

» [Assigning Menu Functions on the HP 30b Keyboard](#)

Gene Wright

Read and see how to program the HP 30b to bring deep menu functions to the keyboard.



Your articles



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As HP Solve grows, the current structure will adapt as well. Learn more about the current changes, goals and feedback from the latest Solve newsletter.



» [Calculator Restorations](#)

Geoff Quickfall

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» [Today's HP-41 User](#)

Peter Platzer

After reading about the 30th anniversary of the HP-41 in HP Solve: Issue 16, Mr. Platzer shares his personal experience with this classic Gen3 HP calculator.



» [E Ink, Haptic Touch and MEMS](#)

Jake Schwartz

The HP-35A helped spark wish lists and dreams among users for future calculator ideas. In this issue, Jake examines three emerging technology ideas as they address historical calculator issues.



» [HP Solve Math Problem Challenge #2](#)

Learn the solution to the first math problem challenge from



» [Fundamentals of Applied Math Series #2](#)

Richard J. Nelson

This new series looks to

Issue 19 June 2010

Welcome to the nineteenth edition of the HP Solve newsletter. Learn calculation concepts, get advice to help you succeed in the office or the classroom, and be the first to find out about new HP calculating solutions and special offers.

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HP in the Classroom



» [HP - Interactive learning for the 21st Century Classroom](#)

Learn how HP designed the affordable, easy-to-use 39gs Graphing Calculator to enable math teachers to spend more time teaching and less time showing students how to use their calculators.

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HP Solve Newsletter

the last newsletter. In addition, here's another opportunity to showcase your ability to solve a new challenge.

explore and explain the math that we use with our calculators in terms of real world application and use. Part two (of a three part series) continues exploring 'Numbers'.

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Assigning Menu Functions on the HP 30b Keyboard

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Assigning Menu Functions on the HP 30b Keyboard

Gene Wright





Ed. Note. The HP30b is extremely fast and while its memory seems limited its speed makes up for it in many ways. Gene recently demonstrated its speed at HHC 2009 with a prime factoring bench mark program⁽⁰⁾. Having the many added scientific math functions on a finance machine is made even more convenient by “assigning” these functions to the key of your choice. Gene provides the step-by-step instructions for doing this.









The HP 30b Business Professional calculator includes a programming capability designed to help automate repetitive calculations and extend the usefulness of the built-in function set of the calculator. The capability includes the creation of up to 10 separate programs using up to 290 bytes of memory among them.

Programs record keystrokes, with each keystroke using one byte of memory, although some commands use more than one byte. In addition, many program-only functions are provided for conditional tests, “gotos”, looping, displaying intermediate results and even calling other programs as subroutines.

This article will show how to bring functions out of menus and assign them onto the keyboard.

As shown in the picture at right, the HP 30b has additional functions assigned to the keys that are program-only functions. Other than the Black-Scholes function (shown as “Black S”), which is not a program function but a financial function, these functions are not printed or labeled on the actual HP 30b itself. However, an overlay is provided that lays over the top rows of keys that help indicate how these functions are mapped to the keys.

Each of these functions is inserted into a program by pressing the shift key and holding it down while pressing the key under which the program function is displayed. For example, to insert a LBL (label) command, press  and, while holding it down, press . In these learning modules describing programming, this will be shown as  + . Pressing that key combination will insert a LBL instruction into a program in program edit mode. Pressing that key combination in calculation mode will do nothing.

There are 10 numbered slots available for programs, numbered from 0 to 9. These are displayed in the program catalog which is viewed by pressing  . In the image above, the program catalog is displayed, showing Prgm 0 or program 0. Pressing the  or  keys will scroll through the list of 10 programs. Pressing  will enter the selected program, allowing you to view the program steps stored in that program slot or to change the program steps. To exit this program editing mode and return to the program catalog, press  . To exit the program catalog and return to calculation mode, press .

At different places within a program, you can insert a Label (LBL) command. A label defines a location

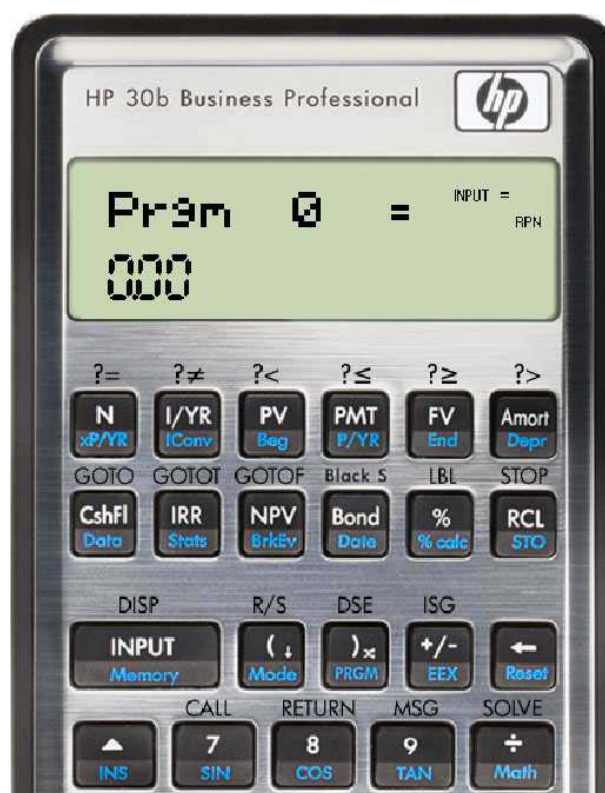
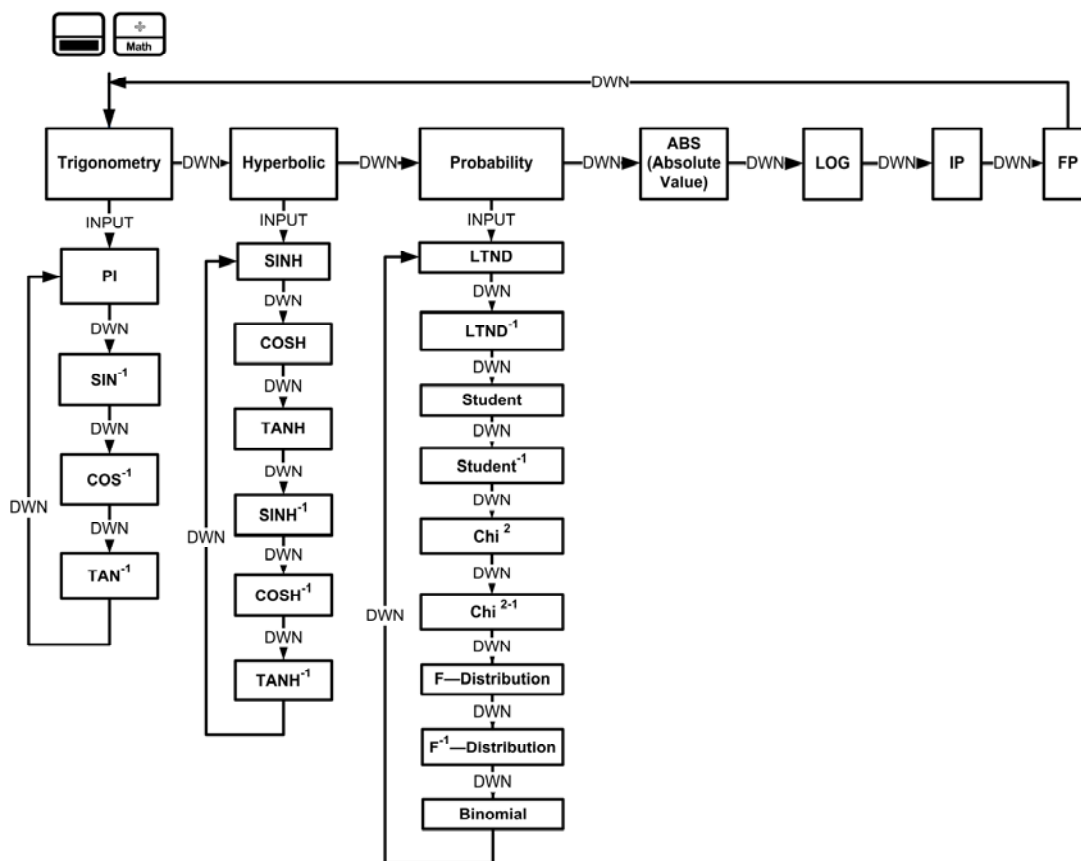









Fig. 1 - HP-30b shown with programming overlay.

to which program control may be transferred. The HP 30b can handle up to 100 labels within the entire program memory. These labels are a two-digit numeric value from 00 to 99. No label can be used more than once, which makes each label a “global” label and defined only once within the global program memory space. If you attempt to enter a label that has already been used, a message saying “Exists!” will be briefly displayed.

When a program is displayed, a number will be shown below it indicating how many bytes are used. If the program name is shown in reverse video, then the program has been assigned to a key and can be executed by pressing the appropriate key combination, even when in calculation mode, as shown in the image at right. This article will give three examples of making such assignments.

Example 1: The HP 30b has the three basic trigonometry functions, sine, cosine, and tangent on the keyboard. The inverse trigonometry functions are in the Math menu, however, as shown below. If you need to use the inverse trigonometry functions often, you can assign these functions to the “shift hold” positions of the three trigonometry functions that are on the keyboard. You can visualize this by looking at the HP 30b keyboard. Every key except the shift key itself has two functions: the function printed on the top of the key and the blue function written on the front slope of the key. Each of these two locations can be “assigned” as the starting key for a program. In addition, you can define assignments of programs to the shift and hold key position as well. In this example, we will assign the inverse sine function to the shift-hold $\boxed{7}$ key, the inverse cosine function to the shift-hold $\boxed{8}$ key and the inverse tangent to the shift-hold $\boxed{9}$ key. To access these functions, you would press $\boxed{\text{Math}}$ and while holding it down, press the corresponding number key.



To automate this type of function found in a menu, make a list of the exact keys pressed to access the function manually. These key presses will be entered in the program. To perform an inverse sine, you would press     . The final  (a final  works just as well) is necessary to have the HP 30b execute the function instead of just previewing the potential answer.

To enter this series of key presses into a program, you would press the following keys.

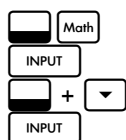


Enters program mode and displays the last program previously viewed in the program catalog. Then press:

```
Prgm 1 =
000
```




Enters program edit mode and displays the first line of the program, which will be blank as shown at right since this is a new program. Then press the keys needed to access the function in the menu.














These key presses will access the inverse sine function in the Math menu. The next step would be step 5.



This key press enters a STOP command. This command ends program execution and returns control to the user. Press  to scroll through the steps of the program, which should look like those shown below.

Math	=	1	Input	=	2
Down	=	3	Input	=	4
Stop	=	5			

To exit program edit mode, press  . This returns the HP 30b to the program catalog and now displays Prgm 1. The number of bytes used by Prgm 1 is shown below it in the display. The automation program uses 6 bytes of memory and has a checksum of 047.

To assign this program to the  +  key position, enter the program catalog by pressing  . Press  to view step 0 of this program where the key assignment will be entered. To assign this program to the  +  key position, press  + . The display should appear as shown below. SH7 stands for “shift-hold 7” which is the shift-hold sine function position.

Press to exit the program edit mode and return to calculation mode. Assuming the calculator is in the degrees angle mode, calculate the sine of a 25 degree angle by pressing . The display should appear as shown below.

To find the angle again by executing the inverse sine function, press + . The display should appear as shown below.

Note that in this example, an assignment was made to a key position that already had a shift-hold function assigned to it by the HP 30b itself: the CALL programming environment function. In the calculation environment, the inverse sine program assignment will be executed. If you press this shift-hold key position while editing a program, the CALL function will be entered into the program, since that assignment is active in program mode.

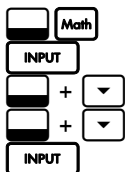
Example 2: To assign the inverse cosine function to the shift-hold 8 key position, make a list of the exact keys pressed to access the function manually. To perform an inverse cosine, you would press . The final (a final works just as well) is necessary to have the HP 30b execute the function instead of just previewing the potential answer. This is the same as the inverse sine program listing except for one additional key press.



Enters program mode and displays the last program previously viewed in the program catalog. Place the inverse cosine program into Prgm 2. You may need to press a few times to move the program catalog location until Prgm 2 is displayed. Then press:



Enters program edit mode and displays the first line of the program, which will be blank as shown at right since this is a new program. Then press the keys needed to access the function in the menu.



These key presses will access the inverse cosine function in the Math Menu.



This key press enters a STOP command. This command ends program execution and returns control to the user.

To exit program edit mode, press . This returns the HP 30b to the program catalog and now displays Prgm 2. The number of bytes used by Prgm 2 is shown below it in the display. The program

uses 7 bytes of memory and has a checksum of 219.

To assign this program to the $\boxed{\text{2nd}} + \boxed{8}$ key position, enter the program catalog by pressing $\boxed{\text{2nd}} \boxed{\text{PRGM}}$. Press $\boxed{\text{2nd}} \boxed{\text{F1}}$ to view step 0 of this program where the key assignment will be entered. To assign this program to the $\boxed{\text{2nd}} + \boxed{8}$ key position, press $\boxed{\text{2nd}} + \boxed{8}$. The display should show SH8, where SH8 stands for “shift-hold 8” which is the shift-hold cosine function position.

This inverse cosine assignment program will now work the same way the inverse sine program does.

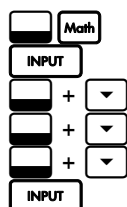
Example 3: To assign the inverse tangent function to the shift-hold 9 key position, make a list of the exact keys pressed to access the function manually. To perform an inverse tangent, you would press $\boxed{\text{2nd}} \boxed{\text{Math}} \boxed{\text{INPUT}} \boxed{\text{2nd}} \boxed{\text{F1}} \boxed{\text{2nd}} \boxed{\text{F1}} \boxed{\text{INPUT}}$. The final $\boxed{\text{INPUT}}$ (a final $\boxed{=}$ works just as well) is necessary to have the HP 30b execute the function instead of just previewing the potential answer. This is the same as the inverse cosine program listing except for one additional $\boxed{\text{2nd}} \boxed{\text{F1}}$ key press (and two more than the original inverse sine program).



Enters program mode and displays the last program previously viewed in the program catalog. Place the inverse tangent program into Prgm 3. You may need to press $\boxed{\text{2nd}} \boxed{\text{F1}}$ a few times to move the program catalog location until Prgm 3 is displayed. Then press:



Enters program edit mode and displays the first line of the program, which will be blank as shown at right since this is a new program. Then press the keys needed to access the function in the menu.



These key presses will access the inverse tangent function in the Math Menu.



This key press enters a STOP command. This command ends program execution and returns control to the user.

To exit program edit mode, press $\boxed{\text{2nd}} \boxed{\text{PRGM}}$. This returns the HP 30b to the program catalog and now displays Prgm 3. The number of bytes used by Prgm 3 is shown below it in the display. The program uses 8 bytes of memory and has a checksum of 159.

To assign this program to the $\boxed{\text{2nd}} + \boxed{9}$ key position, enter the program catalog by pressing $\boxed{\text{2nd}} \boxed{\text{PRGM}}$. Press $\boxed{\text{2nd}} \boxed{\text{F1}}$ to view step 0 of this program where the key assignment will be entered. To assign this program to the $\boxed{\text{2nd}} + \boxed{9}$ key position, press $\boxed{\text{2nd}} + \boxed{9}$. The display should show SH9, where SH9 stands for “shift-hold 9” which is the shift-hold tangent function position.

This inverse tangent assignment program will now work the same way the inverse sine program does.

Example 4: Change the inverse sine program so that step 1 contains the MSG “INV SIN” so that the program will show those characters as a title in the program catalog listing. Remember that to move the character position to a numeric digit as a letter in a message, press the corresponding numeric key. To move to an =, press $\boxed{=}$. Pressing $\boxed{\text{2nd}} \boxed{\text{F1}}$ moves to the ? character. Pressing $\boxed{\text{2nd}} \boxed{\text{F1}}$ moves the character

position to a space. The arithmetic operators move the character position to the corresponding operator character. Press **INPUT** to select the displayed character and prepare to enter another character. Press **ONCE** to select the displayed character and terminate character entry. A maximum of 8 characters may be entered as a message.

To modify the program, do the following.



Enters program mode and displays the last program previously viewed in the program catalog. Press until Prgm 1 is shown in the display. It is shown in “reverse video” to indicate that it is assigned to a key. Then press:



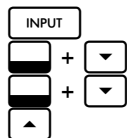
Enters program edit mode and the first line of Prgm 1, the command to enter the Math menu. Then press:



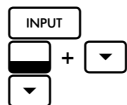
Inserts the MSG command at the presently displayed position. Begins by showing an “A” in the display. Press the following keys to enter the message “INV SIN”:



Moves character position to display an “I”



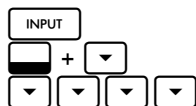
Enters the “I” character and presents a lowercase “a” after pressing the **INPUT** key. Moves character position to show “N”



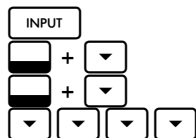
Enters the “N” character. Moves character position to show “V”



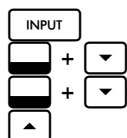
Enters the “V” character. Moves character position to a space, which is present but not visible in the image at right.



Enters the space character into the string. Moves character position to “S”



Enters the “S” character into the string. Moves character position to “I”



Enters the “I” character into the string. Moves character position to “N”

Press **ONCE** to terminate entering the message. The display will shift to show line 2 of the program. Now view the program once again in the program catalog by pressing **PRGM** **PRGM**.



Although this takes some key presses to input, some users will find this ability to give a title to a program very useful, as the function of the program will be much more evident from “INV SIN” being displayed in the program catalog than the generic “Prgm 1”. The title is displayed in “reverse video” because this program is assigned to a key from example 2. Note that inserting the MSG to give this program a title used an additional 9 bytes of memory (15 – 6 for the original program). Remember that if you make a mistake while entering a MSG, you can press **←** at any time before you press **ONCE** and the character at the end of the message will be deleted. Note that the MSG command is perhaps most useful to enter a string of characters in a program to display a prompt to the user before the program stops for input. This prompting message can help the user know what values to enter before resuming program execution. The use of the MSG command here to give a title to a program in the program catalog is simply another use of this function.

