hp calculators

HP 50g Algebraic and RPN Operating Modes

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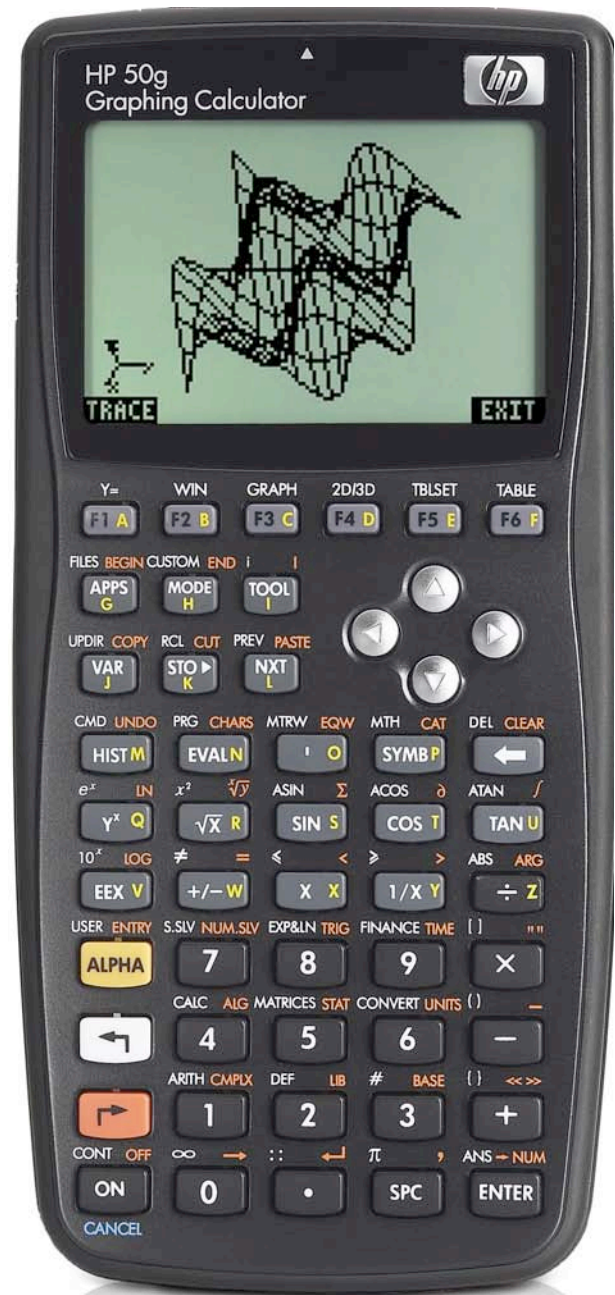
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The Operating Mode

Calculation Modes

You can type calculations on the HP50g, in "textbook" mode, in "algebraic" mode, or "RPN" mode.

When you want to use a formula or an expression, you can type it the way it looks in a textbook. This is neat and is called "textbook" mode. Then you can admire the formula, or plot it, or integrate it, or solve it for different unknown variables. Or you can just work out its value.

Yet to work out the value of a formula it is easier to type it using algebraic mode or RPN mode, and just get the answer.

Here is a very simple example. There is no need to type it on your calculator yet, just read it.

A simple example - the area of a piece of carpet

You want to know the total area of carpet for two rooms, one 6 yards long, one 8 yards long, both 5 yards wide. So you need to calculate (6 + 8) * 5.

In algebraic mode you work out the total length first, that's 6 yards + 8 yards. Then you multiply by the width, 5 yards. So you would type these keys:

|			
⟵	()	This gives the brackets to put around (6+8)	
6	+	8	This gives the 6+8
▶		This moves past the right bracket	
×	5	This multiplies by 5	
ENTER		This tells the calculator that the formula is finished so it can now get the answer	

and you would you see the answer like this:

Figure 1

In RPN you work out the total length first too. You type 6, then type 8 and add it. Then you type 5 and multiply:

6	ENTER	This puts the 6 in the calculator, ENTER separates it from the next number
8	+	This gives the 8 and adds it
5	×	This gives the 5 and multiplies by it

and you would see the answer like this:

Figure 2

Algebraic mode is simple if you know the formula, and it takes just 9 keys. Count them.

