidelines?

Solution: First, enter the time value of money equation into the HP 35s solver as described earlier in this document.

Caroline's monthly income is $75,000 divided by 12, or $6,250. The maximum house payment (including taxes and insurance) Caroline can qualify for is 27% of her monthly income, or $1,687.50.

In RPN mode, press: [7][5][0][0][0][ENTER][1][2][÷][0][.][2][7][×]

In algebraic mode, press: [7][5][0][0][0][÷][1][2][×][0][.][2][7][ENTER]

Then, find the monthly payment needed to buy the house by pressing [EQN] and press [▲] or [▼] to scroll through the equation list until the time value of money equation is displayed. Then press:

[↱][SOLVE][P]

The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution. The value of 0.0000 is displayed below if this is the first time the time value of money equation has been solved on the HP 35s calculator. If any previous equations have used a variable used in the time value of money equation, they may already have been assigned a value that would be displayed on your HP 35s display. Follow the keystrokes shown below and the solution should be found as described.

In RPN mode, press:

[5][ENTER][1][2][÷][R/S] (Enters I)
[1][5][ENTER][1][2][×][R/S] (Enters N)
[0][R/S] (Enters F)
[2][0][8][0][0][0][+/-][R/S] (Enters B)

In algebraic mode, press:

[5][÷][1][2][ENTER][R/S] (Enters I)
[1][5][×][1][2][ENTER][R/S] (Enters N)
[0][R/S] (Enters F)
[2][0][8][0][0][0][+/-][R/S] (Enters B)

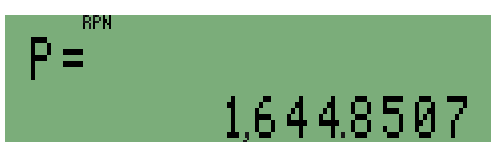


Figure 6

The house payment is $1,644.85 a month. With taxes and insurance, this increases to $1,899.02.

In RPN mode, press: 1 9 0 0 ENTER 1 1 5 0 + 1 2 ÷ −

In algebraic mode, press: − ( ) ( ) 1 9 0 0 + 1 1 5 0 > ÷ 1 2 > ENTER

The $1,899.02 is the total monthly house payment plus taxes and insurance. This is larger than the 27% guideline amount of $1,687.50 previously computed.

Answer: Caroline cannot qualify for this house loan because she does not meet the 27% guideline. Perhaps she should consider a 30 year loan.