(0) *The HP30b is not only fast, it is faster than most other HP calculators. An HP Museum posting is dedicated to comparative hand held speeds using what is called the N-Queens Problem. This involves processing an 8x8 matrix. Gene says that the HP30b runs the test program in 11 seconds. Here are the reports on the HP Museum for other HP calculators: HP-11C in 3,830 seconds. HP38G in 859 seconds. HP42S in 732 seconds. HP48GX in 217 seconds. HP50g in 90 seconds.*

These numbers must be taken with reservation. A calculator's speed will depend on two basic factors – hardware vs. software. For example, the HP30b searches from the top of memory down to the bottom. If you have a full program memory and your speed program is last it will appear to run slower than if it was first.

There are many tests provided for the same machine with each user trying to hold the speed record so speed altering hardware (some under software control e.g. HP50g,) modifications must also be considered. Shorter programs generally run faster than long programs, but not always. When calculator speeds are discussed the devil is in the details. See the long multi model speed claims list at:

<http://www.hpmuseum.org/cgi-sys/cgiwrap/hpmuseum/articles.cgi?read=700>

About the Author



Gene Wright is the author of textbook "Quantitative Analysis for Business", a business math textbook using the HP-10BII and HP-12C, available from Amazon.com. He is also a video lecturer for a CFA exam review course. A former teacher at Lipscomb University in Nashville, Tennessee, he now works for a consumer electronics company. Gene has written many articles on HP calculators and serves on the annual HHC committee.

Regular Columns - From The Editor

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Regular Columns

From The Editor – Issue 19

As *HP Solve* grows the normal seven article structure will be divided into multiple topics under a single grouping. This will allow more articles on more topics. This is the nature of the software we use. The first change is combining the shorter regular columns RPN Tips, and One Minute Marvels into a **Regular Columns**, more generic topic. Two other columns will also be part of this slot. They are *Community News* (content obvious) , and *Did You Know?* (a general collection of assorted tid bits) All readers are asked to contribute to *HP Solve* by alerting me to any new activity happening in the HP User Community, HPUC.

The time for reader feedback from issue 18 has been short as we get back into the even month publishing schedule. I really want to hear from you, and I have responded to those of you who have already sent me emails. One of them was from Peter Platzer. Peter is an active HP calculator user and our email exchanges has resulted in an article on today's use of the HP-41, as a result of the HP-41 article in *HP Solve* issue 16.

New HP calculator users, especially students, will find the mentioning of older HP models curious. You will understand as you log a few hundred hours of HP calculator usage, and you master your machine. The machine tends to grow on you. As you learn about the depth of design that HP has put into so many of its models you will come to depend on your machine. Before you know it, years have passed and you too will want to know the latest on your “older” model.

You may have also noticed the change on the Issue list on the *HP Solve* website. The term Volume is changed to Issue and all references to an *HP Solve* Volume will be the same number as the Issue number. We have also assembled the newsletter into a single pdf file so you may down load the issue to your computer. This feature will become more important as the information content increases. As I mentioned in the last issue I want *HP Solve* to be a technical resource as well as an educational reading newsletter.

Here are the articles in this issue.

HP30b Key Assignments

Gene Wright describes a step-by-step procedure to place any (deep menu) function on the key of your choice. This makes the machine easier and more convenient to use. The article also provides a speed comparison with several other HP calculators and it looks like it is about the fastest machine to date. See the last page of Gene's article. The HP30b may be purchased at Office Depot beginning in mid-August.

Regular Columns

This collection of repeating columns is new. Here is the Issue 19 list.

- ♦ **From the editor.** This column provides feedback and commentary from the editor. A letter from down under mentions HPUC activity in Australia.
- ♦ **RPN Tip 19.** One of the major changes HP has made in computational excellence is expanding RPN into RPL and this is the topic of RPN Tip #19. The Enter key collection has them identified. A photo of a rare HP-35A photo is included.

- ♦ **One Minute Marvels.** This OMM on stopwatch units was promised in Issue 18.
- ♦ **Community News.** The three primary HPUC websites are listed and the HHC conference update is provided.
- ♦ **Did You Know?** HP50g software sources are listed.



Calculator Restorations

Geoff Quickfall from Canada is writing a book on restoring HP calculators. He provides a preview in his restorations article. The HP Classic and Pioneer series are described with 35 photographs. If you have one of the 17 models of these two series you will want to check out some of Geoff's tips.

Today's HP 41 User

Issue 16 described one of the most spectacular calculator systems ever made, the HP-41. Peter Platzer read the article and wrote to tell about a typical HP-41 user today. What is interesting is that these users want the more advanced functions found on an RPL machine, yet they want the RPN user interface of the HP-41. There are many resources provided in the article.

E Ink, Haptic Touch and MEMS

Jake Schwartz examines three new technologies that hold promise for calculators. Of course HP can't discuss what future technologies they are or are not evaluating.

Cutting A Circle In Three Equal Pieces - Solution

Marty had a diet problem described in our last issue that required cutting a circle in three equal pieces. **HP Solve** readers submitted their solutions and Wolf-Dieter Schöne from Germany had the winning submission. See his solution and the **HP Solve** solution. Math challenge #2 is included. The winner just may have the option of a special prize. Is this a simple geometry problem related to silicon molecule model building?

Numbers - Part II

This is the second in our practical Math Review series. Numbers is a broad enough topic that it will take three installments before we can get into some more exotic computational topics.

That is it for this issue. I hope you enjoy it. If not, tell me!

$X < > Y$,

Richard
hpsolve@hp.com

RPN TIPS

RPN Tip #19 – RPN vs. RPL

In *HP Solve* issue 18 the ENTER key was discussed and the article closed asking the following questions.

Q. “BTW, why was the first production ENTER key blue, and why was it changed to blue when the prototype was shown to Bill Hewlett? What color was the first HP-35A ENTER key prototype shown to Bill Hewlett?”

A. The HP-35A design team used yellow for the ENTER key (and white for the case). When they showed a prototype to Bill Hewlett he reminded them that the HP corporate color was blue. It was immediately changed to blue. All but one member of the design team changed his machine to use the blue keys. That machine was donated back to HP at the IEEE HP-35A presentation at HP Labs in May of last year. See *HP Solve* issue 13 and RPN Tip #14 in issue 14 for more details of this event. The HP35A was photographed at that time and is shown below. This is a rare machine indeed.



Fig. 1 – A rare prototype of the HP-35A that used different colors.

The second question that was asked in RPN Tip # 18 is answered below.

Q. "Now that you are thinking about the ENTER key here is a challenge for the serious HP calculator fan suggested by Jake Schwartz. What models used these enter keys? Send the editor your 'guesses.'"

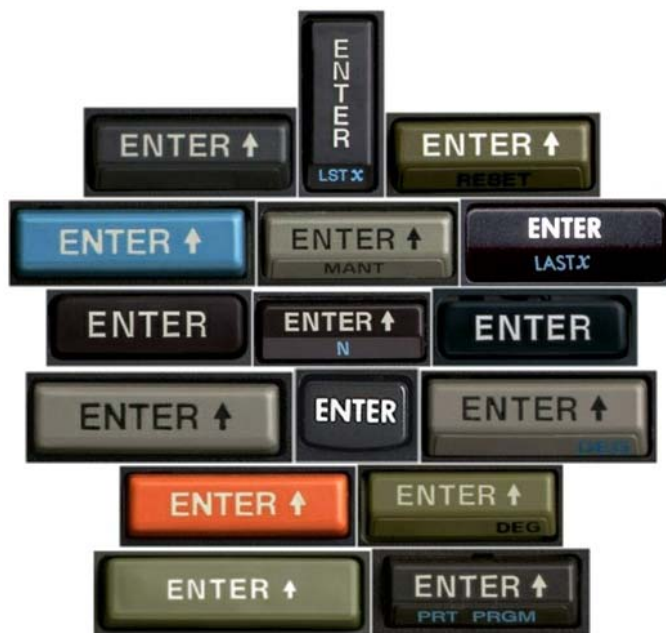


Fig. 2 – Enter key variations used by HP calculators.

A. The ENTER keys are identified in figure three below.

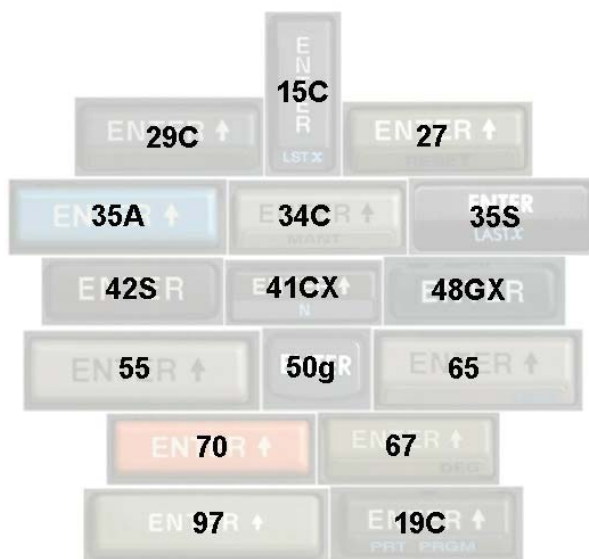


Fig. 3 – Enter key models identified – thanks to Jake Schwartz.

RPN Tip #19 – RPN vs. RPL

The first HP machine to challenge the logic system superiority of RPN was the HP28C announced June 1,

1986 with its introduction of RPL. A Wikipedia article on RPL states: “According to a quote by Dr. William Wickes, one of the original RPL developers, ‘the development team never calls it anything but (the initials) RPL.’” See note 1. It is not the intent of this RPN Tip to describe and explain RPL but rather to contrast RPL with RPN. The important idea the reader should come away with is that RPL and RPN are very similar and yet different.

These two logic systems are similar in that RPL may be thought of as a more “pure” RPN. RPN Tip 4 explained the basic calculator operating systems noting that RPN uses postfix logic. The basis for postscript, and RPN, is that the operator always follows the data.

The most important user concept to remember is that no calculator is “pure” anything. Every HP calculator model is a unique compromise of functions, features, applications, and its operating (logic) system.

The obvious example that makes RPL more of a pure RPN is the store and recall register instructions. With legacy RPN these instructions operate when the key is pressed and then the user must provide the register number. In an RPL system the register number (an object) must be on the stack (data first) when the store key is pressed. This will seem quite confusing (and unnatural?) for an experienced RPN user.

A key feature of RPL as a language is that it is structured. RPN programming “languages” are not. This means that RPN has a GOTO instruction which allows what is often called spaghetti code programming. RPL requires a single entry and exit point for each code sequence so uncontrolled jumping around is not permitted. RPN uses simple assembly type of instructions and RPL uses higher-level language type of instructions.

RPL operates quite differently than RPN internally, and that is what gives the RPL machines their incredibly efficient computational power. Because RPL and RPN operate in a postfix mode and RPL was required for the next generation⁽²⁾ of HP calculators, RPN, as implemented on RPL machines will behave a little differently. The RPL “system” is also used on machines that are not obviously RPL because it is easier for HP to use a common core for their machines. This means that the legacy RPN user will find a few “oddities” in the way their latest HP calculator works in RPN mode.

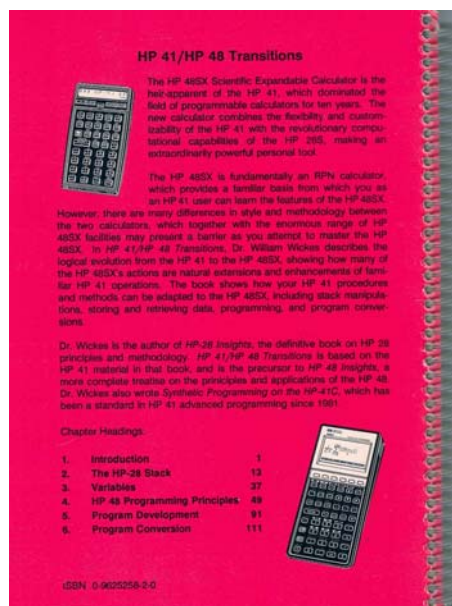
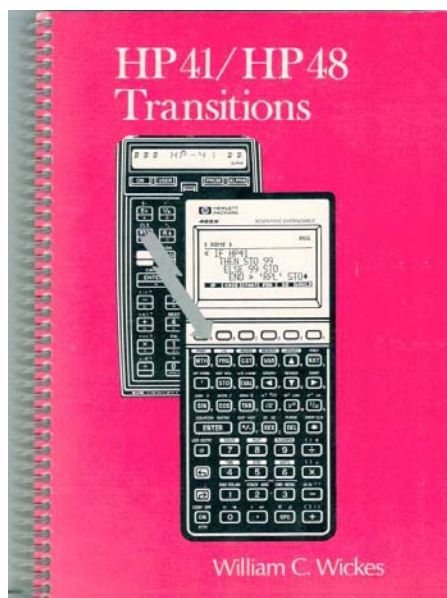


Fig. 4 - Bill Wickes Transitions book is out of print, but copies may some times be found on the Internet.

This similar yet different aspect of RPL is confusing and challenging for legacy RPN users. Bill Wickes recognized this while developing RPL and by the time the 48 machines arrived he decided that a book was needed to explain the differences in RPN terms and HP gave him permission to market the book⁽³⁾. See figure four above.

A comparison of RPN and RPL stack operations is made in two tables in the book. See figures five and six below. Another contrast RPN makes with RPL is that all HP RPN calculators use a four high stack and all HP RPL calculators use a memory limited, open-ended stack. Placing a thousand objects on the stack is common practice for RPL users.

HP 41 Command	Purpose	Nearest HP 48 Equivalent
CLX	Remove last entry Enter a 0	DROP 0
CLST	Clear the stack Enter four 0's	CLEAR 0 DUP DUP2
X<>Y	Exchange X and Y	SWAP
R↑	Roll up four levels Roll up the entire stack	4 ROLL DEPTH ROLL
RDN	Roll four levels down Roll down the entire stack	4 ROLLD DEPTH ROLLD
ENTER↑	Terminate digit entry Duplicate X into Y	[ENTER] or any delimiter or separator character DUP
LASTX	Recover last argument Correct an error	LASTARG [←] [LAST STACK]
RCL X	Copy X	DUP
RCL Y	Copy Y	OVER
RCL Z	Copy Z	3 PICK
RCL T	Copy T	4 PICK

Fig. 5 – RPN & RPL Stack operations.

	Operation	Action
Stack Clearing	DROP	Discard the level 1 object
	DROP2	Discard the objects in levels 1 and 2
	DROPN	Discard the first <i>n</i> objects
	CLEAR	Discard all stack objects
Reordering Arguments	SWAP	Exchange the objects in levels 1 and 2
	ROT	Rotate the level 3 object to level 1
	ROLL	Rotate the level <i>n</i> object to level 1
	ROLLD	Rotate the level 1 object to level <i>n</i>
Copying Objects	DUP	Copy the level 1 object
	OVER	Copy the level 2 object
	PICK	Copy the level <i>n</i> object
	DUPN	Copy the first <i>n</i> objects
Counting Objects	DEPTH	Count the number of objects on the stack
Object Recovery	LASTARG	Return the arguments used by the last command
	LAST STK	Restore the stack to its state before ENTER

Fig. 6 – RPL open ended stack and more powerful stack operations.

From a programming perspective there is a big contrast between the programs are viewed. RPN programs are line oriented. Each instruction has a program line number. This structure dictates that programs instructions are numbered and they are listed in order like a list. RPL programs are simply a series of instructions and numbering them has no meaning. What has meaning is grouping them as objects (programs). This is a major learning curve challenge for the RPN programmer who wants to become an RPL programmer. RPL is different and more powerful. Making the change is a personal choice and what you want to accomplish with your programming.

RPN Tips #19 Notes:

- (1) Common community knowledge knows RPL as Reversed Polish LISP. LISP is an acronym for List Processing Language. LISP as an acronym may have many different meanings. e.g. Language for Internet Scripting and Programming, Local Internet Service Provider, etc. The memorable meaning that is relevant to HP calculator users is "Lots of Insidious and Silly Parentheses." See the Wikipedia article at:
http://en.wikipedia.org/wiki/RPL_%28programming_language%29
- (2) HP calculator generations as used here are defined as: Gen1 – HP65/67, Gen2 – HP-41, Gen3 – HP-71/75, and Gen4 – HP28/48/49/50. Gen4 introduced the RPL era of HP calculators.
- (3) "41 / 48 Transitions" is 6-1/4" x 8-1/4", plastic spiral bound, , 9 oz. (255 gr.), and 149 pages. Published by Larken Publications of Corvallis OR "41 / 48 Transitions" is no longer in print and the Publisher is "gone."

One Minute Marvels

HP 48 One Minute Marvel – No. 6, Electronic Stopwatch Time Units

One Minute Marvels are short, efficient, unusual, and fun HP 48 programs that may be entered into your machine in a minute or less. These programs were developed on the HP 48, but they will usually run on the HP 49 and HP 50 as well. Note the HP48 byte count is for the program only.

In Issue 18 an electronics stop watch One Minute Marvel, OMM, was given to turn your calculator into an electronic stopwatch. The time displayed by this program was in seconds. Because you do not need your machine to be on while timing the OMM stopwatch may be used for longer periods and it may be easily enhanced to automatically convert times greater than 60 seconds to minutes or hours.

This OMM may be called in place of the two underlined commands in the Electronic Stopwatch program to add minutes and hours tagging. Alternately you may key the commands in their place to make one program.

The program is reproduced below for reference.

```
'SW' << 1 FIX TICKS IF 5 FS?C THEN 't' RCL - B→R 8192 / "Sec" →TAG ELSE  
      't' STO 5 SF END >>
```

21 Commands, 100.0 Bytes, # 69F7h.

```
'SWUa' << IF DUP 60 < THEN "Sec" ELSE 60 / IF DUP 60 < THEN "Min" ELSE  
      60 / "Hr" END END →TAG >>
```

22 commands, 122.5 Bytes, # 2DADh.

How the program works

SWUa starts with the time in seconds on level one. An IF THEN ELSE structure is used as indicated by the IF. A copy of the seconds is made with DUP and 60 is placed on level one. A comparison is made and if the seconds value is less than 60 seconds the THEN clause is executed by THEN. The text string "Sec" is placed on the stack. If the seconds value is 60 or higher the ELSE clause is executed. The comparison with 60 consumes one of the seconds values made with the DUP. The ELSE clause places 60 on the stack and the seconds is divided (to convert to minutes) by the /.