RPN mode is simple too. You do not even use a formula, and you press only 6 keys.

Keys:	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Ninth
Algebraic	⬅	()	6	+	8	▶	×	5	ENTER
RPN	6	ENTER	8	+	5	×			

In general, algebraic mode is better if you are using formulas you know, and if you just want to type them and get the results.

RPN mode is best if you want to go through calculations a step at a time, and sometimes even change your mind.

The HP50g lets you use either mode. This training aid will show some examples of using Algebraic and RPN modes, and will explain their differences and the advantages of each one.

Setting the mode

First make sure you know how to switch between algebraic and RPN modes. Press the MODE key and you will see the Modes Form.

```
RAD XYZ HEX R= 'X'            ALG
{HOME}
▒▒▒▒▒▒▒ CALCULATOR MODES ▒▒▒▒▒▒▒
Operating Mode..Algebraic
Number Format....Fix  5      _FM,
Angle Measure.....Radians
Coord System......Rectangular
✓Beep  _Key Click ✓Last Stack

Choose calculator operating mode
FLAGS CHOOS  CAS  DISP CANCL  OK
```
Figure 3

When you open the Modes Form, the cursor is on the top line, which selects the Operating Mode, Algebraic or RPN, and this is highlighted as in Figure 3 above. To change modes, press the F2 key below the ▦▦▦▦▦ menu label. You see the two options, Algebraic and RPN. Use the up arrow key ▲ or the down arrow key ▼ 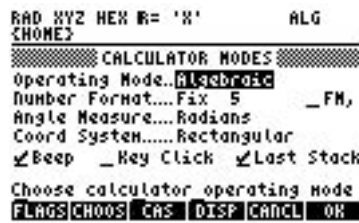to select the mode you want. Then press the F6 key below the ▦▦▦ menu label to confirm your selection, and press ▦▦▦ again to quit the Modes Form.

Tip! A shortcut for switching between the two modes is to press MODE then +/- then ▦▦▦. The +/- key switches between the available choices, without the need for you to press ▦▦▦▦▦.

With the calculator is in Algebraic mode you see the letters ALG at the top right of the display screen, as in Figure 1. In RPN mode this disappears, as in Figure 2.

For the examples below it will be helpful to have "Fix 2" and "Approximate" modes set too. First choose "Approximate" mode, so that "exact" numbers such as 2/3 will be automatically converted to approximate results such as 0.666666666667. Press MODE then F3 below the ▦▦▦▦ menu label to select the CAS Modes form. Press the down arrow key twice ▼ ▼ to reach the Approx selection. If this already has a check mark by it, then you do not need to set it, so press the F5 key below the ▦▦▦▦▦ menu label. If Approx is not checked then press F3 below the ▦▦▦▦ menu label to select Approximate mode, and press ▦▦▦ to confirm the setting. Now select "Fix 2" mode, to display answers with two digits after the decimal point, so you see 0.67 instead of 0.666666666667. Do this as follows: press MODE then ▼ to select the Number Format. Next press ▦▦▦▦▦ then use the arrow keys to pick FIXED and then press ▦▦▦ to choose Fixed mode. Then press the right arrow key ▶ to choose the number of digits after the decimal point. Press ▦▦▦▦▦ again, select 2, and press ▦▦▦ to select Fix 2 mode. Finally press ▦▦▦ one more time to confirm these selections.

Algebraic and RPN modes and the stack

As the example showed, both modes give the same answer. You just press keys in a different order. In Algebraic mode you type the whole formula or expression, then press ENTER and let the calculator work it all out. In RPN mode you give the calculator a number, then tell it what to do with that number. Then you give it another number, or use the number you just got, and tell the calculator what

to do next. Clearly, Algebraic is good when you just want to type in a formula and get the answer. RPN is best if you want to work through a problem, a step at a time, and see what is happening at each step, then decide what the next step is. This does not mean that the calculator has to be used like this; many people use only Algebraic mode or only RPN for all their calculations.

Whichever way the calculator is used, it provides some very helpful tools. The first one is the **Stack**, where formulas and numbers you have already used are kept for future use.

If you now go through the carpet example, pressing the keys, you will see the difference between Algebraic mode doing a whole calculation all at once and RPN mode doing it a step at a time.

First press (MODE) then (+/-) then ▦▦ to switch to Algebraic mode, if it is not already set.