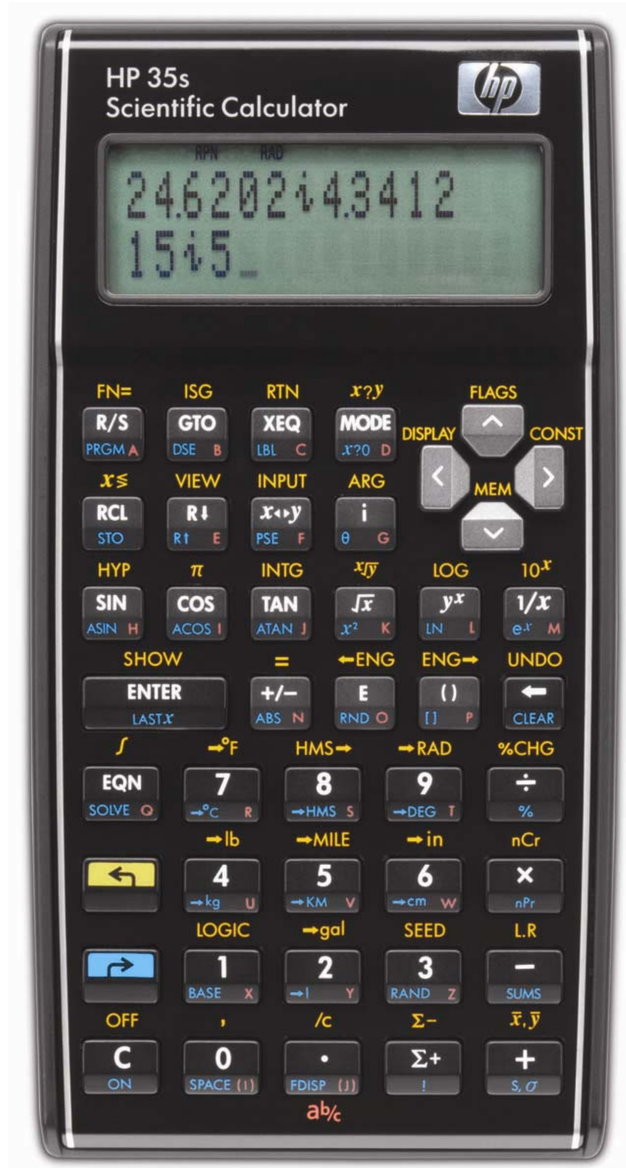
hp calculators

HP 35s Loan down payments

Loan down payments

The Time Value of Money on the HP 35s

Practice solving loan down payment problems



Loan down payments

Down payments are often made on loans to lower the required payment. Other reasons for down payments can be to ensure the loan applicant has an equity interest in the loan collateral, which would make the loan applicant less likely to abandon the property, since the property would be worth more than the loan balance. Down payments are also required to ensure an investment in the property has been made by the loan applicant, thereby reducing the risk to the lender that the loan will be abandoned.

The process to be used is to input the payment the applicant can afford and determine the equivalent Present Value (PV). The difference between this PV and the actual loan amount will be the required down payment.

The Time Value of Money on the HP 35s

To solve time value of money problems on the HP 35s, the formula below is entered into the flexible equation solver built into the calculator. This equation expresses the standard relationship between the variables in the time value of money formula. The formula uses these variables: ***N*** is the number of compounding periods; ***I*** is the ***periodic*** interest rate as a percentage (for example, if the ***annual*** interest rate is 15% and there are 12 payments per year, the ***periodic*** interest rate, ***i***, is 15÷12=1.25%); ***B*** is the initial balance of loan or savings account; ***P*** is the periodic payment; ***F*** is the future value of a savings account or balance of a loan.

Equation: P x 100 x (1 - (1 + I ÷ 100)^ -N) ÷ I + F x (1 + I ÷ 100) ^ -N + B

To enter this equation into the calculator, press the following keys on the HP 35s:

[EQN] [RCL] [P] [×] [1] [0] [0] [×] [()] [1] [−] [()] [1] [+] [RCL] [I] [÷] [1] [0] [0] [>] [y^x]
[+/−] [RCL] [N] [>] [÷] [RCL] [I] [+] [RCL] [F] [×] [()] [1] [+] [RCL] [I] [÷] [1] [0] [0] [>] [y^x] [+/−]
[RCL] [N] [+] [RCL] [B] [ENTER]

To verify proper entry of the equation, press

[↰] [SHOW]

and hold down the [SHOW] key. This will display the equation's checksum and length. The values displayed should be a checksum of CEFA and a length of 41.

To solve for the different variables within this equation, the [↱] [SOLVE] button is used. This key is the right shift of the [EQN] key.

Notes for using the SOLVE function with this equation:

1) If your first calculation using this formula is to solve for the interest rate I, press [1] [↱] [STO] [I] before beginning.
2) Press [EQN]. If the time value of money equation is not at the top of the list, press [▲] or [▼] to scroll through the list until the equation is displayed.
3) Determine the variable for which you wish to solve and press:
   a) [↱] [SOLVE] [N] to calculate the number of compounding periods.
   b) [↱] [SOLVE] [I] to calculate the periodic interest rate. Note: this will need to be multiplied by the number of compounding periods per year to get the annual rate. If the compounding is monthly, multiply by 12.
   c) [↱] [SOLVE] [B] to calculate the initial balance (or Present Value) of a loan or savings account.
   d) [↱] [SOLVE] [P] to calculate the periodic payment.

e) [↱] [SOLVE] [F] to calculate the future value of a loan or savings account.

4) When prompted, enter a value for each of the variables in the equation as you are prompted and press [R/S]. The solver will display the variables' existing value. If this is to be kept, do not enter any value but press [R/S] to continue. If the value is to be changed, enter the changed value and press [R/S]. If a variable had a value in a previous calculation but is not involved in this calculation (as might happen to the variable P (payment) when solving a compound interest problem right after solving an annuity problem), enter a zero for the value and press [R/S].
5) After you press [R/S] for the last time, the value of the unknown variable will be calculated and displayed.
6) To do another calculation with the same or changed values, go back to step 2 above.

The SOLVE feature will work effectively without any initial guesses being supplied for the unknown variable with the exception noted above about the variable I in this equation. This equation follows the standard convention that money in is considered positive and money out is negative.

The practice problems below illustrate using this equation to solve a variety of loan down payment problems.

Practice solving loan down payment problems

<u>Example 1:</u> Leigh Anne wants to buy a car and can afford a payment of $400 a month. If the car costs $25,000 and Leigh Anne can get a 72 month loan at 6.9%, compounded monthly, how much must she give as a down payment to lower her payment to $400 a month?