As second IF clause is executed and a copy of the minutes value is made with the DUP. 60 is placed on the stack and a less than comparison is again made. If the minutes value is less than 60 the THEN clause is executed and the text string "Min" is put on the stack. If the IF clause comparison (<) is 60 or greater the ELSE clause is executed and 60 is placed on the stack. As with the first comparison one of the minutes values was consumed. Next 60 is placed on the stack and the minutes value is divided and the stack has the seconds value in hours on the stack. Since two IF THEN ELSE structures were executed there must be two END's. Depending on the value on the stack – "Sec", "Min", or "Hr" it is tagged with the →TAG command and the program stops.

Brian Walsh of Chicago Illinois suggests that 'SWUa' can be rewritten to save 15 bytes by using the IFTE function as:

```
'SWUb' << DUP 60 < "Sec" { 60 / DUP 60 < "Min" { 60 / "Hr" } IFTE } IFTE →TAG >>
```

18 commands, 107.5 bytes, #E644h checksum

‘SWUb’ is 15 bytes shorter, and faster than ‘SWUa’. This is a good example of the use of the short form IF...THEN...ELSE...END structure — IFTE.

Readers who understand how the IFTE structures work may easily further enhance the units to add days, weeks, months, and years if desired. What would be the maximum time this program could indicate?

Hint: It is thousands of years.

Community News

HP Handheld Conference, HHC2010

The longest running (since 1979) HP User Community activity is the HHC. This annual Conference has been described in *HP Solve* Issue 10 (HHC 2008) and issue 16 (HHC 2009). The Conference will be held on September 25, & 26 2010 – this is the last weekend of September. The location, however, has yet to be determined and is being debated in the HPUC. Las Vegas, Phoenix, Ft. Collins, and Chicago are the leading candidates. *HP Solve* readers who want to know when the decision is made may find the information at the HHC web site at: <http://hhuc.us>. More serious users may sign up on the HHC List at: <http://lists.brouhaha.com/mailman/listinfo/hhc> to receive email related to the Conference. Once you sign up you may also post to the list to ask questions, participate in discussions, etc. Most HHC attendees belong to the list maintained by Eric Smith.

HP Museum

This site is where much of the HPUC goes to get the most timely information of current topics of interest and the older technical information that a Museum would be expected to provide. Check out: <http://www.hpmuseum.org/>

The Museum of HP Calculators displays and describes Hewlett-Packard calculators introduced from 1968 to 1986 plus a few interesting later models. There are also sections on calculating machines and slide rules as well as sections for buying and selling HP calculators, an HP timeline, collecting information and a software library.

A daily discussion forum is open to everyone and you will find it on the center right side of the opening page. See example at the right. Buying one of the HP Museum CDs is well worth having for the Owner’s Manuals technical details and photographs of the many machines supported.

Navigation

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- [Manuals on CD/DVD](#) (11/18/09)
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Discussion & Guest Areas

- [HP Forum](#)
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- [HP Forum Archives](#)
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- [Biographies](#)
- [Classified Ads](#)
- [Ads without Auctions](#)

Newsgroup

<http://www.usenext.com/>

HPCC

The British User’s group has published Datafile for many years. You may explore their website at: <http://www.hpcc.org/>

hpcalc.org

Hpcalc.org is the premier source of software for and information about the HP 50, HP 49, HP 48, and HP 28 RPN programmable graphic calculators and the HP 38G, HP 39, and HP 40 programmable graphic calculators, with 7078 files by 2136 authors and 2969 screenshots totaling 697.9MB.

Calling all Engineering Educators and Professionals

HP Calculators will be presenting at the exposition of the American Society for Engineering Educators (ASEE) annual conference June 20-23 in Louisville, Kentucky.

The Annual ASEE conference is a place where educators and professionals from all disciplines of engineering come to exchange ideas, develop 21st century teaching methods, and network with like-minded colleagues.

ASEE members include 11,000 college and university professors, 90% of all engineering deans in the U.S., and over 10,000 corporate and government representatives. To learn more about this distinguished professional organization, events, and publications, visit www.asee.org.

Also if you find yourself at the ASEE conference this year, stop by the HP exhibit and mention “HP Solve” for free giveaways while supplies last. Come for a free calculator or flash drive, and stay to check out our powerful calculators and workstations. We specialize in the tools engineers use most!

Did You Know?

This **HP Solve** column is a general collection of assorted tid bits related to HP Calculators.

HP 50g Software

1. One of the more prolific developers of HP 50g software is Andreas Moeller in Langenhagen Germany (North of Hannover). He has an extensive web page that provides the details of his many programs. One is a browser program for the HP50g. Another is a stopwatch program that is far more capable than the one given in One Minute Marvels. Andreas’ program is called StopWatch-C. See his many programs at:

<http://www.software49g.gmxhome.de/index.html?http://www.software49g.gmxhome.de/EnglishSeite01.htm#GUISLV>

You may contact Andreas at: Andreas_Moeller@gmx.de

2. Another resource that offers an extensive line of HP50g software is located in Lauben Germany. They offer a large selection of scientific and engineering software, especially in Physics, Electronics, Chemistry, and mathematics.

HEUSON-SOFTWARE started in 1992 and offers programs for the HP48SX, HP48G/G+/GX, HP48GII, HP49G(+), HP50G.

The software for the Hewlett-Packard calculators HP49G(+), HP50G is directed to engineers, technicians, scientists, teachers and students. The great advantage of the HEUSON-SOFTWARE: all data can be edited freely, so as to never lose their values.

You may obtain the details at: <http://www.heuson-software.de>

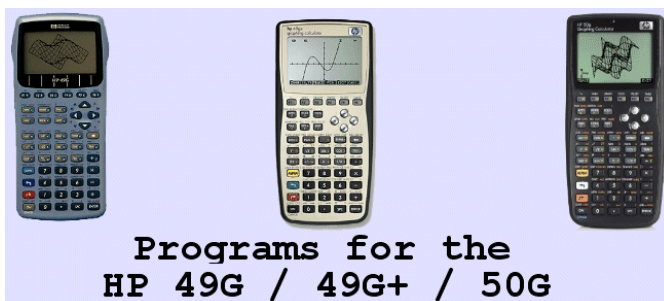


Fig. 1 – Andreas Moeller’s website offers programs.



Fig. 2 – Extensive HP50g software source.

3. **hpcalc.org** (<http://www.hpcalc.org>), is the premier source of software for and information about the HP 50, HP 49, HP 48, and HP 28 RPN programmable graphic calculators and the HP 38G, HP 39, and HP 40 programmable graphic calculators, with 7078 files by 2136 authors and 2969 screenshots totaling 697.9MB. You may also order the complete website on a CD or DVD. Once the content exceed the CD it will be burned on to a DVD.



Fig. 3 – Primary machines supported.

4. If you are a surveyor you should check out the D'Zign website. Ted Kerber has been offering low cost HP calculator survey software for many years. If you are a surveyor and you use the HP33s, HP35s, or the HP50g you will want to checkout Ted's offerings. Get the details at: <http://www.softwarebydzign.com/>



Fig. 4 – lowest cost survey programs.

Calculator Restorations

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Calculator Restorations

Geoff Quickfall

Ed. Note. **HP Solve** interviewed Geoff in Issue 12.

Introduction:

Calculators have been around in one form or another for many years but the arrival of the HP 35 in 1972 heralded a new era. Here we are thirty eight years later and the demand from users and collectors for HP calculators is extremely high including the now 38 year old HP 35!

The HP community, which I divide into users and collectors (big overlap on that bell curve), have long been interested in preserving their favorite calculator either for sentimental reasons or for use as a preferred model. Many questions have been posed about keeping calculators functioning, which have exceeded their design life, and are still desired by the owner. Subscribers to the various forums dedicated to the HP calculator user are responsible for many innovative techniques developed to keep these marvels of design alive and well.

To that end I am creating a book titled “*A Guide for the restoration of Hewlett Packard calculators.*” This book is directed at the collector and user and spans the families of HP calculators from the Classics circa 1972 to the Stretch Pioneers produced until 2003 inclusive.

Physical Design:

A major problem evolved during the evolution of the calculator. I refer to it as the *repair design philosophy*. In the early days the *reparability* cost was considered with reference to the physical design both of the shell and the logic PCB. The financial cost of a scientific programmable calculator like the HP 65 was equivalent to the purchase of a laptop computer of today. Therefore an ability to easily access and repair components was developed to aid in repairs. After all, you would not expect to throw out your new laptop because a RAM chip died. This paradigm ensures the early versions of HP calculators are easy to access for repair

As time passed a choice was made to make the calculators disposable. The cost of memory decreased and the size of components shrunk, production was more automated and the life expectancy of the materials increased. Hence the physical construction veered from removable screws to permanent heat stakes. Concomitantly the cost of repair of individual components outweighed the benefit of purchasing or replacing the unit. This is fine as long as there are replacements for your calculator out there. What do you do if your prized calculator is discontinued?

Collector or User:

Let's say you are a *collector* that would like to own and use a functioning HP 65 with its gorgeous LED display and programmability. Their continued use still happens; I, for example, have been known to pack my HP 65 in my flight bag. The looks I get when I pull it out and it performs a function for the flight is always one of appreciation or downright awe, especially when the card reader is used for program loading. Conversely, as a *user*, my day to day calculator for work is an HP42S which I have upgraded from 7K to 32K and have also repaired due to a bad keyboard PCB to logic PCB connection (more on that later).

Fortunately for you; the collector or user, there are forums, clubs and discussion groups out there all working individually and as a group creating new ways of repairing and extending the shelf life of HP calculators.

Examples from the book:

There are many examples of the failure of the physical components of the calculators when they survive beyond their design life. The HP 41 family suffers from cracked screw posts, battery leakage, cracked LCD panels, and faulty logic PCBs and RAM. The card readers from the HP 65, HP 67, HP 97 and the HP 41Cs all suffer from decomposed pinch rollers and faulty dampening couples. The Pioneers and Stretch Pioneers fail at the foam pressure contact material, and the list goes on. These are a function of time, plastics and electronics that age and reach their *mean time before failure*. This usually occurs well past the designed life of the calculator. Just a note about this article: there are many books and resources that will describe the calculator fully. The intent here is to illustrate procedures used to open these calculators and repair them. The topic however deserves a much larger venue such as a book.

Let's use the following calculators as examples for this article:

- The HP 65 represents a calculator from the early era; 1974. We will open this calculator and disassemble it to its main components.
- The HP42S. Again we will open the calculator but this time we will isolate the faulty foam pressure pad connecting the keyboard PCB to the Logic PCB. We will fabricate a replacement and then reassemble the calculator.

These two examples represent each end of the spectrum with relation to the *repair design philosophy* mentioned earlier. The HP 65 was made to be repaired; its initial cost was 700 USd, which is the equivalent of approximately 2100 USd today. It made sense to repair it! The HP42S, however, is held together by heat stakes and contact adhesive. The stakes were a permanent bond and the calculator shell was most likely opened and sacrificed under the warranty. Outside the warranty it was cheaper to purchase a new one. Of course they no longer are made and tech support is non existent now. A used one goes for 100 to 200 USd depending on the demand at auction sites. The problem with purchasing a used replacement is it will, if it does not already, suffer from faulty foam pressure contact material as well as any other abuse that it may have suffered from the previous owner.

The HP 65 Classic

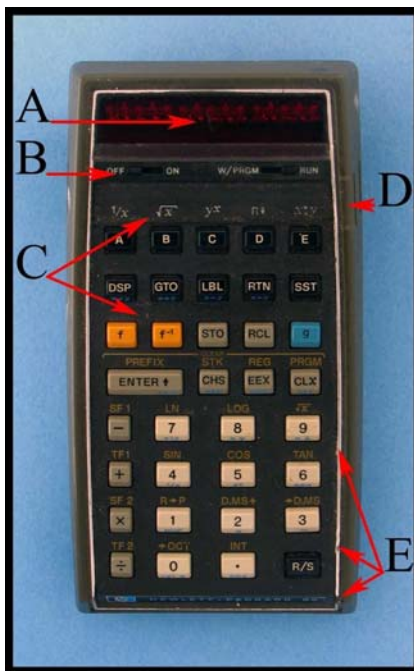


Figure 1: Faulty HP 65.

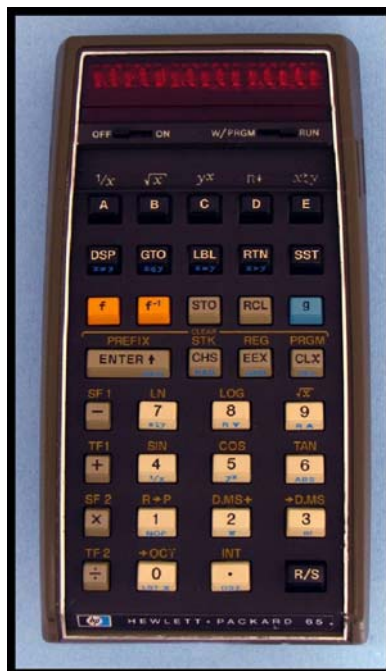
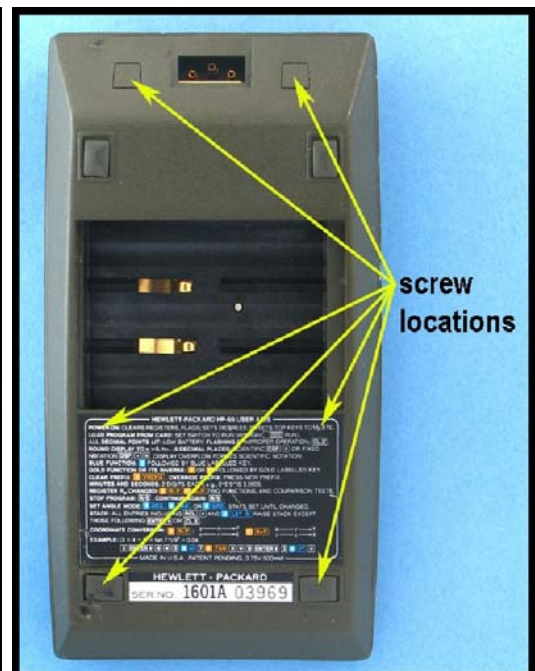


Figure 2: Completed calculator.



This calculator represents the early days of programmable calculator design. It was the first with a card reader, hours-minutes-seconds (HMS) conversion to decimal hours (HR) and base conversions. It also has the distinction of accompanying the astronauts on the Apollo-Soyuz mission where it performed mission critical computations. The reason for the card reader was that memory was expensive; limited in size and not continuous; that is once the machine was turned off the program was lost. Therefore the addition of a card reader to the calculator solved the problem of keying in programs each time the calculator was turned on.

Figure 1 illustrates the calculator-requiring repair. There were quite a few things wrong with this calculator, some cosmetic and some electronic:

- A Crystal is scratched and gouged.
- B The OFF/ON switch is intermittent in function.
- C Two keys do not register and 5 more bounce (multiple registers per single push).
- D Case damage preventing access to the card reader.
- E The bezel is dented and chrome paint worn or missing.

The following also needed repair:

- Corrosion on the contacts of the keyboard PCB to logic PCB.
- Missing battery tab.
- Case dented.
- Non functional card reader.

The chapter titled Classics in the book addresses all the concerns above and more and led to a fantastic looking, fully functional HP 65, Figure 2, however in this article we will focus only on the disassembly of the calculator to its individual components.

Place the calculator face down on a towel to access the screw locations, Figure 3. Locate the two tiny rectangles at the top, two rubber feet at the bottom and the large label. There are two more screws under the label and the reason was for warranty information. If the calculator was opened by the owner the label would indicate such with two holes punched in them at the top corners. Or the label would have been deformed as it was peeled back exposing the screws, Figure 4.

Well that was when it was under warranty, and since this is over 34 years old, the warranty is well past! Gaining access to the screws, however, does not have to ruin the label. The following steps can be used to remove the label and restore it to its pristine condition for reapplication at the end of the repair.

1. Carefully insert a sharp pen knife under the corners of the label.
2. Lift the corners as indicated in Figure 4 exposing the two middle screws.
3. Carefully insert a sharp pen knife under the corners of the label.
4. Carefully insert a sharp pen knife under the corners of the label.
5. Lift the corners as indicated in Figure 4 exposing the two middle screws.
6. Pry off the two rectangles at the top of the calculator exposing the top screw.
7. Lift the outer edge of the two lower rubber feet. These feet are pinned on the inner half to the calculator so don't try to remove them. Just lift enough with a pen knife to expose the two lower screws.



Fig. 4 – Hidden warranty screws.

8. Remove all six screws.

Once separated from the top shell the label can be heated by a hair dryer. As the label heats, the adhesive softens and the label can be pulled off. Using a cycle of heating and pulling, remove the label. Try not to crimp the label but don't worry as all the creases will be removed. To smooth the label for use after the calculator is fixed follow the next seven steps:

1. Heat the label.
2. Remove the label.
3. Remove the adhesive from the label, citric based adhesive. remover will work.
4. Remove the adhesive from the bottom shell.
5. Place the label between two thick sheets of vinyl, an ID holder works well, Figure 5.
6. Place the ID holder and label facing up on a flat surface; a thick glass pane on a kitchen counter for example
7. Heat the label.



Fig. 5 - Example of label in vinyl ID holder.

8. Remove the label.
9. Remove the adhesive from the label, citric based adhesive. remover will work.
10. Remove the adhesive from the bottom shell.
11. Place the label between two thick sheets of vinyl, an ID holder works well, Figure 5.
12. Place the ID holder and label facing up on a flat surface; a thick glass pane on a kitchen counter for example.
13. Using the bowl of a spoon, rub the ID holder containing the label.
14. Flip the ID holder over and rub the back side of the label. This has the effect of cupping the label which aids in its reapplication in the future.

The internal components of the calculator including the card reader are exposed in the top shell. Referring to Figure 6 the following components are labeled as well as the location of six more screws indicated by yellow dots.

- A Card reader motor.
- B Battery contacts and polarity.
- C Logic PCB assembly
- D Card reader connector board.

At the lower end of the calculator highlighted in red are the keyboard PCB to logic PCB connector pins. The yellow highlight at the bottom end of the card reader connector board indicates the position of the card reader connector board to logic PCB connector pins. These pins are gold plated as are the contact holes in the logic PCB. These can suffer poor contact or corrosion. To remove the logic PCB, follow these steps:

1. Gently lift up the card reader connector board at the yellow highlighted end. The gold plated contact pins will separate from corresponding holes in the logic PCB.
2. Now using a pry tool of some type, preferably not metal, lift the logic PCB away from the top shell using the red highlighted area as the pry point.
3. The logic PCB will separate completely as seen in Figure 7.