Now you are ready to go through the example. Press these keys:

(←)	( )		This gives the brackets to put around (6+8)
(6)	(+)	(8)	This gives the 6+8
(▶)			This moves past the right bracket
(×)	(5)		This multiplies by 5
(ENTER)			This tells the calculator that the formula is finished so it can now get the answer

You typed in the whole expression (6+8)*5 and then you pressed (ENTER) to get the answer. The HP50g helped you by putting the whole expression and the result on the stack, as you saw in Figure 1. If you need to use the expression or the answer for a future calculation, you can get them by pressing the (HIST) key, then using the up and down keys to select what you need, then pressing the menu keys. These let you edit an expression, or view it in textbook mode, or echo a copy to the bottom of the stack so you can use it again, see Figure 4.

Figure 4

If you want to use an earlier answer in another calculation, you can also use (←)(ENTER) to access the ANS function which is above the (ENTER) key. By default, the HP50g gives you ANS(1), the answer to the calculation you did one step back, but you can change this to earlier answers, for example ANS(2), the answer to the calculation two steps back. To get ANS(2), press (←) ANS , then use the arrow keys to get to the 1, then press the delete key (◀) to delete the 1, and then type in a 2. With Fix 2 mode selected, as in these examples, you will see ANS(2.00) on the screen, but that makes no difference to the results.

For example if the carpet you want costs $17.32 per square yard, you get the total price of the carpet you need by pressing (1)(7)(.)(3)(2)(×)(←) ANS , then pressing (ENTER) as below.

Figure 5

If you begin a new calculation by pressing ⊕ or ⊗ or ⌐ʸ⌐ or any other command that needs two numbers, the HP50g will assume that you want to use the previous result, and will automatically put ANS(1) in your calculation. As an example, multiply the cost of the carpet by 1.035 to add 3.5% tax to its cost. Press ⊗ ⌐1⌐ ⌐·⌐ ⌐0⌐ ⌐3⌐ ⌐5⌐ and you will see:

```
RAD XYZ HEX R~ 'X'          ALG
{HOME}



: (6.00+8.00)*5.00
                    70.00
: 17.32*ANS(1.00)
                  1212.40
ANS(1)*1.035
EDIT VIEW STACK RCL PURGE CLEAR
```
Figure 6

The HP50g automatically put ANS(1) in front of the * when you pressed ⊗ with nothing before it. ANS(1) is now the number 1,212.40, the most recent answer. The number 70.00 is ANS(2). After you press ⟨ENTER⟩ it will become ANS(3).

As you see, the HP50g provides a range of ways to work in Algebraic mode. You will develop your own favorite ways to work as you gain experience with the calculator.

Why "Algebraic"? You can see that the formula to calculate was typed and is displayed 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 invented for use with unknown variables, such as X, but over the centuries it has also developed 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".

To compare the above to RPN mode, switch to RPN, pressing ⟨MODE⟩ then ⌐+/-⌐ then ▓▓▓. Now type the RPN keys for the carpet area calculation.

⌐6⌐	⟨ENTER⟩	This puts the 6 in the calculator, ENTER separates it from the next number
⌐8⌐	⊕	This gives the 8 and adds it
⌐5⌐	⊗	This gives the 5 and multiplies by it

There is a clear pattern here. You type a number, then you do something with that number. Then you type another number, and do something again. In this example, you add the 8 to the 6 that you entered before, then you multiply by 5, but RPN works the same way for other actions too. Just for example, to calculate the square root of 30, you type 30 and then press the ⌐√x⌐ key.

At each step, RPN takes one or more numbers it needs, then puts the answer on the stack.

Why "RPN?" You might have noticed that calculating the carpet area in RPN did not use brackets, and indeed RPN is designed to work without brackets. This makes it somewhat quicker to type than Algebraic mode; the carpet example took 6 keystrokes in RPN and 9 in Algebraic mode. Polish Notation, a mathematical notation without brackets, was introduced by the Polish mathematician Jan Lukasiewicz in the 1920s. In RPN, the operations such as ⊕ or ⊗ or ⟨SIN⟩ are done *after* the number is entered, not before it, so this method of calculation is called Reverse Polish Notation, RPN for short. The numbers it uses are on the stack, not inside brackets, so it is also called "Stack notation".

