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Calculator Lesson 1

Introduction and Basic Operations

For many years, in Calculus I and in almost all higher level math courses students were required to have an HP-50g calculator. These calculator lessons and all of the demonstrations in class are based on that calculator, but they also work for the HP-48gII and the HP-49g+ which are virtually identical the 50g in operation. The differences are that the 48gII has less memory, the 50 has a slightly different display screen for graphics, and the colors of the shift keys are different on the three calculators.

The HP-50g can work in either of two operating modes, algebraic or RPN. We will do all of our work in RPN mode. RPN is much easier and more efficient than algebraic, but people who are accustomed to the algebraic system tend to have a bit of trouble with RPN when they first start to use it. With practice everyone can master RPN, and once they do, they never want to go back to algebraic.

The HP-50g has four arrow keys; up arrow, down arrow, right arrow and left arrow. These will be referred to as UA, DA, RA, and LA respectively. There are three shift keys; a yellow ALPHA shift, a white left shift, and an orange right shift. These will be referred to as AS, LS, and RS respectively. The keys in the top row of the calculator are the soft menu keys, F1, F2, ..., F6. They execute the command on the screen immediately above the key. These keys will be referred to by the soft key and its command; for example, F6-CLEAR. Some commands, especially in RPN mode, require that a shift key be held down while the command is pressed. In such cases the command will be given as LS(hold) UPDIR.

The calculator comes with a small instruction booklet called *User's Manual* and a CD that contains a much more comprehensive (but not complete) set of instructions called *User's Guide*. The *User's Guide* is also on the Web at the HP site. There is a link to it on the Department of Mathematics and Computer Science "Useful Links" page. The *User's Guide* has many errors and omissions that HP is slowly correcting. For this reason, the on line version of the *User's Guide* is more likely to be accurate. For this lesson, however, you will find most of what you need in the first three chapter of *User's Manual*.

Calculator Modes: When the calculator comes out of the box it is in algebraic mode and the menus are set to CHOOSE boxes. Our first task will be to change those to RPN mode and to soft MENU, and that is the way we will use them throughout all of our math courses at Thiel. Press the MODE key and a dialog box will open that shows "Operating Mode ..Algebraic. Press the +/- key and the mode will change to RPN. For most of our calculator usage we will want the Number Format set to Std, Angle Measure set to Radians, and Coord System set to Rectangular. If any of these are not so set, use the arrow keys to highlight the offending setting, press F2-CHOOS, use UA or DA as needed to select the required value, then press F6-OK. Finally, to prevent a chorus of beeps during class, and especially during tests, use the arrow keys to highlight "Beep" then press F2-CHK as needed to leave it unchecked.

Menu display: Now press F1-FLAGS and UA 7 times. Flag 117 should now be highlighted and show "CHOOSE boxes." Press F3-CHK and flag 117 changes to "Soft MENU." Now press F6-OK.

CAS modes: Now press F3-CAS to get into the CAS MODES dialog box. Indep var: should be 'X', Modulo should be 13, Numeric, Approx, Rigorous, and Simp Non-Rational should be checked, the rest should be unchecked. Use the arrow keys to highlight any that are set wrong and change them by pressing F3-CHK, then press F6-OK.

Display modes: Press F4-DISP to get into the DISPLAY MODES dialog box. Most of the options here can be set to your comfort level, but it is recommended that you check "Textbook." When the settings are to your satisfaction press F6-OK twice to get out of the MODES dialog box.

As we progress through this and higher level math courses, we will want to save things in our calculator, and to make them easier to find later, we will want to organize the data into folders the same as we do on our computers. In the language of HP, folders are called directories. Let's create a directory called CalcI and within it a directory called ChP. If your calculator is new you are probably in the home directory. You can tell this because the annunciator at the left end of the second row on the display is {HOME}. If there is more than just HOME in the braces, you can get back to the home directory by pressing LS(hold) UPDIR. From the HOME directory press LS FILES F6-OK NXT F3-NEW DA. The cursor is now waiting for you to type in a name. To type upper case letters type AS followed by the letter. For lower case letters, AS LS followed by the letter. It is also possible to lock the calculator in alpha mode by pressing AS AS. After entering all the letters, AS will release the alpha mode. To enter the name CalcI, type

AS AS C LS A LS L LS C I AS F6-OK

Finally, press F3-CHK to tell the calculator that we are creating a directory and F6-OK. Now press CANCEL (the ON button) and VAR. You now see the directory (folder) CalcI over the F1 soft key, the directory CASDI over the F2 soft key, and the rest of the soft keys are blank. To enter your folder press F1-CalcI. You now see that the annunciator has changed to {HOME CalcI}. From the CalcI directory repeat the above steps to create a directory ChP and get into it.

Now suppose that we are going on a shopping spree in a community where we will have to pay 4.5% tax on most of the items we buy. We want to keep track of our spending on the calculator, but we don't want to have to key in .045 each time we must compute a tax. We decide to store the value .045 in memory so all we have to do is recall it each time we need it. To save such a value we must put the number on level two of the stack, the name we want it to have on level 1, then press STO. Key in

.045 ENTER ' AS AS T A X ENTER STO.