Clean the contact points highlighted in yellow in Figure 7 as well as the pins on the top shell extruding from the keyboard and the card reader connector board.

Continuing further into the calculator requires the removal of six more screws, the round dots in Figure 6.

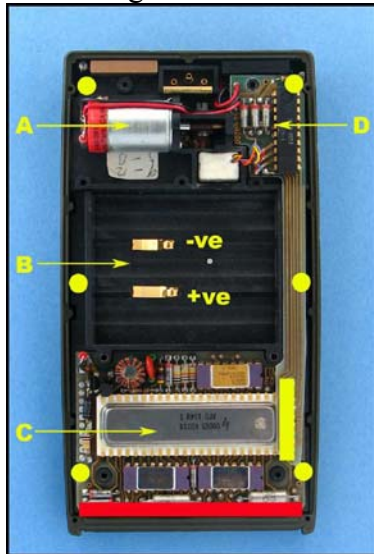


Fig. 6 – Internal components and screw locations.

To access the top, mid and lower right screws require you to gently move the lower end of the card reader connector board to the right.

Since the screws and logic PCB are now removed the entire mid section of the calculator can be separated from the top shell. A note here, the keyboard PCB is attached to the top of the mid section by two power wires. When the mid section is lifted the keyboard PCB will want to pivot at the top allowing the bottom to swing out, so carefully lift the mid section away keeping the keyboard PCB in place with the mid section. Once the mid section is removed the top shell will remain behind with the keys floating in their respective holes covered by a plastic grid and thin sheet of clear plastic. The two sliding switches will also be residing in their respective slots in the top shell or attached via hardened silicon grease to the keyboard PCB.

Locate the two power wires that connect the keyboard PCB to the mid section of the calculator. These vary in colour in differing production Series but are usually marked with red and black to differentiate the two.

Trace them back to the keyboard PCB and note their location. Some of these are soldered to the board and some are connected via a plug system. In one production version the wires were swapped as to their polarity! It is important to remember the colour reference on the wire to its location as reversing these by accident will destroy the logic PCB; they are the power wires. Unsolder these wires after noting their respective positions to free the keyboard PCB, Figure 8. The same figure also illustrates one method of cleaning debris and corrosion between the keyboard contacts. The letters A and B refer to the sliding switch contacts which should be cleaned and lubricated with silicon grease.

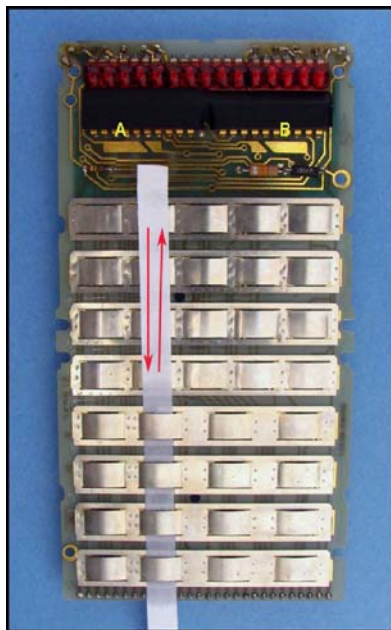


Fig. 8 - Keyboard PCB, switch location and cleaning method.

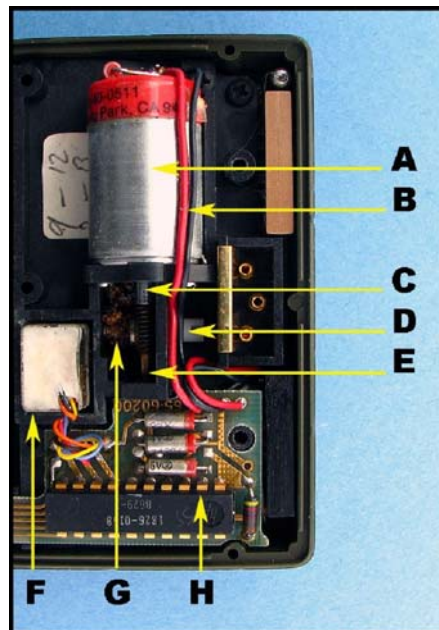


Fig. 9 – Card reader components.

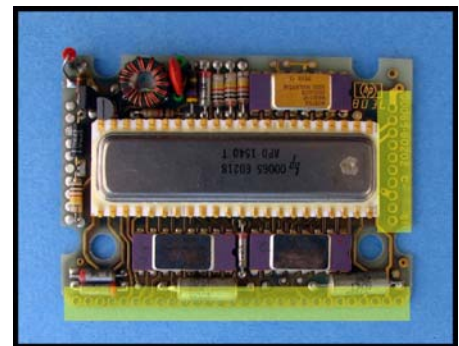


Figure 7: logic PCB with contact points highlighted.

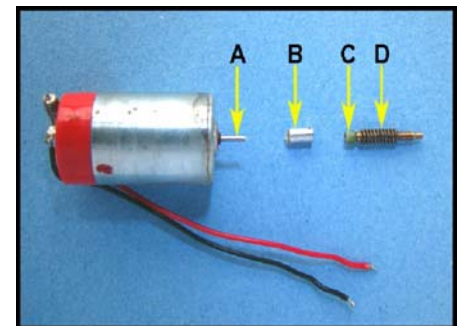


Fig. 10 – Card reader motor coupling and worm gear.

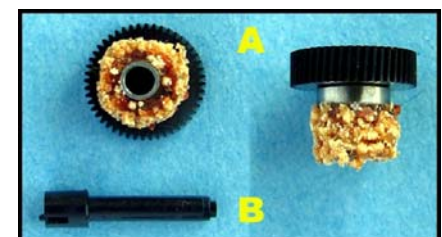


Fig. 11 – Deteriorated pinch roller.

The card reader is part of the mid section and its parts are listed in Figure 9:

- A Motor.
- B Power wires associated with motor.
- C Dampening couple.
- D Eccentric cam.
- E Worm gear.
- F Card reader head.
- G Pinch roller.
- H Card reader logic PCB.

As we have completely disassembled the calculator to its main components this would be a good point to stop with this disassembly. The entire HP 65 has been laid bare and to continue with sub component disassembly would involve another 11 pages! The book goes into much more detail and the chapter labeled *Classics* is 23 pages in length with 37 figures.

One interesting point about the HP 65, which applies to the other card reader versions, including the HP 41C involves the card reader dampening couple and the pinch roller. In Figure 10 the individual parts of the card reader drive system are laid out:

- A Motor shaft.
- B Aluminum sleeve.
- C Urethane dampener.
- D Worm gear.

Figure 11 shows a deteriorated urethane pinch roller. The reason I have included these is to point out the main failure point of all the card reader calculators. The dampening couple and the pinch roller are composed of the same urethane compound which turns to goo. It has been speculated that this in fact is a bacterial infection of the rubber. Figure 11 sure looks like the result of an agar culture dish in a biology lab. In the book you will see methods that repair the dampening couple, Figure 12, and change the pinch roller from the Petrie dish specimen above to that pictured in Figure 13.

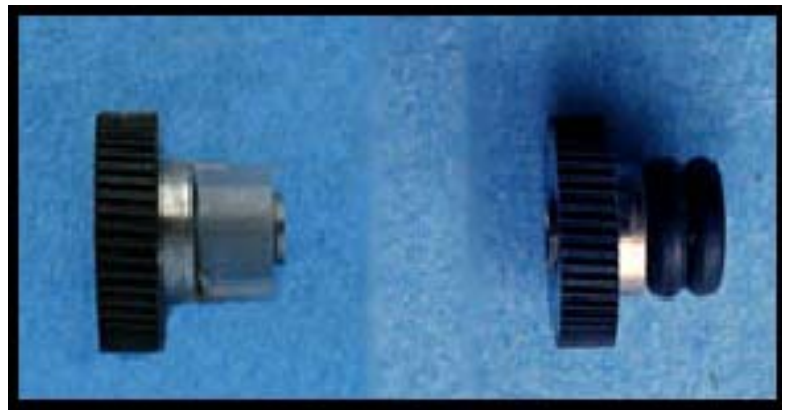
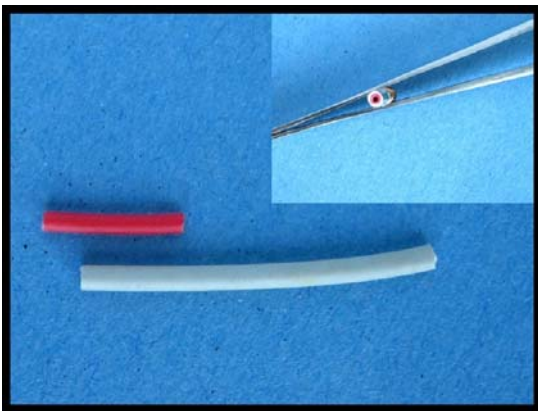


Fig. 12 - Fabrication of new dampening couple. Fig. 13 - Two methods of replacing the pinch roller urethane.

The book also tells you how to reassemble and it does not use the term “reassembly is the opposite of disassembly.” Mainly because it isn’t in all cases therefore explanations are required.

The HP42S Pioneer:

The HP42S was introduced in 1988 as a proposed replacement for the 41 series of calculators. On the plus side its suite of over 600 functions, addition of the solver, matrix computations and complex number

ability has made it a must have for collectors as well as professionals, many of which still use this calculator 22 years after its introduction. On the down side, some find the lack of a real time clock, I/O ability and memory (7.2K) to be limiting. The user can increase the memory to 32K with the simple swap of the RAM chip and a change in jumper switches and this is described in the book

For this article we will look at what is probably the main failure point on the Pioneer and Stretch Pioneers series; the failure of the keyboard. This problem manifests itself in many ways starting with the obvious: The calculator won't turn on! Other indications is once 'on' the calculator won't turn off or a row or more of keys become unresponsive.

This is usually due to the fact that the keyboard is not communicating physically with the logic PCB. The physical aspect of the communication relies on a foam pressure pad to maintain a pressure contact between the keyboard flex PCB and the surface of the logic PCB. The failure of the foam is gradual and usually indicates itself by the need for increased pressure to execute a key function and continues until a row of keys are unresponsive. If this involves the far left set of keys then the calculator may not turn on. To confirm the foam pressure pad is the culprit, simply press gently on the keyboard in the area indicated by the yellow strip in Figure 14. While pressing, turn the calculator on and execute any of the faulty keys. If they work you have confirmed the fault to be the foam pressure pad.

Since the pressure pad is determined to be at fault it is time to open up the calculator. What, no screws! As stated earlier, this calculator was not meant to be opened by the user, yet thanks to the intrepid community; techniques have been derived to access the internal components.

The following is one such technique but by no means the only one. It is however the preferred method of the author. You will need for this project: (A hammer is not required)

- One stiff foam mouse pad.
- Exacto knife or razor blade.
- Pen knife.
- Adhesive remover (citric based).
- Contact cleaner (isopropyl alcohol works well).
- Contact cement
- 11/64th inch drill bit
- Flat edged pliers.

Firstly, remove the batteries. Next slide a thin pen knife blade between the keyboard overlay which is thin aluminum and glued to the keyboard as seen in Figure 15. Start at the bottom as indicated. This gives more control over the separation process near the top where the LCD frame is. The control is required so that the overlay is not damaged at its weakest point. The intent is to enter and exit the calculator while leaving no trace. Continue maneuvering the blade between the overlay and keyboard and between the keys until you can physically grab the overlay with your fingers. This usually involves separating the two parts up to the third row



Fig. 14 - Pressure point for testing fault.

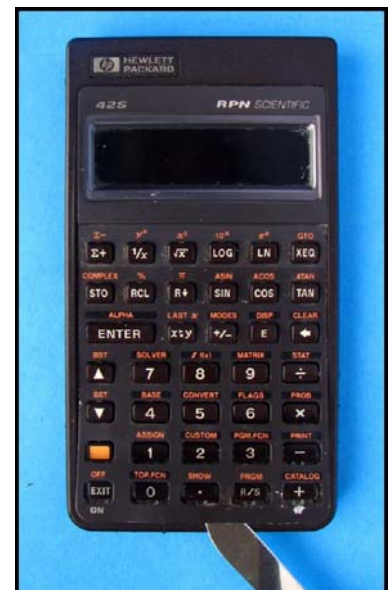


Fig. 15 - Separating the keyboard overlay.

from the bottom.

Once enough of the label has been lifted off the keyboard, grasp the free end while firmly holding the calculator on a flat surface. Now pull the overlay up and at the same time, towards your body. Do not pull the overlay upwards greater than 45 degrees to vertical, Figure 16. By using this method the overlay avoids being creased or crimped. As with the HP 65 label we will remove any crease but if they are not there in the first place then that is less work at the reassembly procedure.



Fig. 16 – Less than 45 degrees to the vertical.

Now that the label has been removed you will see the reason in the following set of figures and accompanying explanation. This calculator as you have discovered has no screws. Compare that to the HP 65 which has fifteen if you include the card reader motor! Instead we have discovered HEAT STAKES! There are four under the overlay, Figure 17 and four in the battery compartment, Figure 18.

The heat stakes along with some clips built into the plastic case on the sides holds the calculator together. To separate and yet preserve the heats takes we will carefully shave off the extreme top surface using a sharp 11/64th inch drill bit. Starting with the battery compartment, take the drill bit in your hand, no need for a drill here.



Fig. 17 – Four heat stakes under overlay.

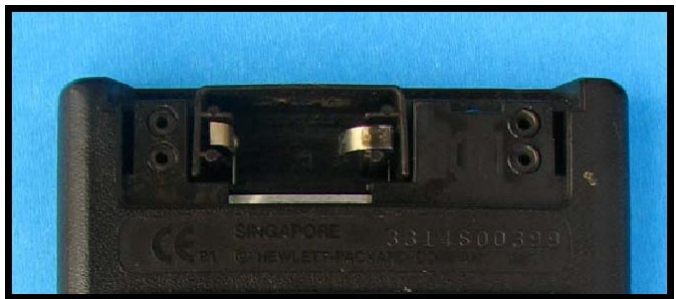


Fig. 18 – Four heat stakes in battery compartment.

Place the drill bit over the top of the heat stake and gently shave off some of the heat stake.

Remove very little as it is better to go back and shave off more then to overdo the drilling and ruin the heat stake. Repeat on the other three stakes. Now using a knife insert it between the top shell and the lower shell as indicated in Figure 19. Twist the knife gently to see if the heat stake will separate. If you require too much twisting force then stop. Shave off more of the heat stake and try again. The intent is to leave enough heat stake to have the calculator actually snap firmly back together when the procedure is completed.

If you are successful then repeat the exercise to the lower four heat stakes on the keyboard side of the calculator. Figure 20 is a shot of the lower heat stakes after they have been drilled out. Compare this to Figure 17 to see just how little drilling is required to separate the halves and yet retain the heat stake integrity for a reassembly.

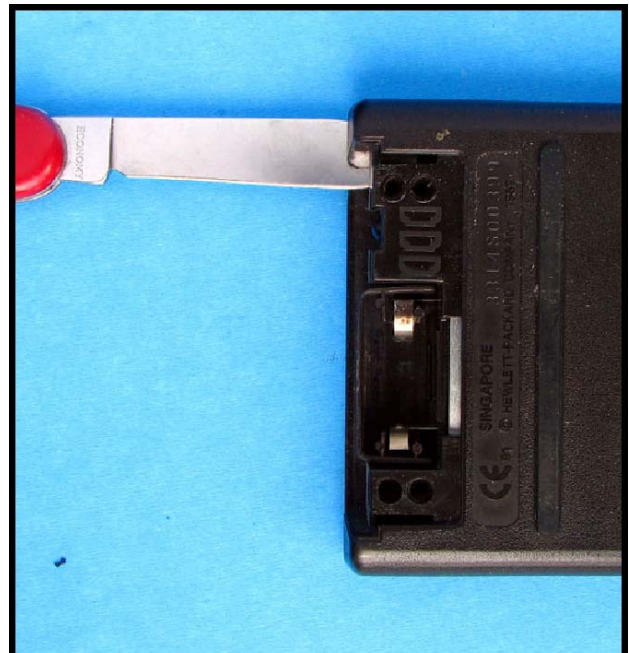


Fig. 19 - Prying the shells apart

Now that the heat stakes are prepared, using the knife



Fig. 20 – Heat stakes drilled.

and starting at the battery housing, gently pry the shells apart. The heat stakes will snap apart, a good sound as this indicates you left enough heat stake material to have the calculator snap back together.

Continue to work down the side of the calculator separating the halves as you go, Figure 21.

When you have separated both halves from the top and the sides insert the knife at the bottom. A gentle twisting force should allow the four remaining heat stakes to snap apart. You will be left with two shells; the top containing the logic PCB and problematic connection, Figure 22; and the bottom shell, containing the shielding and piezo transducer, Figure 23.

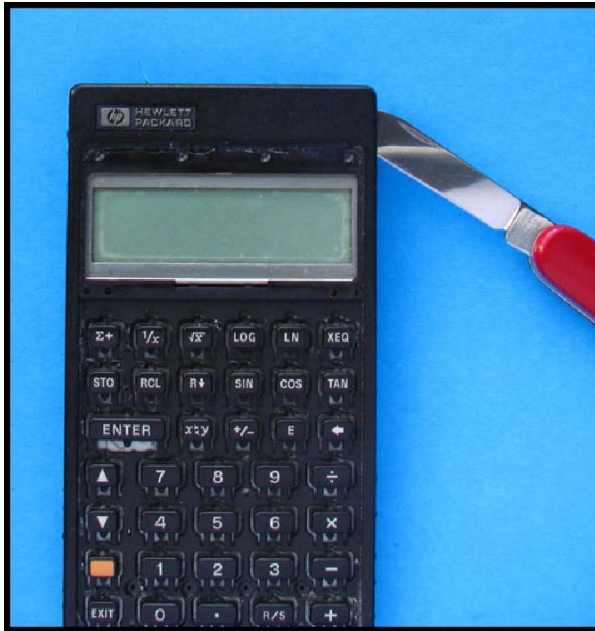


Fig. 21 - Separating the halves.



Fig. 22 – Top shell.



Fig. 23 - Shielding and piezo transducer.

Examine the top shell; the central large framed CPU is visible as is the 7K memory chip at the lower end of the logic PCB. Just to the right of the CPU is a quartz crystal for logic timing purposes.