The ⟨ENTER⟩ key has a special task in RPN. It puts onto the stack the number you have just typed, without doing anything else to that number. Then the number is ready for what you want to do next, for example add another number to it. If you press ⟨ENTER⟩ again, it repeats its action, putting another copy of the number onto the stack. It does the latter in Algebraic mode as well.

As in Algebraic mode, the stack works to help you, but in a different way, suited to RPN calculations. The RPN stack is made up of numbered levels, with a value in each level. The values are the results of earlier calculations, or numbers you put on the stack with the ⟨ENTER⟩ key. The formula for the previous calculation is not put on the stack, because each calculation is just one step, but if you want to bring back what you just did, press ⌐←⌐ ⌐CMD⌐ to see the last 4 lines you typed, and select what you want with the arrow keys, then press ▓▓▓.

The numbers on the stack are ready for you to use in further calculations. As with Algebraic mode, the HP50g has commands to let you pick numbers off the stack, and there are also commands to move numbers around the stack. In fact RPN uses the stack as a central tool, and there is a whole set of stack commands. You can find them by pressing ⌜←⌟ PRG and then selecting the STACK option.

Tip! The most important stack commands in RPN are **DUP**, which copies the number in level 1 to level 2, and **SWAP**, which swaps the numbers in levels 1 and 2. **DUP** is done by pressing the ENTER key, as was described above. **SWAP** is needed in many cases, for example if you want to divide the number in level 1 by the number in level 2 then you must swap them before pressing the ÷ key. **SWAP** is so important that there is a shortcut key for it, just press the right arrow key ▶ in RPN mode when you are not editing anything, and it will swap the numbers in levels 1 and 2.

The command line

As you typed the example in Algebraic and in RPN modes, what you typed went into a special line, below the stack, but above the menu keys. If you are still in RPN mode, try calculating the price of the carpet again. First type the number 17.32, and the display will look like this:

Figure 7

The previous result, 70, is on level 1 of the stack. The new number is between the stack and the menu keys, on a special line called the **Command Line**. Both Algebraic mode and RPN mode use this for numbers and text you are typing or editing. When you press ENTER the contents of the command line are evaluated and the result is put on the stack.

In RPN you do not need to press ENTER to put a number on the stack, if you are going to use it at once. In the case above, you can press ENTER to put 17.32 on the stack, and then press ✕ to multiply 70 by 17.32, but you can skip the ENTER and just press ✕ to get the answer. You do need to press ENTER if you are typing two numbers one after another, as in the carpet example.

Example – a more complicated expression

Here is a more complicated expression to compare Algebraic and RPN modes further.

$$\sqrt{((3.2*5^2)+3!)}$$

In Algebraic mode it is possible to type the expression almost as it stands. The only difference is that the x-squared key x^2 must be pressed before a number, whereas the x-squared symbol is written after the number to be squared. Set Algebraic mode and type the following:

√x̄ ⌜←⌟ () ⌜←⌟ () 3 · 2 ✕ ⌜←⌟ x^2 5 ▶ ▶ + 3 ALPHA → 2

Figure 8

The square root comes before the number it works on, the multiplication sign comes between the numbers it uses, and the factorial sign comes after the number it works with. The x-squared symbol was written after the number to be squared, but on the calculator it had to come before. There are three sets of nested brackets, which have to be treated correctly. Note that when you press ⌐ x^2 in Algebraic mode the brackets are automatically put in for you. To enter the factorial sign you have to use ALPHA mode to type the exclamation mark. Even though the calculator makes things easy for you, you still need to take care when typing the expression. Now press (ENTER) to see the result.

```
RAD XYZ HEX R~ 'X'          ALG
{HOME}
_____
                       1212.40
: √(3.20*SQ(5.00)+3.0…
                          9.27
EDIT VIEW STACK RCL PURGE CLEAR    Figure 9
```

The calculator has figured out what to do and in what order, and has given the result. The calculator knows the "rules of operator precedence" when it calculates a result, for example that addition and subtraction should be done after multiplication and division, so it has simplified the expression, taking out the unnecessary brackets in (3.2*SQ(5)). Whenever you type an expression with any possible ambiguity in it, the HP50g applies the rules of operator precedence in evaluating the expression.