<u>Solution:</u> First, enter the time value of money equation into the HP 35s solver as described earlier in this document. Press [EQN] and press [▲] or [▼] to scroll through the equation list until the time value of money equation is displayed. Then compute the present value of a loan for 72 months of $400 per month at Leigh Anne's interest rate. To do this, press:

[↱] [SOLVE] [B]

The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution. The value of 0.0000 is displayed below if this is the first time the time value of money equation has been solved on the HP 35s calculator. If any previous equations have used a variable used in the time value of money equation, they may already have been assigned a value that would be displayed on your HP 35s display. Follow the keystrokes shown below and the solution should be found as described.

Figure 1

In either RPN or algebraic mode, press: [4] [0] [0] [R/S]

Figure 2

In RPN mode, press: [6] [·] [9] [ENTER] [1] [2] [÷] [R/S]

In algebraic mode, press: [6] [·] [9] [÷] [1] [2] [ENTER] [R/S]

Figure 3

In either RPN or algebraic mode, press: [7] [2] [R/S]

Figure 4

In either RPN or algebraic mode, press: [0] [R/S]

Figure 5

With a payment of $400 per month, Leigh Anne can afford a loan amount of $23,527.99. To buy the car costing $25,000, Leigh Anne must make a down payment of the difference.

In RPN mode, press: [2] [5] [0] [0] [0] [+]
In algebraic mode, press: [+] [2] [5] [0] [0] [0] [ENTER]

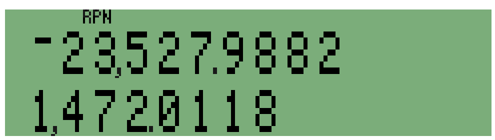


Figure 6

<u>Answer:</u> To lower her monthly payment to $400, Leigh Anne needs to make a $1,472.01 down payment.

<u>Example 2:</u> Jane is looking to buy a house and can afford a payment of $1,200 a month. If the house costs $270,000 and Jane can get a 30 year loan at 5.4%, compounded monthly, how much must Jane give as a down payment to lower her payment to $1,400 a month?

<u>Solution:</u> First, enter the time value of money equation into the HP 35s solver as described earlier in this document. Press [EQN] and press [▲] or [▼] to scroll through the equation list until the time value of money equation is displayed. Then compute the present value of a loan for 72 months of $400 per month at Jane's interest rate. To do this, press:

[↱] [SOLVE] [B]

The HP 35s SOLVER displays the first variable encountered in the equation as it begins its solution. The displays for these prompts are not shown in this example. Follow the keystrokes shown below and the solution should be found as described.

In RPN mode, press:	1 4 0 0 R/S	(Enters P)
	5 · 4 ENTER 1 2 ÷ R/S	(Enters I)
	3 0 ENTER 1 2 × R/S	(Enters N)
	0 R/S	(Enters F)
In algebraic mode, press:	1 4 0 0 R/S	(Enters P)
	5 · 4 ÷ 1 2 ENTER R/S	(Enters I)
	3 0 × 1 2 ENTER R/S	(Enters N)
	0 R/S	(Enters F)

Figure 7

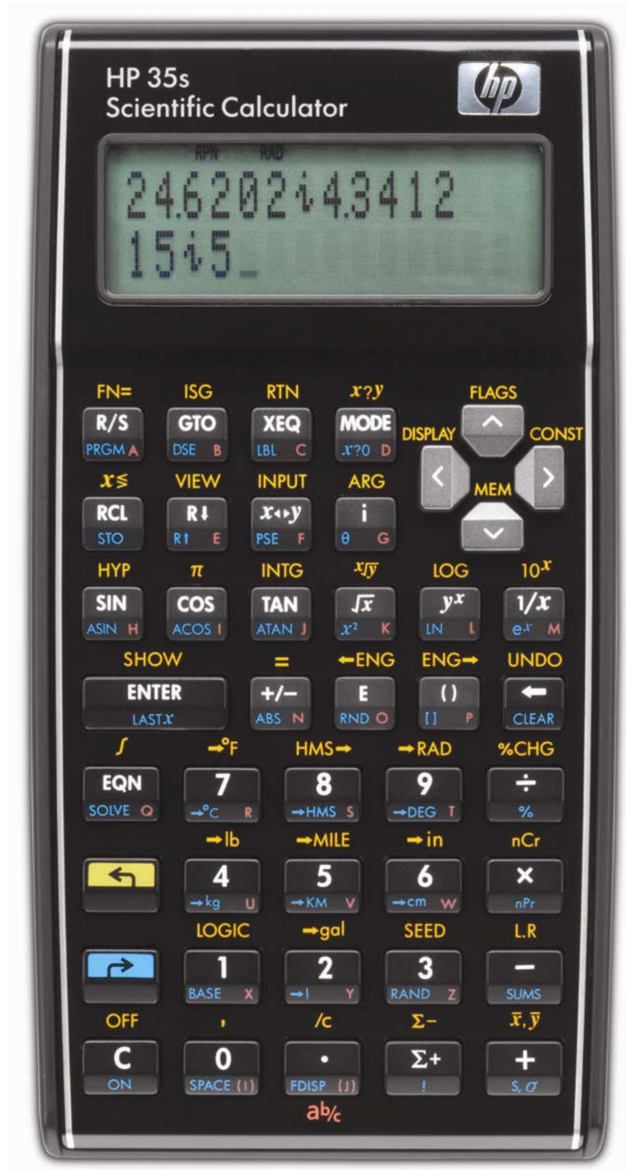
With a payment of $1,400 per month, Jane can afford a loan amount of $249,318.47. To buy the house costing $270,000, Jane must make a down payment of the difference.