With reference to Figure 24, the yellow highlighted dots indicate the position of six tabs bent to hold the logic PCB in place. The tabs will line up with slots in the logic PCB when straightened. This will allow the logic PCB to separate from the top shell exposing the keyboard PCB and foam pressure pad (remember, that's why we are doing this!). Now gently straighten the tabs in a direction opposite to the factory bend, in effect, reverse the direction of the bend done at the factory. Bend them back 90 degrees and not forward 90 degrees. This varies on who at the factory bent them in the first place. The tabs are strong but they were not meant to be twisted. Too much bending will fatigue them and if one breaks you end up with a very nice set of spare parts for another calculator. I have separated them as much as six times in repair attempts so they will take it but who knows what the fatigue point is, seven consecutive bends back and forth? Suffice to say, we are trying to fix this at one go with no need to remove the logic PCB again.



Fig. 24 – Yellow tabs.

You may need the knife to gently pry the logic PCB away from the top shell; this is dependent on how good the alignment of the tabs is to the slots they fit into. Once off, the LCD panel and keyboard flex PCB are exposed. Under the keyboard flex PCB is a 4.2cm long strip of grey foam, Figure 25. This is

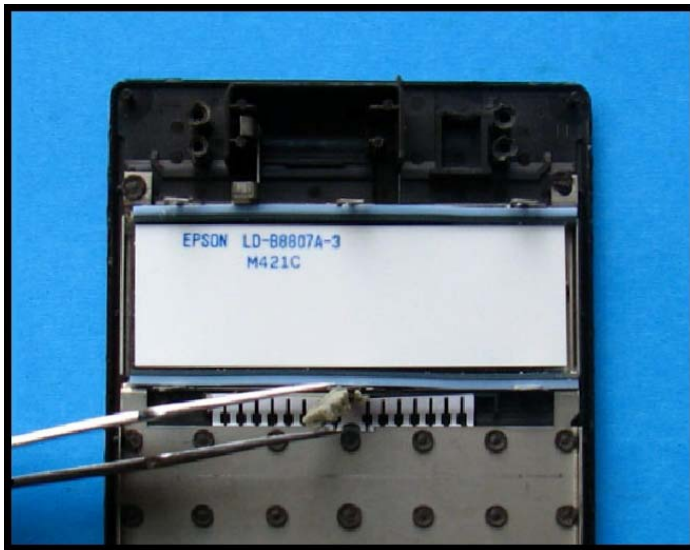


Fig. 25 - Removing the foam under the keyboard ribbon.

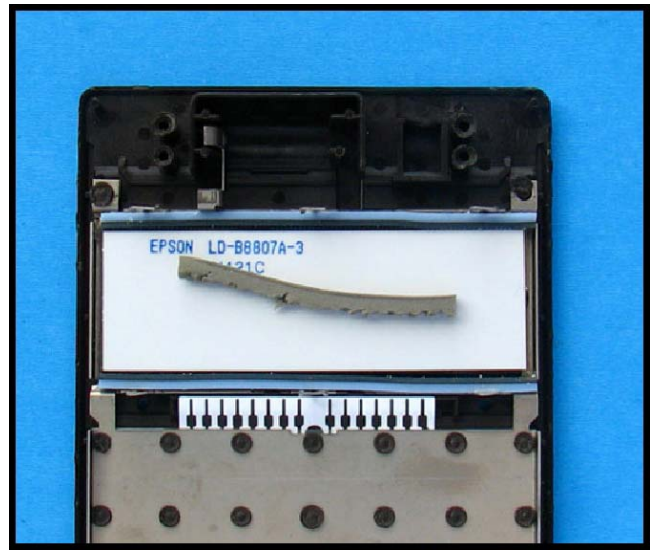


Fig. 26 - foam removed, use as template for replacement foam.

the culprit. Over the years it has been compressed to the point where it no longer fulfills its designed purpose; to press the keyboard flex PCB into the contact points of the logic PCB. A combination of double sided adhesive and pressure holds this foam in place.

Using tweezers and starting at either side:

- Lift the keyboard flex PCB out of the way.
- Grasp the foam in the tweezers, Figure 25.
- Pull the foam out, as much as possible as some may adhere to the bottom of the rectangular frame holding it
- Cut new foam, using the dimensions of the original, from the stiff mouse pad or suitable replacement foam. I make mine slightly taller and thicker. The caveat is that the foam be dense and springy, memory foam would be the opposite of what is required.
- Insert the foam and check from the side view that the keyboard ribbon is raised, Figure 27.

In Figure 27 we see that the old compressed foam raises the keyboard flex PCB about 30 degrees. The new foam insert should raise the keyboard flex PCB at least 45 degrees. Use the tab height **B** as a reference for the height of the keyboard ribbon **A**, Figure 27.

Once you are satisfied with your new foam insert and the resulting height of the keyboard flex PCB, it is time for reassembly. If you are upgrading the memory, now is a good time, of course you will need the book for that modification. All contacts should be cleaned and free of contaminants, Figures 28 and 29. Use contact cleaner on a cotton rag such as an old bed sheet and blow any remaining dust from the contacts. Place the logic PCB

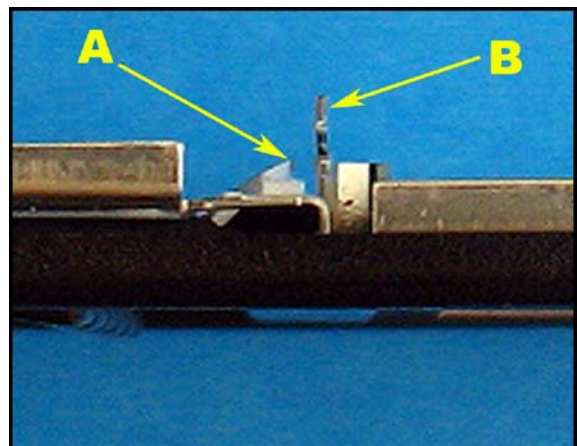


Fig. 27 - relative height comparison of keyboard ribbon to tab.

in place over the straightened tabs. Press firmly at each tab area and bend the tabs back in place. Use the same direction used by the factory. Ensure that there is a good contact at each tab, Figure 30. At this point replace the batteries and test the functions as per the manual.



Fig. 28 - Clean highlighted areas.



Fig. 29 - Clean highlighted areas.



Fig. 30 - Logic PCB in place.

The only function that should not work, although the calculator self test does not register a fault, will be the piezo transducer as it is attached to the bottom shell. If successful it is time to close the calculator. If not successful, then check the tabs are bent correctly as they were initially. The tabs are responsible for holding the logic PCB in position firmly over the keyboard flex PCB and the foam pressure pad. Check for dirt on the contacts and retry.

Now that the logic PCB is in place and successfully tested we can snap the bottom shell in place. This requires nothing more then lining the two shells up and starting at the battery housing. Place the calculator on a solid flat surface over a towel with the keyboard facing up. Press down firmly on the top above the metal keyboard overlay. The yellow highlights in Figure 31 show the correct areas for pressing the shells together. There should be a healthy snap as both halves of the four heat stakes in the battery compartment engage. While on the flat surface, work your way down the side of the calculator pressing on the plastic edge surround and feel it engage its clips. When you have the battery and edges in place and while the calculator is still on a firm surface, find a pen or drill bit with a flat surface at one end larger then the diameter of the heat stakes. A ¼ inch drill bit works perfectly here. Place the flat end on a heat stake and press until it snaps together. Work you way across until all four heat stakes are engaged. The two shells are now together. Do another systems test and this time listen for the ‘beep’ of the piezoelectric transducer as it is now part of the system.

At this point retrieve the now warped but separate keyboard overlay. Apply adhesive remover, not solvent. I use a citric based remover that



Fig. 31 - pressing points for attaching the top shell to the lower shell.

does not interfere with the silk screened writing. Remove all remnants of the old adhesive then wash the overlay in soap and water with a soft cloth, Figure 32. While waiting for the overlay to dry and using a good set of tweezers and tooth picks remove the adhesive from the keyboard.

Now that the keyboard and keyboard overlay are clean of any remaining adhesive, we can remove the kinks from the overlay and soften the warp. As with the HP 65 label, insert the now clean and dry keyboard overlay between two heavy sheets of vinyl. Note that the overlay is not flat but has compound curves at the LCD frame. Leave the LCD frame outside the vinyl sleeve during this process. Ensure the keyboard overlay is face up and rub the vinyl wrapped overlay with the under side of a large spoon. Remember to stay away from the LCD frame part of the overlay. The crimps and creases incurred while removing the keyboard overlay will disappear. Flip the overlay over and rub the back side now. You want to place a tiny convex curve on the



Fig. 32 – Comparison of overlays.

keyboard overlay when it is facing upwards. This allows the corners to lie flat when the overlay is glued in position. Look at Figure 32 to see a slightly curved glue free overlay example at the left. Compare this to the warped adhesive covered overlay on the right. If the LCD frame part of the overlay is crimped straighten it by placing the overlay face down and rub the area from behind gently with the flat end of a rounded dinner knife handle.

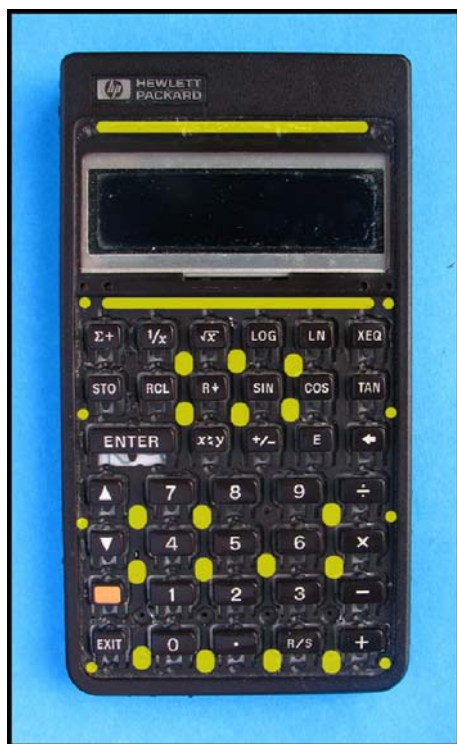


Fig. 33 – Yellow highlights on HP42S indicate suggested glue pattern for reassembly.



Fig. 34 - Upgraded memory HP42S with SIZE 025 and new keyboard flex PCB pressure pad.

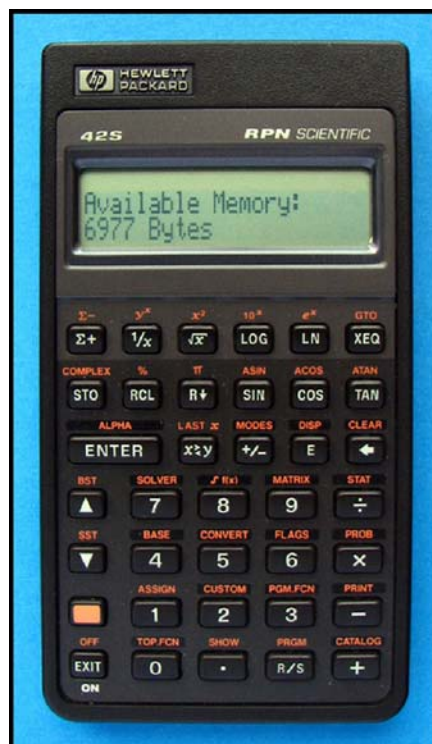


Fig. 35 – non-upgraded memory HP42S with SIZE 025 and new keyboard flex PCB pressure pad.

When you are satisfied with the results it is time to glue it in place, remember, the overlay is 90% of the look of the calculator. Using contact cement and the end of a toothpick or some other fine pointed instrument, apply glue to the keyboard in a manner suggested in Figure 33. Apply corresponding drops of

glue to the keyboard overlay. These should be thin applications. Following the directions on the tube, allow the glue to dry and become slightly tacky to the touch prior to applying the overlay.

Line up the bottom edge of the overlay onto the bottom edge of the keyboard. Get this right the first time otherwise you will have to repeat the entire overlay cleaning and straightening exercise! Once in place apply pressure to the four corners, the top edge and the bottom edge and sides to ensure a good contact.

If you ever have to enter the calculator again this technique allows you to open the calculator using a fine knife without ever having to remove the overlay again. In effect you will have a snap together HP42S just waiting for memory upgrade. Speaking of which here is the finished product with a new foam overlay and the memory upgrade, Figure 34. Compare the display with that of an original HP42S with only the foam upgraded, Figure 35!

Closing Notes:

1. The historical information used in this article may be found in “*A Guide to HP Handheld Calculator and Computers*”, W.A.C. Mier-Jedrzejowicz, PHD
2. The label smoothing method referred to in the HP 65 and HP42S sections is similar to one Mark Hoskins described in 2002 at the Museum of HP Calculator, Dave Hicks curator.
3. The keyboard diagnostics for the HP42S may be found in its manual.
4. The keyboard overlay removal method mentioned in the HP42s was described to me by the creator of the method; Tony Duell, HPCC librarian, member and *hacker in residence*.
5. In the section, HP42S if you drilled too much off the heat stakes resulting in a loose fit, place a small drop of liquid plastic model cement on the exposed heat stake surface while applying pressure for the correct amount of time as per the instructions.

Conclusion:

I hope you found the above instructions helpful and maybe they will get you into the repair mind set. The book itself will be approximately 200 pages with about 200 illustrations similar to the figures in this article. In fact most of these figures are from the book. I am a great fan of illustrations as they make the text much more understandable. Like a cookbook with the end product of your labour displayed in full colour.

About the Author



Geoff Quickfall is an HP calculator user, restorer and member of the London chapter of the HPCC. His background includes ten years of flying in Canada's North and the last 22 years as an airline pilot. A graduate of Simon Fraser University with a M.Sc. in Palynology he is currently writing a book entitled “*A Guide for the restoration of Hewlett Packard calculators*”. Geoff's collection includes over sixty HP calculators ranging from the HP 35 to the HP 35s and all the families in between, each one restored to working condition with museum restoration standards in mind. He would like to thank his wife Janice for supporting his *calculator hobby*!

Today's HP-41 User

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Today's HP-41 User

Peter Platzer

*Ed. Note. Peter Platzer read about the 30 year old HP-41 in “**HP Solve**” issue 16 and wrote to share his current experience with this classic Gen3 HP calculator⁽⁰⁾.*

I have loved the HP41 ever since it was introduced. We were huddling around our classmate, Georg, who was showing off his brand new HP-41C (with card-reader and printer!). Compared to our puny TI-51-II (11 steps, 9 storage registers, no alpha) the 41C was a marvel of technology. The now famous ‘HP Key click’ made it a haptic delight to use and its revolutionary I/O ports promised unlimited powers to solve problems (or simply have fun). No question, I wanted one. Alas, it was many years before I was able to realize that dream, spending a summer’s worth of earnings on a used 41CV which eventually was completed with a card-reader and X/F module. By then the PPC module⁽¹⁾ had been out for a couple of years, the CCD⁽²⁾ module was old news, and first sightings of the 41CY and MLDL’s⁽³⁾ were reported. Again, not being able to afford the necessary equipment (aka gadgets), true HP-41 development and discovery was a spectator sport for me,



Fig. 1 - Nelson F Crowle was one of the earliest pioneers of MCODE development on the HP-41 and the developer of one of the first commercially available MLDLs. The above pictured ProtoROM and ProtoCoder each offers 4k of user-programmable RAM and 4k of ROM if used in combination with the ProtoEPROM.

Fast-forward 20+ years. One day at work I needed a calculator to tackle the odd little calculation for which you don’t want to fire up Excel or Matlab. Remembering the HP-41 (and all the nostalgic longing it embodies for me) I thought, ‘Maybe I can pick one up on eBay for cheap, for memories sake.’ Boy was I in for a surprise.

That purchase opened the door for me to a vibrant, brilliant and exceptionally helpful community of HP-Calculator enthusiasts. Today, 30 years after its introduction, the HP-41 is as revered, used and talked about as ever. I was not alone with my dream, not by a long shot. In the ensuing years I learned a lot of math by solving ‘Short And Sweet Math Challenges,’ repaired the odd HP-41C or HP-IL peripheral, and learned that esoteric programming language MCODE.⁽⁴⁾ Eventually I started to give back to this most collegial community by writing my very own module (multiprecision arithmetic up to 1000 digits, written in MCODE see <http://www.hpmuseum.org/cgi-sys/cgiwrap/hpmuseum/archv018.cgi?read=143386>). Hand in hand with these exploits I built a small but respectable collection, acquiring items that I could only dream of back when I was first introduced to the HP-41. Focusing on literature, MLDL devices and HP-IL peripherals, I acquire almost solely items that I want to learn, use and program with.

What is most amazing about the HP-41 is that even today, 30 years after its introduction, there continue to be brilliant engineers around the world that, encouraged and inspired by its legendary quality, develop new hardware extensions. Leveraging today’s technology of PICs and flash, they continue to breathe life into this little machine of wonder. In the pictures you can see the development of MLDL devices over time, from the early pioneering devices, bulky and crude, to the latest devices that can store basically any and all software and modules that have ever been developed for the 41. The I/O capabilities of the HP-41 allow us to do some very modern tricks, such as connecting the calculator and steering an X.10 network in the house, running an HTTP server (albeit a very slow one...) or connecting the HP-41 to a PC via USB.

Today an HP-41CX, outfitted with a AdvHepax⁽⁵⁾, Finance, Games and Sandbox module (implemented in a modern MLDL device called NoV64⁽⁶⁾) is a faithful companion on my desk, where it solves three purposes. First, its high quality and familiar interface (it was chosen by NASA as backup computer on board the space shuttles) helps me to solve day-to-day problems easily and quickly - like calculating bps spreads from two prices where you only want to type in the significant digits rather than the whole number. The first crude version of this program took less than 90 seconds to write. Eventually I made it more comfortable to use, with hotkeys, alpha prompts and now use it almost daily. You'll also find 'SCATGO' in my CAT 1 ('Scattergories.'), which I wrote to play this fun game and to help me with my English and knowledge of US pop-culture (a task that seems futile at times...). Second, the HP-41 and its community is a constant source of puzzles and challenges to keep my grey cells busy, be that solving math challenges that fellow members post or writing new programs in MCODE, like the Spigot program that calculates ~5000 digits of π (see <http://www.hpmuseum.org/cgi-sys/cgiwrap/hpmuseum/archv019.cgi?read=147587>) Third, it connects me with a worldwide community of like-minded people, many of whom I knew for years in the cyberworld before meeting them face-to-face in one of the annual or bi-annual conferences held in the US and Europe. And then there is always the excitement of the hunt for that one elusive device for my collection that is particularly hard to find (64k W&W⁽⁷⁾ Rambox anyone?).