One important consequence of the rules of precedence can cause confusion. This is that an expression such as -5^2 works out as –25.00, not 25.00. Raising a number to a power has higher precedence than changing a sign, so it is done first, and the expression is worked out as $-(5^2)$.

Switch to RPN mode and try doing the same example calculation.

⑤ ⌐ x^2 ③ · ② × ③ ALPHA → ② + √x

As you went through the calculation, you saw intermediate results at each step, so you could notice any obvious errors, but when you are finished you only see the final result.

```
RAD XYZ HEX R~ 'X'
{HOME}
_____
7:
6:
5:
4:                    1,212.40
3: : '√(3.20*SQ(5.00)…
2:                       9.27
1:                       9.27
EDIT VIEW STACK RCL PURGE CLEAR    Figure 10
```

The RPN calculation takes 6 fewer keys, and you see what is happening step by step, but you have to work out for yourself what to do and in what order. Even if you did not put in the extra brackets in the Algebraic example above, RPN would take 3 less keystrokes. If you are willing to work out how to do the calculation, RPN saves you any confusion about brackets, and works with fewer keystrokes.

If you are new to HP calculators, try using both modes and see if you prefer one or the other, or if you want to switch between them as you use the HP50g.

Example – which stepladder?

Many people would prefer to type the example above as a formula in Algebraic mode, rather than use RPN mode and do it a step at a time. Now here is an example to show how RPN mode is useful for solving step-by-step problems.

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 one is better, but it's raining, so why not work it out first on your HP50g by seeing what angle each ladder will make with the vertical when you lean it against the roof?

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⟩ ⟨ENTER⟩ ⟨÷⟩ . You get 1.04. That cannot be right, sines and cosines should be smaller than 1. Use ⟨→⟩ ⟨UNDO⟩ to get the numbers back, then ⟨▶⟩ to swap them, as described in the tip above. Now press ⟨÷⟩ to divide them again, in the right order, and see 0.97.

Actually, pressing ⟨1/x⟩ would get the same result, and 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 use ⟨→⟩ ⟨UNDO⟩ again to undo the arc sine, but it is quicker to press ⟨SIN⟩ , then ⟨←⟩ ⟨ACOS⟩ . Your ladder would be only 15.09 degrees away from the vertical. That is uncomfortably steep. So try the same calculation for your neighbor's 38 foot ladder.

Type ⟨2⟩ ⟨8⟩ ⟨SPC⟩ ⟨3⟩ ⟨8⟩ ⟨÷⟩ then ⟨←⟩ ⟨ACOS⟩ . You can use the space key ⟨SPC⟩ instead of ⟨ENTER⟩ to separate two numbers on the command line, and ⟨SPC⟩ is nearer to the numeric keys, so you have to move your finger a shorter distance to type it. When you press a calculation key afterwards, the HP50g knows that the space is separating two different numbers. This time the answer is 42.54 degrees. The ladder would be at a shallow angle on the ground and might slip away as you stand on it.

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.

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 ⟨←⟩ ⟨ANS⟩ must be used repeatedly to bring back the result of the previous calculation.

Once all the examples have been completed it may be worth returning the calculator to its normal modes. It can also be helpful to clear the stack by pressing ⟨→⟩ ⟨CLEAR⟩ .

The Operating Mode

The examples and explanations in this training aid have used only real numbers, but the same principles apply with complex numbers, vectors, matrices, lists of numbers, and other objects. Whether you use Algebraic mode or RPN mode, the stack is a basic tool. The combination of stack and Algebraic or RPN mode is so important in the use of the HP50g that Algebraic or RPN is called the calculator's **Operating Mode** – it is the way in which the calculator operates.

These examples have shown how the user can switch between the two modes as necessary, but the modes can be combined further. Results on the stack from RPN mode calculations can be put in Algebraic calculations with the ANS command, and results from Algebraic calculations are on the stack ready for use if the calculator is switched to RPN mode. RPN mode works with all kinds of objects on the stack, even programs and algebraic expressions. To put an algebraic expression on the stack in RPN, press the ⟨'⟩ key first and then type the algebraic expression and ⟨ENTER⟩ . That expression can then be used in RPN calculations, or plotted or solved. The Algebraic mode and the RPN mode need not be treated as exclusive, one or the other; it is possible to treat them as complementary and use whichever one suits a given task best.