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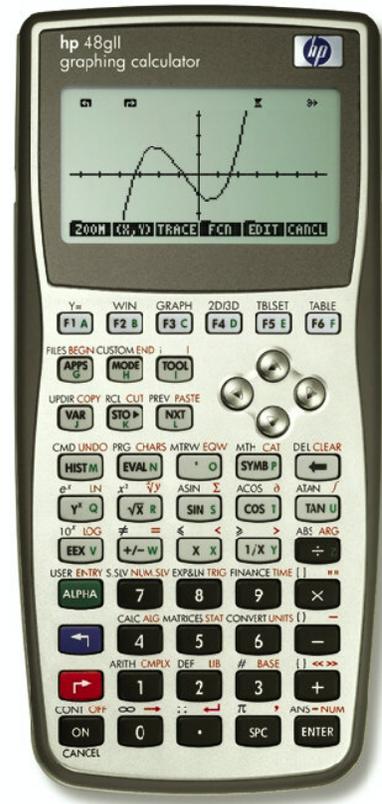
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Calculation Modes

You can type calculations on the HP48GII, 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)
-    This gives the 6+8
-  This moves past the right bracket
-   This multiplies by 5
-  This tells the calculator that the formula is finished so it can now get the answer

and you would see the answer like this:

```
DEG XYZ HEX R= 'N'      ALG
{HOME}                USR 03:26 JAN:30

:(6+8)5
                                70
EDIT VIEW RCL STOP PURGE CLEAR
```

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:

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

and you would see the answer like this:

```
DEG XYZ HEX R= 'N'      ALG
{HOME}                USR 03:26 JAN:30
5:
4:
3:
2:
1:                                70
EDIT VIEW RCL STOP PURGE CLEAR
```

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.

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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 **MODE** 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 HP48GII 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.

```
DEG NYZ HEX R= 'N'      ALG
{HOME}                USR 03:27 JAN:30

: (6+8)*5
                          70
EDIT VIEW ECHO KEEP DROP INFO
```

Figure 4

If you want to use an earlier answer in another calculation, you can also use **ANS** to access the **ANS** function which is above the **ENTER** key. By default, the HP48GII 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 **17.32** **×** **ANS**, then pressing **ENTER** as below.

```
DEG NYZ HEX R= 'N'      ALG
{HOME}                USR 03:29 JAN:30

: (6.00+8.00)5.00
                          70.00
: 17.32*ANS(1.00)
                          1,212.40
EDIT VIEW RCL STOP PURGE CLEAR
```

Figure 5

If you begin a new calculation by pressing **+** or **×** or **yx** or any other command that needs two numbers, the HP48GII 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 **×** **1.035** and you will see:

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```
DEG XYZ HEX R~ 'X'   ALG
[HOME]          USR 03:30 JAN:30
:(6.00+8.00)5.00    70.00
:17.32*ANS(1.00)   1,212.40
ANS(1)*1.035
[EDIT] [VIEW] [RCL] [STO] [PURGE] [CLEAR]
```

Figure 6

The HP48GII automatically put ANS(1) in front of the * when you pressed \square 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 \square it will become ANS(3).

As you see, the HP48GII 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 \square then \square then \square . Now type the RPN keys for the carpet area calculation.

\square	\square	This puts the 6 in the calculator, ENTER separates it from the next number
\square	\square	This gives the 8 and adds it
\square	\square	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 \square 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 \square or \square or \square 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 \square 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 \square 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 \square 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 \square to see the last 4 lines you typed, and select what you want with the arrow keys, then press \square .

The numbers on the stack are ready for you to use in further calculations. As with Algebraic mode, the HP48GII 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 \square and then selecting the STACK option.

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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 $(3.2 \cdot \text{SQ}(5))$. Whenever you type an expression with any possible ambiguity in it, the HP48GII 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.



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.



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 HP48GII.

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 HP48GII 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. 29 ENTER.

Then enter the height and divide so you can get the angle, 28 ENTER ÷. You get 1.04. That cannot be right, sines and cosines should be smaller than 1. Use right arrow UNDO to get the numbers back, then left arrow to swap them, as described in the tip above. Now press ÷ to divide them again, in the right order, and see 0.97.

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Actually, pressing $\frac{1}{x}$ 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 \leftarrow 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 \rightarrow UNDO again to undo the arc sine, but it is quicker to press SIN , then \leftarrow 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 $28 \text{ SPC } 38 \div$ then \leftarrow 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 HP48GII 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 $28 \text{ ENTER } 20 \text{ COS } \div$. 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 \leftarrow 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 \rightarrow 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 HP48GII 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 \cdot 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.