Fig. 2 - One of the first commercially available MLDL's was produced by the Dutch company Eramco. It provided 24k space for EPROMs and 8k of RAM into which the user could write MCODE using ERAMCO's operating system.

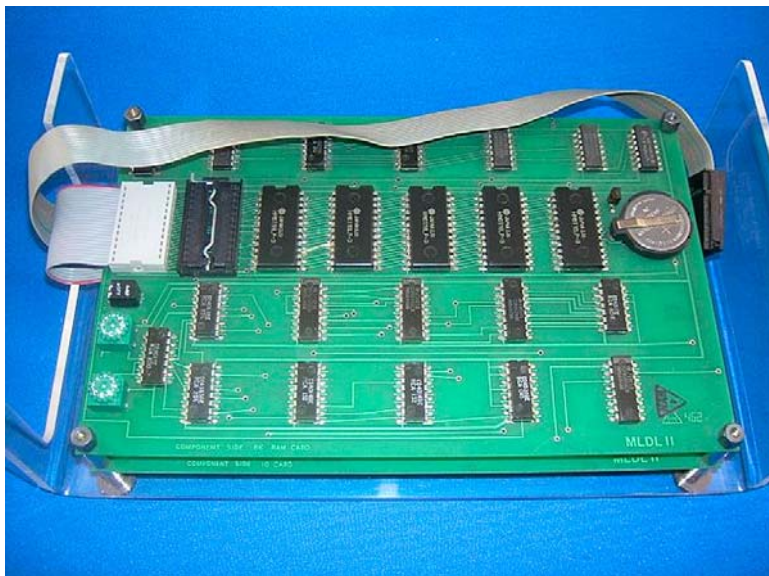


Fig. 5 - A very early MLDL, probably designed by Lynn Wilkins, providing 4k of user-programmable RAM. And this is already version 2, with the earliest versions being mostly wire-wrapped concoctions.

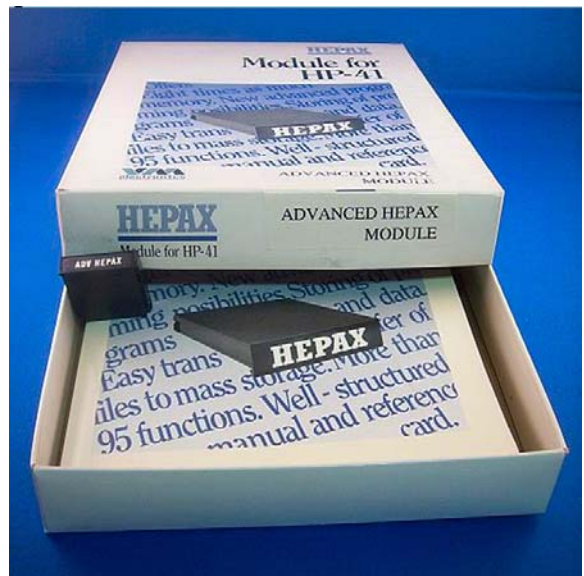


Fig. 6 - Photograph of the Advanced Hepax mentioned in the article and explained in note 5. This is a good example of the many third party products produced for the HP-41 system.

The HP-41 is a great example of the powerful benefits individual users can get from being part of a large network. It was sold over 1m times, creating a powerful network effect for its users. Whatever your particular problem, chances are that one other user has had the same problem and has come up with a solution. This is still true today. Case in point is one of the most recent modules for the HP-41, written

by Angel Martin, one of the most prolific MCODE developers⁽⁸⁾ of the HP community - A very comfortable unit-conversion module that covers 100+ units and 10+ important constants.⁽⁹⁾



Fig. 3 - One of the most sophisticated MLDL's devices of its time, the ProfiSet was produced by the German Company MBK. It provided a full 32k of user-programmable RAM as well as 16k of ROM with one of the most comfortable operating systems to write MCODE as well as use the 32k RAM for extended program, ASCII file or data storage.



Fig. 4 - The modern MLDL2000, developed by Meindert Kuipers. This innocuous little device in the shell of a card reader provides 255 4k pages of ROM and 63 4k pages of user-programmable RAM. Enough storage capacity to virtually hold all ROM's ever developed for the HP-41.

Today's HP-41 User Notes

- (0) The HP-41 has been an inspiration for its users for 30 years to such an extent that a microprocessor designer, Monte J. Dalrymple has redesigned the NUT processor to increase its speed and improve its overall performance. You may find the technical details at: <http://www.systemyde.com/pdf/newt.pdf>
- (1) The PPC ROM project was undertaken in 1979/80 by HP Calculator users and members of the HP calculator club called PPC. Hundreds of programmers contributed to the 153 basic "building block" routines programmed into an 8 KB plug-in module for the HP-41 series of machines. They donated over \$300,000 towards the project and 5,200 Custom ROMs were made by HP. A 500 page User's Manual (30.000 copies printed) was written by users for users as an example of the kind of applications information they thought was important. The project itself was unusual because it involved so many people in many different countries donating in excess of 876,581 hours of work (one man century) without compensation of any kind. This was before the Internet. The project is an example of what is often called open source software and was recently mentioned in an embedded systems blog at: <http://www.embeddedcomponents.com/blogs/2007/04/community-software-development-for-embedded-devices/>
- (2) CCD module, an 8k extension module with ~100 new functions, was created by the Computer Club Deutschland and produced by W&W Software GmbH. It was a true extension of the Operating System of the HP-41 and allowed manipulation of the system registers with unsurpassed ease, powerful matrix and binary functions and many other advanced functions that made working with the HP-41 an even greater delight.
- (3) MLDL, Machine Language Development Laboratory, is an external device to the HP-41 that allows programming the HP-41 in its native Assembler language of the NUT CPU (MCODE, see below). It allows the creation of individual system extensions as well as up to 32k RAM storage in its first versions, about 14x the stock RAM of the HP-41CV. Later versions provided up to 128k RAM and today there is an MLDL available with 1276k(!) of extra storage (MLDL2000 from Meindert Kuipers: <http://kuiprs.nl/hp41.htm#MLDL2000>)
- (4) MCODE, Machine Code, is the native assembler language of the NUT CPU, the main processor of the HP-41. HP programmed the OS of the HP-41 in MCODE and later made that code available to the user community. It

was ferociously consumed and leveraged to write OS extensions for the HP-41 like the CCD or AdvHepax.

- (5) The AdvHepax module is arguably the most sophisticated extension module written in the 20th century for the HP-41. Produced by VM Electronics in Denmark, it offered 16k of OS extensions, an additional 16k of storage with a sophisticated file management system and a full service MLDL, by far the most compact of its time. To this day the techniques employed to achieve all of the above in the size of just one module are par none.
- (6) NoV64 is the brainchild of Diego Diaz and one of the most powerful extensions that is available to the modern user of the HP-41. (http://www.clonix41.org/Projects/Nov64/Nov64_00.htm) It provides 4 blocks of 16k RAM (64k total) that are hot swappable via the use of a control word. Additionally it provides 48k ROM, 16k of which are occupied by a HEPAX while the other two blocks of 16k are again hot-swappable via the use of a control word. This allows you to have 8 different configurations of your HP-41 constantly available, each geared towards different tasks, all without any increase in form factor!
- (7) W&W Software (<http://wwwsoftware.de/homepage/en.html>) was founded in 1984 in Germany by members of the CCD club to focus on MCODE development for the HP-41, with the CCD module being its first product. Its most famous product from that period is probably the HP-41CY, an HP-41CX with an internal 64k memory expansion as well as a 'turbo' switch that made the CY run twice as fast as a stock CX.
- (8) Angel Martin created, among other modules, the famous HP-41Z that gives the HP-41 full complex math capabilities and the Sandmath module that provides 128 advanced math functions, all written in MCODE. Generous with his hard work, he publishes all his code, including the source code, under a GNU license. (<http://www.hp41.org/LibView.cfm?Command=Author&AuthorID=2974>)
- (9) A collaboration between Angel Martin and the author; it can be found here: <http://www.hp41.org/LibView.cfm?Command=View&ItemID=905>

About the Author



Peter Platzer was born in Vienna, Austria where he studied Physics at the TU Wien. After a short and breadless stint as a scientist he joined capitalism, first somewhat tentatively as a consultant for the Boston Consulting Group in Germany and Asia. Later, while at Harvard Business School, Wall Street's siren song lured him to New York City where he is still searching for the wonders promised. In his free time a career coach, captain of a Volleyball team, singer at Carnegie Hall and hiker in the hills of the east-coast, he passionately programs, repairs and collects HP- calculators. Email me at: pplatzer@hbs.edu

E Ink, Haptic Touch and MEMS

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E Ink, Haptic Touch and MEMS

Jake Schwartz

Ed. note. When it comes to calculator ideas there is an endless supply. Users have had wish lists and blue-sky dreams for the future since the HP-35A. Jake, however, examines three emerging technology ideas as they address historical calculator issues. There should not be any implication here that HP is considering these technologies.

Consider yourself on a typical day with a collection of HP calculators, whereby you can reach for and use any one, depending upon the particular need at the moment. For balancing the check book, you might pick up an HP32SII or 11C; for computing the interest payments on your next car loan, you might grab the HP17bII+; and for converting kilometres per liter to miles per gallon or perhaps plotting a function curve the 50g. Now how about if by magic, all these machines could share the same stack and memory registers, so a problem started on one could be continued and completed on another without skipping a beat. What would be simulated here would be a “universal” HP calculator with multiple personalities, each with a real tactile keyboard (and keys in all the familiar places) and actual authentic display. A not-quite-fulfilling attempt at making this come true might be to install multiple HP calculator emulators onto a touchscreen device such as one of the recently-popular “smartphones”. In fact, now that Hewlett-Packard has made its own Voyager-series (12C, 15C) emulators available on the iPhone, the entire concept has been further legitimized. However, for those of us who prefer to feel the tactile feedback of real keys, this solution is far from optimal.

Touchscreen HP-Calculator Proposals Through The Years

The idea of an HP calculator operating on a touchscreen device is by no means new; in fact an early proposal of such a device appeared in the PPC Journal back in 1984 when suggestions were being solicited for the never-implemented “PPC44” club project. This one shown in figure 1a suggested a

1. An old idea to “solve” the problem of keyboard space versus display space fighting each other for property on such a small surface area: the entire top surface (or perhaps most of it) is a touch-sensitive (capacitive ala digitizers?) screen over an LCD dot matrix. Perhaps a numeric keypad could remain as real keys below this screen:

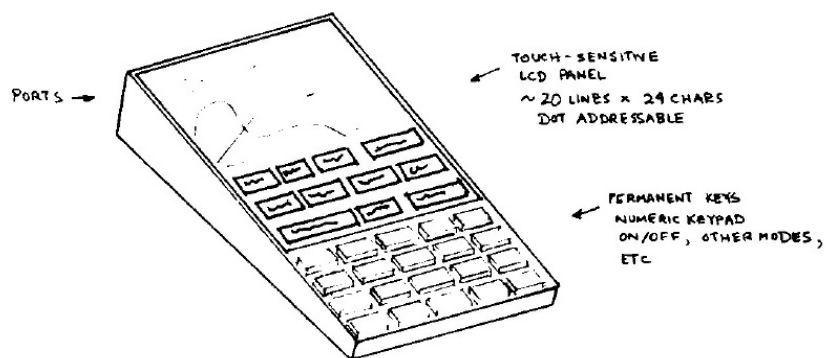


Figure 1a (above): From PPC Journal VIINIP42 - Proposed hardware layout for PPC44 machine in early 1984.

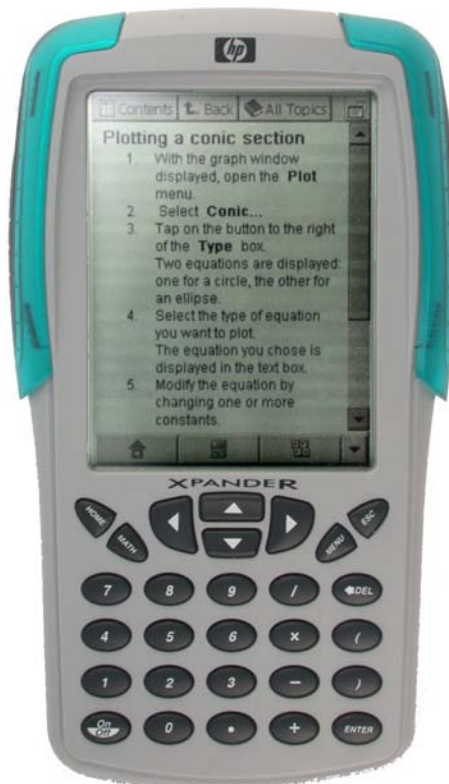


Figure 1b (right): Circa-2000 Xpander from the HP ACO group, never released.

configuration of real keys in a numeric keypad below a touchscreen which occupied the remainder of the

top surface. Not until around fifteen years later did we see prototypes of the ill-fated HP Xpander, with virtually the identical layout.

In 1989, at the annual HP conference that year at Triton College in Melrose Park, Illinois (where we celebrated the HP41s tenth anniversary, by the way), a proposal was made, suggesting that the HP28 could be enhanced by locating all the “hard” keys on the right side and having a full touchscreen occupy the entire left side of the clamshell. This could allow multiple-row softkey menus, large graphics, a QWERTY keyboard and more. It was also the time of the release of the first Sharp Wizard, with its keys on one side and touch-sensitive clear surface on the other, under which a plug-in card with function markings denoted to the user the location of soft keys. The following year, the HP48 debuted with all the HP28 functionality on its single keyboard, but alas without the touchscreen.

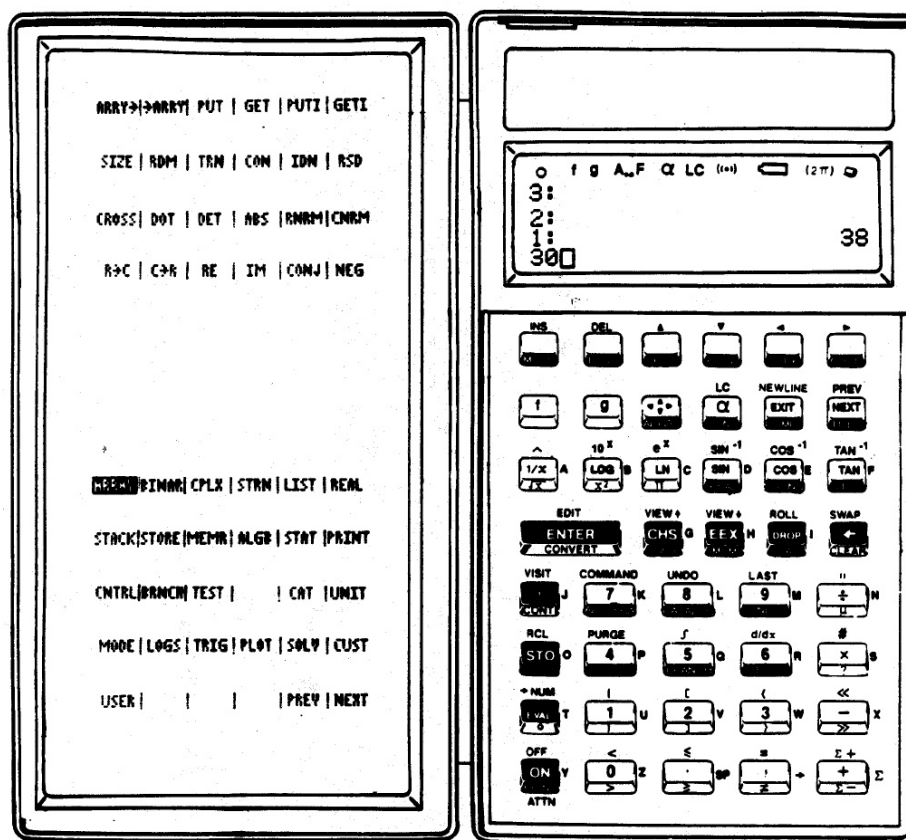


Figure 2. A proposed clamshell calc with HP28 functionality on the right and full touchscreen on the left.

Starting in the mid 1990s Sebastien Carrier’s emu48/49 program for the PC appeared and was later adapted to the Pocket PC PDAs running the Windows CE operating system. With its keyboard markup language (KML), users had the freedom to choose any calculator keyboard layout or image which could range from an actual photo of the machine to a line drawing. Keys would be mapped to x- and y-pixel positions within the KML file. After the HP49 version was developed, my favorite keyboard image was a modified key layout which restored the ENTER key’s size and position back to the HP48 arrangement, as shown in figure 3.



Figure 3. An example emu48 image file (left) and modified emu49 image file (right), both for the Pocket PC PDAs.

No Tactile Feedback

One of the problems with all these touchscreen solutions, from Xpander to iPhone has been the lack of tactile feedback like a real HP calculator keyboard. Recently, a few companies have started offering “haptic” touchscreens on their products. These usually cause the device to vibrate momentarily when touched, giving the user a feeling of having positively pressed something on the flat surface. However, all the ones I have experienced have suffered with the same shortcoming; which is that feedback is always provided, no matter where the screen is touched. If a key has actually been pressed, I want feedback, but by the same token, if I press between the keys or anywhere else, I need that keyboard to do nothing. This represents the realistic way to know that the touch did not activate any key(s). It is felt that this difference would represent a significant advance toward simulating a real keyboard.

Electronic Ink and Keyboards

Another upcoming technology in consumer electronics has been the use of “electronic ink” (or E-ink) based displays. Two major advantages of these are extremely high contrast along with persistence when powered off. Both these attributes make E-ink ideal for digital signage, and examples of small digital signs using this technology were shown at a recent Consumer Electronics Show by the LG Company. Another currently-popular use for E-ink is in handheld digital book readers, such as the Amazon Kindle and Sony E-book Reader. However, it would be great to use in handhelds as well. One such idea,

proposed in 2005 by Tim Wessman, won HP's annual Design-the-Calculator contest. He suggested physical keys surrounded by an E-Ink surface where the key labels would appear and remain there (even if powered off), until changed. More recently, Samsung has developed a mobile phone called the "Alias 2", with E-Ink on each key so the labels may change depending upon the currently-active application. (See figure 4.)