NOTE: The ENTER commands unlocks the alpha mode. We now see the variable TAX over the F1 soft key. To access it, just press F1-TAX. Now suppose you are going to

continue your shopping in a community where the tax is only 4.25%, so you want to change the value in TAX. To change value of an existing variable, you put the new value on level 1 of the stack then press LS and the soft key for the variable. In this case, key in

.0425 LS F1-TAX

If you want to delete this variable put its name on the stack by pressing ' F1-TAX, ENTER. Now press TOOL, then F5-PURGE, but don't delete this one yet as we want to use it in an example below. To delete several variables put all the names in a list (in HP language a list is any group of objects enclosed in braces) and press TOOL, then F5-PURGE. To create a list of variables for deletion, press LS {} to open the list, then press the soft menu key for each of the variables you want to delete. When the list is complete, press ENTER TOOL F5-PURGE.

The basic idea behind RPN is that when you push an operation key, it immediately performs the operation on the value(s) on the stack. For example, press 5. A 5 shows at the left bottom of the screen in what is called the command line. Now press ENTER and the 5 is placed on level 1 of the stack. Press 7 and a 7 appears in the command line. Press ENTER and the 5 is moved up to level 2 of the stack and the 7 is now on level 1. Press + and the sum 12 now shows on level 1 of the stack. Actually, the second ENTER was not necessary. If there is a value in the command line when an operation key is pressed, the calculator automatically executes an ENTER before performing the operation. Press

5 ENTER 7 +

and you will see 12 on level 1 of the stack. To clear data from the stack press LA CLEAR. Now let us try a few more examples.

You are on your shopping spree in the second community and are considering an item that costs $72.00. You want to know the tax and total price. Key in the following and watch the stack:

72 ENTER ENTER F1-TAX × +

The second ENTER put another copy of 72 on the stack. Just before you press + you see the price on level 2 and the tax, 3.06, on level 1. After the +, the total, 75.06 is on level 1.

Now consider $\frac{7+5}{24-2^3}$. Press the following keys and watch the stack carefully to see what happens:

7 ENTER 5 + 24 ENTER 2 ENTER 3 Y^X - ÷.

The answer .75 should now be showing on level one of the stack. Notice that no parentheses were necessary. They do not show in the expression, but they would be necessary in a typical algebraic machine.

This is a good time to consider another choice of mode that is available on the calculator, **exact mode** versus **approximate mode**. Press MODE and F3-CAS. Now

uncheck _Numeric and _Approx then F6-OK twice to get back to normal operation. Now repeat the computation above. This time the solution will show as $\frac{3}{4}$. To convert this answer to decimal form press RS $\rightarrow$ NUM. Go back to the CAS dialog box and recheck _Numeric and _Approx.

Now consider $\dfrac{1+3\cos(\pi/4)}{1-\dfrac{1}{7}\sqrt{10-8}}$. Key in the following sequence and watch the stack:

1 ENTER 3 ENTER LS π 4 $\div$ COS $\times$ +
1 ENTER 7 1/X 10 ENTER 8 - $\sqrt{x}$ $\times$ - $\div$.

You should see the answer 3.91157854832. You may find it interesting to repeat the above calculation in exact mode, but be sure to set the calculator back to approximate mode afterwards so that the examples that follow will work as presented.

Because all calculators and computers are finite machines, it is inevitable that they will have limitations on magnitude and precision. The magnitude limits of a calculator are the smallest and largest positive numbers it can handle. The magnitude range of the HP-50g is from 1×10^{-499} to $9.99999999999\times10^{499}$. With that large range in magnitude, we seldom encounter overflow (a number bigger than the biggest number) or underflow (a positive number smaller that the smallest positive number) problems, but they are possible.

The precision of a calculator is the number of significant figures with which it can deal. The precision of the HP-50g is 12 digits. One problem with finite precision that is common to all calculators and computer can be seen by the sequence:

3 1/X 3 $\times$.

The answer, of course, should be 1, but the calculator shows .999999999999. This is called roundoff error. Some calculators give the illusion that they have conquered this problem by having one or two digits of precision that are hidden from the user and the display rounds to the number of digits that are actually in the display. You can create the same illusion on the HP-50g by pressing the MODE key and setting the Number Format to Fix 11. A more subtle, and hence more problematic issue, with roundoff error is seen in the following example.. The two solutions to 12 significant figures in scientific notation to the polynomial equation

$$\pi x^2 - x + 0.000001 = 0$$

are

$$x_1 = \frac{1+\sqrt{1^2 - 4\pi(.000001)}}{2\pi} = 3.18308886181\times 10^{-1}$$

and

$$x_2 = \frac{1-\sqrt{1^2 - 4\pi(.000001)}}{2\pi} = 1.00000314161\times 10^{-6}.$$

If you compute each of these on the calculator you will get the correct answer for x_1, but for the other root you get $x_2 = 1.00000313421\times 10^{-6}$. The last four digits are off. If, however, we rationalize the numerator in the expression for x_2 and write it as

$$x_2 = \frac{2\times(.000001)}{1+\sqrt{1^2 - 4\pi(.000001)}}$$

and evaluate it that way on the calculator we get the correct answer to 12 significant figures. The reason things go wrong the first way is that in the numerator we are subtracting nearly equal values. A more obvious example is 1234 - 1233 = 1. This is the difference of two numbers with four digits of precision but the answer has only 1. Subtracting nearly equal real numbers on any finite machine is going to result in a loss of precision.

RPN logic is a bit confusing at first, especially for people who are accustomed to the algebraic logic found on most scientific and graphing calculators, but anyone who makes an honest effort can master it. The key to success is plenty of practice. As you progress through higher level math courses you will find the power of RPN logic more and more advantageous over algebraic, and you will want to use it. The time to master RPN is now, on the easy problems, not a year from now when it becomes almost essential for the more complex problems you will be tackling. It is strongly recommended that you put your calculator in RPN mode, make up examples like those above, and practice, practice, practice.

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