In RPN mode, press: 2 7 0 0 0 0 +
In algebraic mode, press: + 2 7 0 0 0 0 ENTER

Figure 8

Answer: To lower her monthly payment to $1,400, Jane needs to make a $20,681.53 down payment.

hp calculators



HP 35s Average sales prices

Averages and standard deviations

Practice finding average sale prices and standard deviations

Averages and standard deviations

The average is defined as the sum of all data points divided by the number of data points included. It is a measure of central tendency and is the most commonly used. A standard deviation is a measure of dispersion around a central value. To compute the standard deviation, the sum of the squared differences between each individual data point and the average of all the data points is taken and then divided by the number of data points included (or, in the case of sample data, the number of data points included minus one). The square root of this value is then taken to obtain the standard deviation. The property of the standard deviation is such that when the underlying data is normally distributed, approximately 68% of all values will lie within one standard deviation on either side of the mean and approximately 95% of all values will lie within two standard deviations on either side of the mean. This has application to many fields, particularly when trying to decide if an observed value is unusual by being significantly different from the mean.

On the HP 35s, values are entered into the statistical / summation registers by keying in the number (or pair of numbers) desired and pressing [Σ+]. This process is repeated for all numbers or pair of numbers. When entering a pair of numbers in RPN or algebraic mode, key the Y value, press [ENTER], then key the X value and press [Σ+].

To view the mean, press [↰] [$\bar{x},\bar{y}$]. To view the standard deviation, press [↱] [S,σ]. When either of these is pressed, the HP 35s displays a menu of possible values. Items on this menu are viewed by pressing the [<] or [>] cursor keys.

To use a value displayed on the menu, press the [ENTER] button and the value will be copied for further use. This is illustrated in the problems below.

Practice finding average sale prices and standard deviations

Example 1: The sales price of the last 10 homes sold in the Parkdale community were: $198,000; $185,000; $205,200;$225,300; $206,700; $201,850; $200,000; $189,000; $192,100; $200,400. What is the average of these sales prices and what is the sample standard deviation? Would a sales price of $240,000 be considered unusual in the same community?

Solution: Be sure to clear the statistics / summation memories before starting the problem.

[↱] [CLEAR] [4]

The keystrokes are the same whether in RPN or algebraic mode:

[1] [9] [8] [0] [0] [0] [Σ+] [1] [8] [5] [0] [0] [0] [Σ+] [2] [0] [5] [2] [0] [0] [Σ+]
[2] [2] [5] [3] [0] [0] [Σ+] [2] [0] [6] [7] [0] [0] [Σ+] [2] [0] [1] [8] [5] [0] [Σ+]
[2] [0] [0] [0] [0] [0] [Σ+] [1] [8] [9] [0] [0] [0] [Σ+] [1] [9] [2] [1] [0] [0] [Σ+]
[2] [0] [0] [4] [0] [0] [Σ+]

To find the average, press: [↰] [$\bar{x},\bar{y}$]. Figure 1 displays the menu shown.

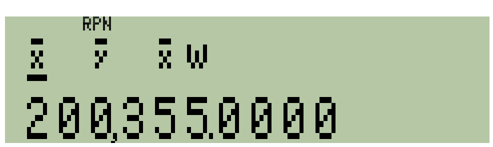


Figure 1

To find the sample standard deviation, press: [↱] [S,σ]. Figure 2 displays the menu shown.