Figure 4. Left, Tim Wessman's 2005 HP Design-A-Calculator contest winning entry with E-Ink "land" around blank real keys; Right, the Samsung Alias 2 mobile phone with E-Ink keyboard which changes with applications.

The Case for MEMS

To me, the ideal handheld display surface would be a touchscreen with tactile feedback exactly where the application needed it – and nowhere else. One idea I wondered about was whether this was a problem which might be solved by some sort of MEMS (MicroElectroMechanical Systems) solution. Recalling how Texas Instruments created a totally-original approach to projection television with their DLP (digital light processing) MEMS chip which consists of a large matrix of microscopic addressable, movable mirrors, perhaps a MEMS-based display/tactile screen could be devised for this use as well. Unless someone can confirm that something like this is on the drawing board or has already been done, consider the concept of a display consisting of an array of square "Surface Elements" (or perhaps "SurfEls", for short?), whose dimensions are 75-by-75 to the inch. Each would be part of a MEMS device which could be individually addressed electronically. Like the DLP chip, these SurfEls would be in two possible states, "engaged" or "not engaged", whereby when engaged, they would provide slight but definite mechanical feedback when pressed with a finger. Each one would also contain a 4-by-4 array of addressable e-ink pixels on its top surface, so as to comprise a 300 DPI display. (See figure 5.)

In software, the upper portion of the surface could be designated as the calculator "display", with the lower portion for the virtual keyboard. A KML-like application could not only specify the position and

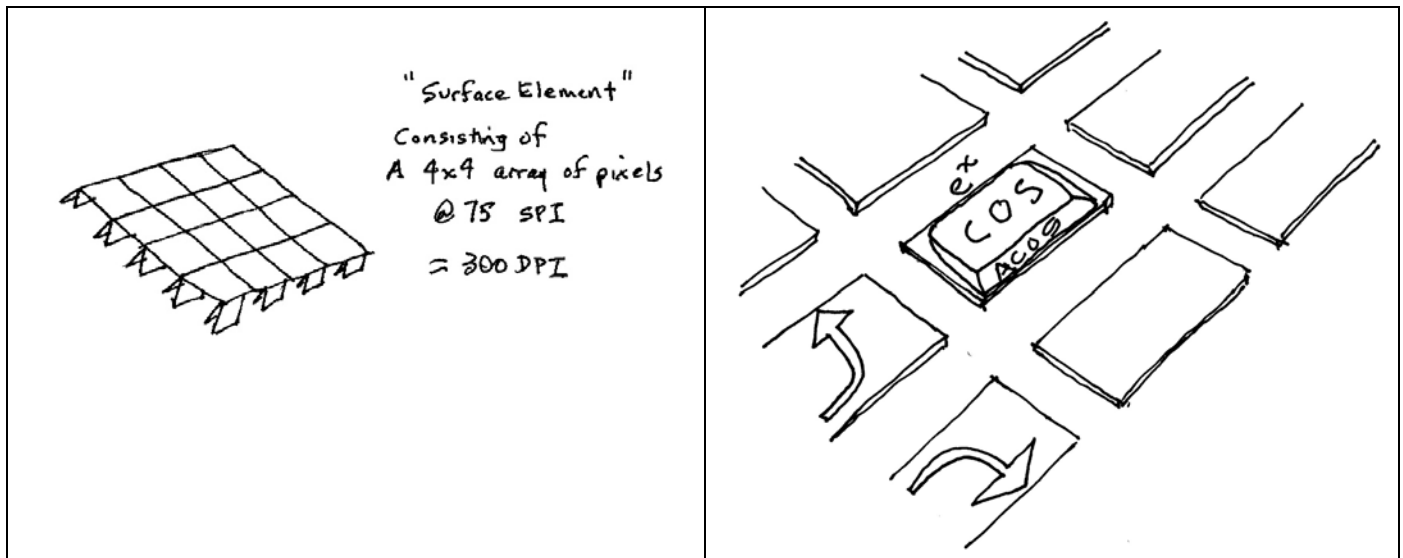


Figure 5. Left, a proposed "SurfaceElement", shown in the "engaged" position; Right, a view of an E-ink./MEMS-based surface with calculator key labels drawn in the designated key positions.

shape of the virtual keys, but could also provide image data for the portions of the E-ink display over each key. When activated, the Surface Elements in the designated key positions would be engaged and the images drawn. Pressing the surface between the designated keys would provide no feedback, but pressing in the area of a key would result in somewhat of a "click-like" feel. Should key presses cause a mode change, the drawn keys could be changed accordingly. In fact, if necessary, changing modes could completely change the virtual keyboard with respect to the position and number of keys as well. As a result, a machine could hold multiple calculator emulators in its firmware and could change between them via user commands, with virtual tactile keyboards changing at the same time. Imagine embedding Eric Smith's Nonpareil emulator on a box like this, with an opening mode screen where the functions on the keyboard are labeled "Classic", "Woodstock", "Spice", "Voyager", "Pioneer", etc. and after making a selection, a subsequent keyboard would be labeled with calculator model numbers. That might be the HP fanatic's ultimate dream machine.

About the Author



Jake Schwartz has been an HP calculator fan since 1971 after first trying the HP9810A desktop RPN machine at a co-op job at RCA in New Jersey. He has owned most of the scientific top-of-the-line handhelds since the HP35A in the early 1973, joined the PPC Calculator Club in 1977 and contributed to many of the clubs since, including serving as Peripheral Routines coordinator for the PPC ROM project for the HP41 in 1980. Currently working at Lockheed-Martin as a software engineer, Jake has been presenting at and videotaping the annual U.S. HP calculator conferences for more than two decades.

HP Solve Math Problem Challenge #2

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Cutting A Circle In Three Equal Pieces - Solution

Introduction

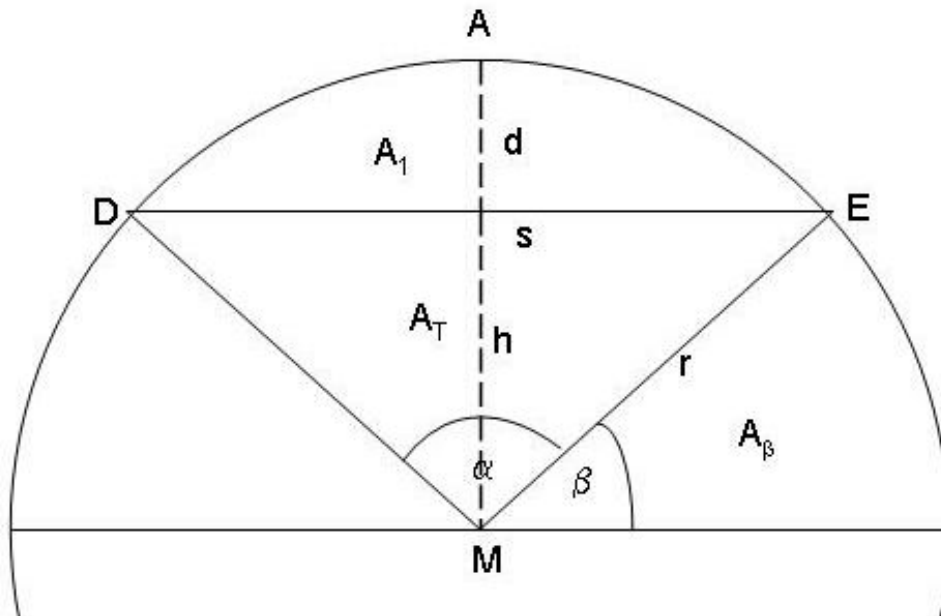
In our last *HP Solve* issue 18 Marty had a problem of cutting a circle into three equal area pieces by making two parallel cuts. The easiest way to make the cut is to measure from the circle along the diameter knowing the length, h , as shown in figure one. The challenge as given in the problem was to calculate the ratio of h to the diameter; h/D . Converting this ratio to a percentage would make cutting any sized circle into three equal pieces a simple task if the diameter is known or can be measured.

Two *HP Solve* readers responded with solutions, Robert Orban and Pete Burns. Robert solved the problem using Derive and Pete solved it using a more direct means rather than a software program. While the latter is what was desired both *HP Solve* readers used document software that made it difficult to incorporate into Word 2003 which the editor uses. Normally we are able to “process” inputs in various formats, but as usual time was limited so we were not able to include their inputs here. Kudos to you both. The “winner”, however, is Wolf-Dieter Schöne of Cochem Germany. His solution arrived just as the issue was being assembled. Excellent work Wolf. Here is his solution.

Solution of *HP Solve* Math Problem Challenge #1

Wolf-Dieter Schöne

In order to solve the problem the following figure is helpful. The points A, D, and E correspond to the same points in the figure of the newsletter. M denotes the center of the circle. So d corresponds to the distance \overline{AG} of the figure in the newsletter and h to half of the length of \overline{GH} .



s is the segment \overline{DE} and the basis of the triangle MED. h is the height of this triangle, A_T its area. According to the figure there are seven unknowns, the angles α and β , the areas A_1 , which should be one third of the area of the full circle, A_β , the section corresponding to β , and A_T and furthermore h and s . The radius r is given.

These unknowns are connected by seven equations:

$$(I) \quad \beta = \frac{\pi}{2} - \frac{\alpha}{2}$$

$$(II) \quad A_{\beta} = \pi r^2 \cdot \frac{\beta}{2\pi} = \frac{r^2}{2} \beta$$

$$(III) \quad A_1 + A_T = \frac{r^2}{2} \alpha$$

$$(IV) \quad A_T + 2 A_{\beta} = \frac{1}{2} A_1$$

$$(V) \quad \cos\left(\frac{\alpha}{2}\right) = \frac{h}{r} = \sin(\beta)$$

$$(VI) \quad h^2 + \frac{s^2}{4} = r^2$$

$$(VII) \quad A_T = \frac{1}{2} \cdot s \cdot h$$

Inserting (I) in (II), the new (II) in (IV) and rewriting (III) gives

$$(I) \quad \beta = \frac{\pi}{2} - \frac{\alpha}{2}$$

$$(II) \quad A_{\beta} = \frac{r^2}{4} (\pi - \alpha)$$

$$(III) \quad A_1 = \frac{r^2}{2} \alpha - A_T$$

$$(IV) \quad A_T + \frac{r^2}{2} (\pi - \alpha) = \frac{1}{2} A_1 = \frac{r^2}{4} \alpha - \frac{1}{2} A_T$$

$$(V) \quad \cos\left(\frac{\alpha}{2}\right) = \frac{h}{r} = \sin(\beta)$$

$$(VI) \quad h^2 + \frac{s^2}{4} = r^2$$

$$(VII) \quad A_T = \frac{1}{2} \cdot s \cdot h$$

Solving (IV) for A_T and equating with (VII) leads to a system of the three unknowns, α , h , and s and the three equations:

$$(V) \quad \cos\left(\frac{\alpha}{2}\right) = \frac{h}{r}$$

$$(VI) \quad s^2 = 4(r^2 - h^2)$$

$$(VII) \quad \frac{r^2}{3} (3\alpha - 2\pi) = s \cdot h$$

Inserting (VI) and (VII) in (V) finally gives a single equation for α ,

$$\cos\left(\frac{\alpha}{2}\right) = \frac{1}{r} \cdot \frac{r^2}{3s} \cdot (3\alpha - 2\pi) = \frac{1}{r} \cdot \frac{r^2}{3 \cdot 2 \cdot \sqrt{r^2 - h^2}} \cdot (3\alpha - 2\pi) = \frac{r}{6 \cdot \sqrt{r^2 - h^2}} \cdot (3\alpha - 2\pi)$$

This equation can again be rewritten leading to:

$$\sin\left(\frac{\alpha}{2}\right) \cdot \cos\left(\frac{\alpha}{2}\right) = \frac{1}{6}(3\alpha - 2\pi) = \frac{\alpha}{2} - \frac{\pi}{3} \text{ or } \sin(\gamma) \cdot \cos(\gamma) = \gamma - \frac{\pi}{3},$$

with $\alpha = 2\gamma$. Typing the latter equation into the calculator and using NUM.SLV gives the result for γ , $\gamma = 1.3026628373$ or $\alpha = 2.6053256746$ (in degrees $\alpha = 149.274165412^\circ$). h is thus determined to be:

$$h = r \cdot \cos\left(\frac{\alpha}{2}\right) = 0.264932084603 \cdot r.$$

The thickness of the first slice d is:

$$d = r - h = r \left(1 - \cos\left(\frac{\alpha}{2}\right)\right) = 0.735067915397 \cdot r.$$

Thus the desired ratio \overline{AG} to \overline{AB} is:

$$\frac{\overline{AG}}{\overline{AB}} = \frac{d}{2r} = 0.367533957698.$$

The result can be checked independently by integrating a quarter circle of radius $r = 1$:

$$2 \int_0^h \sqrt{1-x^2} dx = \left[x\sqrt{1-x^2} + \arcsin(x) \right]_0^h = 0.523598775599$$

$$\int_h^1 \sqrt{1-x^2} dx = \frac{1}{2} \left[x\sqrt{1-x^2} + \arcsin(x) \right]_h^1 = \frac{\pi}{4} - \frac{1}{2} \cdot 0.523598775599 = 0.523598775598,$$

showing that the above result is correct.

Here Is the Editor's Math Solution

Figure one at the right shows the relationships of a segment of a circle. The chord is one of the cuts and the second cut is a mirror image. The math challenge #1 is to calculate h .

The first step is to check a math text book, reference book, or the Internet to get the equations that show how these values are related.

Let's use a circle of unit diameter, $D = 1$. Table 1 shows the selected equations. We will use an HP35s for our calculations.

1. Unit Circle Area: $(\pi \cdot 1^2)/4$, $A = 0.785398163398$.

2. Area of cut $(1/3^{\text{rd}})$ piece, $= 0.785398163398/3 =$
 $K = 0.261799387799$.

3. We now know two variables, K and r . h requires

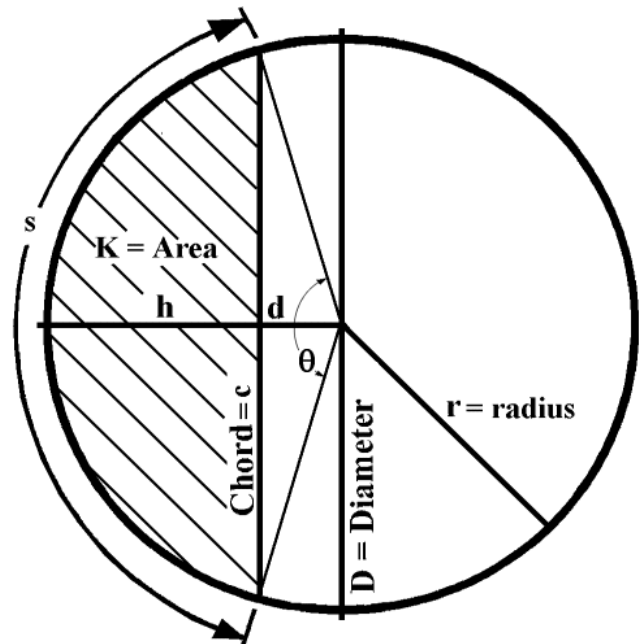


Fig. 1 – Segment of a Circle values identified.

that d is known. d requires that θ is known. It seems that h cannot be easily calculated directly. EQ 2 shows that we can calculate θ with what we know so far. Solving EQ 2 for Theta requires that we either make a guess (trial and error) or we use one of the most powerful tools our HP calculator offers, HP's Solver. $2K/r^2 = 2 * 0.261799387799/0.25$. $2.09439510239 = \theta - \sin\theta$. Storing the equation, $K=T-\sin(T)$, into the HP35s equation list in radian mode allows the Solver to solve for T.

$T = \theta = 2.6053256746$ radians. $T = \theta = 149.274165412$ degrees when the radian to degree conversion is made with two keystrokes.

4. EQ 3 allows d to be calculated $= 0.5 * \cos(2.6053256746/2)$, $d = 1.32466042302$.

5. EQ 4 allows h to be calculated $= 0.5 - 1.32466042302$, $h = 0.367533957698$.

Marty simply measures 36.8 percent of the diameter from the circle on each end of a diameter and he is able to cut the circle into three equal area pieces using parallel cuts perpendicular to the diameter. The correct value of h is very close to one third (0.333333333333) which is 9.30543250458 percent too low.

Table 1 – Equation Relationships of the variables shown in figure 1⁽¹⁾.

Variables:

A is the area of the circle.

r is the radius of the circle.

c is the chord length of a segment of a circle.

K is the area of a segment of a circle as shown in figure one.

s is the arc length of the segment.

h is the height of the chord at the midpoint.

d is the distance from the chord to the center of the circle.

θ is Theta, the angle subtended by the arc length measured in radians.

$$\text{EQ 1. Circle Area} = \pi r^2, \text{ also } \frac{\pi D^2}{4}$$

$$\text{EQ 2. } K = \frac{r^2(\theta - \sin\theta)}{2}, \text{ isolating } \theta; \frac{2K}{r^2} = \theta - \sin\theta$$

$$\text{EQ 3. } d = r \cos(\theta/2)$$

$$\text{EQ 4. } h = r - d.$$

Is this answer correct? How do you actually know? How could you confirm this by measuring the circle and cut area with minimum effort? What tool(s) would you need?

Here Is the Editor's Experimental Solution

One technique is to obtain a large uniform thickness and composition piece of heavy card stock or paste board similar to what is used for the back of a writing tablet. Alternately you could use a thin piece of sheet metal and a tin snips. A piece of wood and a saw are unsuitable because of the "lost" saw dust. Get the heaviest material you can to increase the resolution of the measurement.

1. Draw the largest circle you can and draw a diameter and one of the two cut lines.
2. Cut out the circle carefully and weigh it. Record the weight.
3. Cut off one 36.8 % segment and weigh it. Within the errors of the scale and the uniformity of the material the cut piece should be one third of the weight of the full circle.

Electronic scales that measure to 0.1 gram (a new US nickel⁽²⁾ weighs 5.000 grams) are low cost and becoming more available to the average student. If you have access to an electronic laboratory scale that is sensitive to 0.1 milligram you will be able to achieve greater (1,000 times) accuracy.

Let's confirm the result experimentally. A small piece of 26 Ga. sheet metal was used to cut a circle 18 cm (7.09 in) diameter.