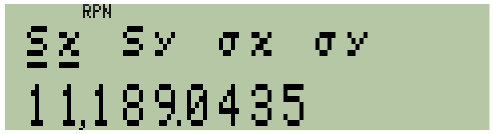


Figure 2

To find the value two standard deviations above and below the average, press the following:

In RPN mode:

[↱] [S,σ] [ENTER] [2] [×] [ENTER] [ENTER] [↰] [$\bar{x},\bar{y}$] [ENTER] [+] [x↔y] [↱] [LASTx] [x↔y] [−]

In algebraic mode:

[↱] [S,σ] [ENTER] [×] [2] [+] [↰] [$\bar{x},\bar{y}$] [ENTER] [ENTER] (computes the above value)
[↰] [$\bar{x},\bar{y}$] [ENTER] [−] [2] [×] [↱] [S,σ] [ENTER] [ENTER] (computes the below value)

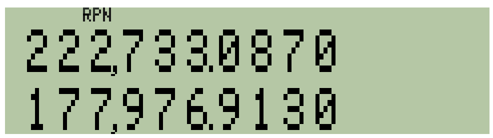


Figure 3

Answer: The average sales price is $200,355 and the sample standard deviation is $11,189. Within two standard deviations on either side of this average, in this case between $177,977 and $222,733, 95% of all home sales prices should fall. If a home were to sell for $240,000 in this area, it would be an unusual event. Figure 3 indicates the display in RPN mode.

Example 2: The sales price of the last 7 homes sold in the real estate office's zip code were: $245,000; $265,000; $187,000; $188,000; $203,000; $241,900; $222,000. What is the average of these sales prices and what is the sample standard deviation?

Solution: Be sure to clear the statistics / summation memories before starting the problem.

[↱] [CLEAR] [4]

The keystrokes are the same whether in RPN or algebraic mode:

[2] [4] [5] [0] [0] [0] [Σ+] [2] [6] [5] [0] [0] [0] [Σ+] [1] [8] [7] [0] [0] [0] [Σ+]
[1] [8] [8] [0] [0] [0] [Σ+] [2] [0] [3] [0] [0] [0] [Σ+] [2] [4] [1] [9] [0] [0] [Σ+]
[2] [2] [2] [0] [0] [0] [Σ+]

To find the average sales price, press: [↰] [$\bar{x},\bar{y}$]. Figure 4 displays the menu shown.

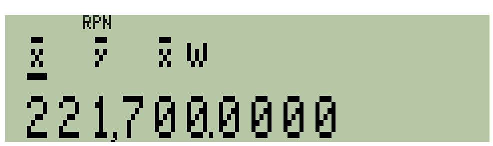


Figure 4

To find the sample standard deviation, press: [↱] [S,σ]. Figure 5 displays the menu shown.

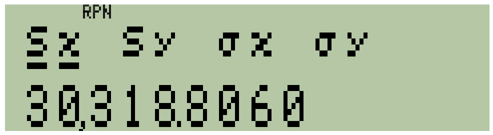


Figure 5

Answer: The average sales price was $221,700 and the standard deviation was $30,318.81

Example 3: Julie has bought gas this week while showing houses at four gasoline stations as follows: 15 gallons at $1.56 per gallon, 7 gallons at $1.64 per gallon, 10 gallons at $1.70 per gallon and 17 gallons at $1.58 per gallon. What is the average price of the gasoline purchased?

Solution: The HP 35s has a weighted average mean calculation built-in that will solve this problem easily. Be sure to clear the statistics / summation memories before starting the problem.

[↱] [CLEAR] [4]

In RPN or algebraic mode, press:

[1] [5] [ENTER] [1] [·] [5] [6] [Σ+] [7] [ENTER] [1] [·] [6] [4] [Σ+] [1] [0] [ENTER] [1] [·] [7] [Σ+]
[1] [7] [ENTER] [1] [·] [5] [8] [Σ+]

To find the weighted average price of gasoline purchased, press: [↰] [$\bar{x},\bar{y}$] [>] [>]. Figure 6 displays the menu shown.

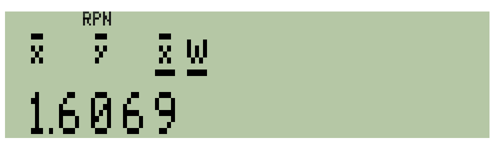


Figure 6

Answer: The average price per gallon Julie has paid this week while showing houses is slightly less than $1.61.