The recorded data is shown in table two. The circle was cut based on the solution described above and the pieces were weighed. See figures two and three.

As the data of table two shows the "error" was within 0.9 percent.



Fig. 2 – Whole circle on scale.



Fig. 3 – 1/3 circle on scale.

A complete error analysis of this "test" would include such factors as sheet metal variations (very small), cutting variations (a little more significant), and measuring variations (significant, skill and tool dependent). Note Table Two entry #9. The cut length (Chord) is about 171 mm. If the width of the cut varies by $\pm 25.2 \text{ mm}^2 / 171 = \pm 0.15 \text{ mm}$ (5.9 mils = 0.0059 in) the scale wouldn't detect it because of the 0.1 gr. resolution.

With these considerations in mind what would have been a better circle size to use?

The scale has a capacity of 250 gr. The circle could have been larger (and/or thicker, but still cut able) to just be within the maximum of the scale capacity. The resolution of 0.1 gr. in 250 gr. is 0.0004 or 0.04% vs. 0.1 gr. in 99.5 gr. or 0.10%. At least the larger size would provide a greater resolution in the weight ratio. The actual accuracy of the scale isn't important just its linearity. Scale linearity adds another factor to consider in an error analysis. What other methods or materials would provide a more accurate measurement?

Table 2 – Sheet Metal Circle Cutting Experiment #1

1	Circle material (galvanized sheet metal)	0.53 mm (0.021") thick.
2	Circle Diameter	18 cm (7.09 in).
3	Circle area	$254.5 \text{ cm}^2 = 25,450 \text{ mm}^2$
4	Distance to cut using 36.8%	6.62 cm. (2.61 in).
5	Circle weight to nearest 0.1 gr.	99.5 gr. (3.51 oz.)
6	1/3 circle cut piece weight	32.9 gr. (1.16 oz.)
7	Cut weight difference of 1/3 rd weight	33.2 vs 32.9 is -0.9%
8	Test piece (26.0 mm x 27.1 mm) weight	2.8 gr. for 704.6 mm^2 area.
9	Scale resolution	25.16 mm^2 per 0.1 gr.

Table 3 – Sheet Metal Circle Cutting Experiment #2

1	Circle material (galvanized sheet metal)	0.38 mm (0.015") thick.
2	Circle Diameter	29.1 cm (11.46 in).
3	Circle area	$2,660 \text{ cm}^2 = 266,000 \text{ mm}^2$
4	Distance to cut using 36.8%	10.7 cm. (4.21 in).
5	Circle weight to nearest 0.1 gr.	194.7 gr. (6.87 oz.)
6	1/3 circle weight to nearest 0.1 gr.	65.7 gr. (2.32 oz.)
7	Cut weight difference of 1/3 rd weight	64.9 vs 65.7 is +1.2%
8	Test piece (26.0 mm x 27.1 mm) weight	2.1 gr. for 704.6 mm^2 area.
9	Scale resolution	33.55 mm^2 per 0.1 gr.

A second measurement (experiment #2) was made using a 25% thinner, but larger, piece of similar galvanized sheet metal which was available. See recorded data in Table 3. Note that the error is + in the second experiment and – in the first experiment - compared to theory.

Do any Questions Remain?

The problem has been solved, but it required a calculator solver to arrive at the answer.

Are you convinced that the 36.8% solution is correct?

Are there other solution methods?

Is it possible to solve the problem using a direct trigonometry solution without iterating (trial and error) as done by the solver? Is there an exact solution?

Share your comments on these questions, via the editor, with the readers of **HP Solve**. hpsolve@hp.com

Math Challenge #1 Notes:

- (1) *The equations you find will vary greatly depending on the reference you use. The Table 1 equations were used because they provided one obvious path for a solution. Would other equations provide an even simpler solution?*
- (2) *US coins are useful to use as informal and readily available “standards.” Go to any bank and get a roll of uncirculated coins (nickels). Since the nickel does not have reeds it may also be used as a length measurement caliper check as well. See http://www.usmint.gov/about_the_mint/?action=coin_specifications*

#2 in the **HP Solve** Math Problem Challenge series

HP Solve Math Problem Challenge #2 - A Simple Geometry Problem?

In 1963 Marty worked for an oil company research center as an IBM 1401 computer operator which was used as an input for an IBM 7094 computer. All of the computer center users were researchers, and most had PhDs.

At that time was he was building molecular models and studying transistors. He wanted to build a model of silicon with a bond angle of ≈ 109 degrees, and he needed a method to locate four equally spaced points on the surface of a sphere of a given diameter, D.

Marty could not afford commercially sold model building kits because they were so expensive – and he wanted to make a really large model for teaching purposes. He could find a source of low cost wood spheres so the primary issue was determining the four points to drill the holes.

Figure one shows a two inch Styrofoam sphere with four wood food skewers inserted at equally spaced points on the surface of the sphere.

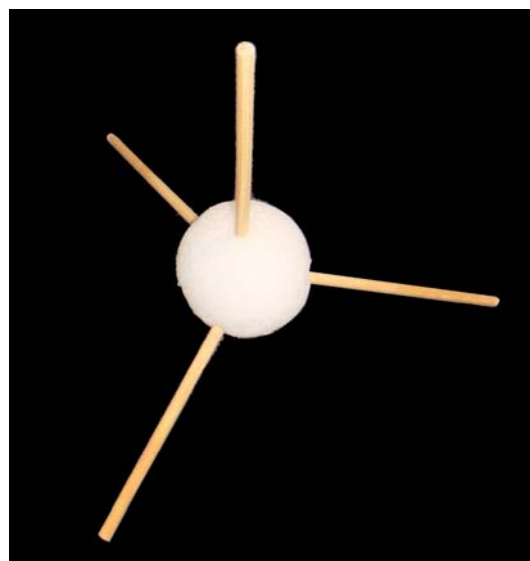


Fig. 1 – Two inch Styrofoam sphere with four wood sticks inserted equally spaced $\approx 109^\circ$.

The problem is being able to design and construct a fixture or jig to hold the sphere and provide the four points to mark on the surface. A means to do this immediately came to mind, but the calculations required for the dimensions did not. Marty went to the highly educated group that he ate lunch with every day and posed the mathematical problem. He was sure that they understood what he was asking, but none of them would help. They gave a few ideas, but no answers. What he needed was a “simple” ratio.

Marty was reminded of this 47 year old “problem” because he recently unpacked the Styrofoam ball shown in figure one above. It had only four holes in it. He found four wood skewers and they fit perfectly into the holes. He also found a cardboard fixture that he had made and then it all made sense.

Forty seven years ago Marty had solved the four-equally-spaced-point-location-on-a-given-sphere problem (with sphere diameter, D), by constructing a polyhedron with four triangular faces, e.g. a pyramid with a triangular base. The idea is to drill a small hole in the center of each triangular face and hinging one side to open and insert the sphere to use as a fixture. Marty wanted the simplest fixture

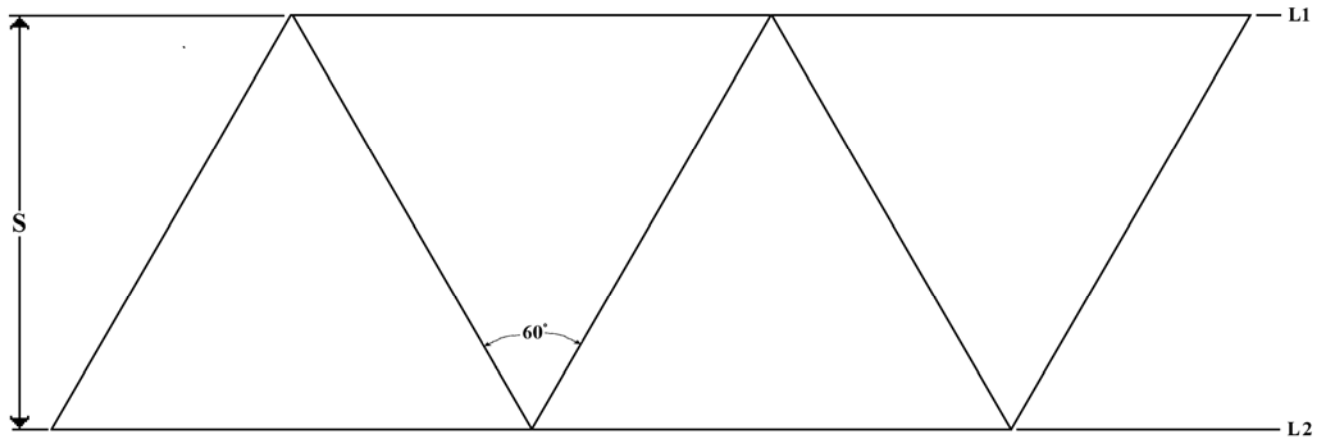


Fig. 2 – Equilateral triangles constructed by drawing two parallel lines, $L1$ and $L2$, with a spacing of S . design construction method by drawing two parallel lines on cardboard or sheet metal, and then drawing the sixty degree angles to cut the four triangles. See figure two above.

Marty used clear packing tape for the “hinge.” The three edges are spaced by the thickness of the material used for the sides. Smaller diameter toothpicks are used to locate the holes and show the sphere inside the fixture as shown in figure four.

Here is the problem. What is the relationship of the space between the two lines needed to construct the triangles, and the diameter of the sphere, D , in order to mark four equally spaced points on the sphere, e.g. $S = f(D)$?

This is the second problem in a series of real world practical problems offered as a challenge to *HP Solve* readers. Send your solution to the editor and if your solution is judged as the most practical, clear, using minimal math, and if needed, a calculator, it will be published in *HP Solve*.

The winning idea is to give a clear step by step explanation of the solution. Is it obvious that the sphere is tangent to the surface of the triangular sides? The published solution winner will be determined by the following.

1. The decision of the judge(s) is final.
2. The description and clarity of the solution.
2. The use of graphics, if needed, to make understanding the solution easier and clearer.
3. The use of minimal mathematics, i.e. algebra instead of calculus.
4. The use of an HP Calculator if helpful.

What Marty wanted was a relationship between S and D. He remembered spending a lot of time doing the math and then finding that the relationship was very simple. He is fairly sure that he remembered that relationship, but he would like independent confirmation.

Figure three shows how the four cut triangles are configured. The marking/drill holes are located by drawing a line normal to the side at the half way point on two sides. The center (tangent point) is where the lines intersect.

Figure four shows his fixture with the two inch diameter sphere inside. The cardboard was obviously cut from an orange and black sign.

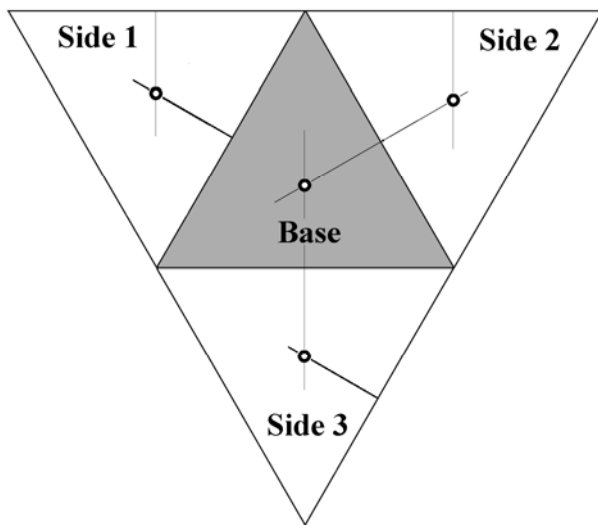


Fig. 3 – Fixture with marking hole locations shown.



Fig. 4 – Styrofoam sphere in fixture with four holes to mark the equally spaced locations on the sphere.

Extra “points” are possible if multiple solutions are provided, or if derivations of the solution equation/ratio are provided.

Remember, just getting the answer is not enough to distinguish your result from everyone else. Send your entry to the Editor. The dead line is before the next issue is posted.

Marty is still wondering how he derived the simple ratio after nearly five decades. He is so curious that he just may be able to come up with a prize for the *HP Solve* reader who sends in a clear, simple, and readable solution.

Fundamentals of Applied Math Series #2

[← Previous](#) **Article** – [Next →](#)

Numbers - Part II

Richard J. Nelson

Introduction

Numbers – Part I, in *HP Solve* Issue 18, outlined the guidelines for this series and set the scene by asking what is the “best” number to put into a calculator display for a photograph⁽¹⁾ (note at the end). A brief history of HP calculator displays was provided to illustrate the various considerations for the best display “number.” The numbers in Table One were keystroke/digit evaluated with the golden ratio, ϕ , suggested as one of the most interesting numbers. In terms of the guidelines provided, however, the golden ratio required a few too many keystrokes, especially if you are photographing multiple machines in the same photo - because of auto turn off.

Numbers, as a topic of popular interest, is interesting enough to merit its own U. S. prime time TV series - Numb3rs, 2005-????.



Fig. 1 – HP35s number keyboard is typical⁽²⁾.

Table 1 – Suggested Photographic Display Numbers

$\pi = 3.14159\ 26535\ 89792\ \dots$	$e = 2.71828\ 18284\ 59045\ \dots$	$\sqrt{2} = 1.41421\ 35672\ 373095\ \dots$
$\sqrt{3} = 1.73205\ 08075\ 68877\ \dots$	$\tan 7^\circ = 0.12278\ 45609\ 02906\ \dots$	$\phi = 1.61803\ 39887\ 49894\ \dots$

Every number has its own personality and Wikipedia accepts “number N” (N = number) as an input. The reader can explore his or her own favorite numbers to discover the personality of the numbers discussed thus far on Wikipedia. An example (including linked references if you want to explore advanced number concepts further) for the “Lucky” Number 7 is copied in shadow box 1 on the next page - from Wikipedia.

The mathematical details in Shadow Box 1 are only one aspect of the in depth information of the numbers that are included on Wikipedia. Shadow box (2) on page three shows the many other aspects of numbers that are also included. **What is your favorite number?**

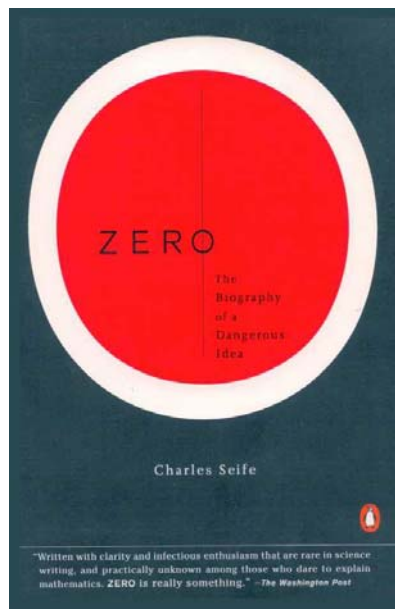


Fig. 2 – This entire book is dedicated to the concept of zero.

The reader may explore the history of how we have come to shape our numerals (zero to nine) by reading the many references provided by Wikipedia and other Internet references. Zero is such an important topic in itself that a 248 page book has been written on the subject. See figure two⁽³⁾ (note at the end). A simplified history of our numerals is shown on page 68 of the book. See figure four below.

Nine also has “special” value and a booklet has been written about “The rule of nine.” See figure three⁽⁴⁾.

This installment of the Math Review series will focus on numbers as related to their use on our calculators.



Fig. 3 – “9” checks +, -, ×, ÷, math.

1. Seven is the fourth prime number. (http://en.wikipedia.org/wiki/Prime_number) It is not only a Mersenne prime (http://en.wikipedia.org/wiki/Mersenne_prime) (since $2^3 - 1 = 7$) but also a double Mersenne prime (http://en.wikipedia.org/wiki/Double_Mersenne_prime) since it is itself the exponent for another Mersenne prime (127). It is also a Newman-Shanks-Williams prime (http://en.wikipedia.org/wiki/Newman-Shanks-Williams_prime), a Woodall prime (http://en.wikipedia.org/wiki/Woodall_prime), a factorial prime (http://en.wikipedia.org/wiki/Factorial_prime), a lucky prime (http://en.wikipedia.org/wiki/Lucky_prime), a happy number (http://en.wikipedia.org/wiki/Happy_number), a safe prime (http://en.wikipedia.org/wiki/Safe_prime) and the fourth Heegner number (http://en.wikipedia.org/wiki/Heegner_number).
2. Seven is the lowest number which cannot be represented as the sum of the squares of three integers.
3. Seven is the aliquot sum (http://en.wikipedia.org/wiki/Aliquot_sum#Definition) of one number, the cubic number (http://en.wikipedia.org/wiki/Cubic_number) 8 (http://en.wikipedia.org/wiki/8_%28number%29) and is the base of the 7-aliquot tree.
4. $n = 7$ is the first natural number for which the next statement does not hold: "Two nilpotent (<http://en.wikipedia.org/wiki/Nilpotent>) endomorphisms (<http://en.wikipedia.org/wiki/Endomorphism>) from \mathbb{C}^n with the same minimal polynomial (http://en.wikipedia.org/wiki/Minimal_polynomial) and the same rank are similar."
5. 7 is the only dimension, besides the familiar 3, in which a vector cross product (http://en.wikipedia.org/wiki/Cross_product) can be defined (http://en.wikipedia.org/wiki/Seven-dimensional_cross_product).
6. 999,999 (http://en.wikipedia.org/wiki/999999_%28number%29) divided by 7 is exactly 142,857 (http://en.wikipedia.org/wiki/142857_%28number%29). Therefore, when a vulgar fraction (http://en.wikipedia.org/wiki/Vulgar_fraction#Vulgar_2C_proper_2C_and_improper_fractions) with 7 in the denominator (<http://en.wikipedia.org/wiki/Denominator>) is converted to a decimal (<http://en.wikipedia.org/wiki/Decimal>) expansion, the result has the same six-digit (http://en.wikipedia.org/wiki/Numerical_digit) repeating sequence after the decimal point, but the sequence can start with any of those six digits.^[1] For example, $1/7 = 0.142\ 857\ 142\dots$ and $2/7 = 0.285\ 714\ 285\dots$
7. A seven-sided shape is a heptagon (<http://en.wikipedia.org/wiki/Heptagon>). The regular n -gons for $n \leq 6$ can be constructed by compass and straightedge (http://en.wikipedia.org/wiki/Compass_and_straightedge) alone, but the regular heptagon cannot. Figurate numbers (http://en.wikipedia.org/wiki/Figurate_number) representing heptagons (including seven) are called heptagonal numbers (http://en.wikipedia.org/wiki/Heptagonal_number). Seven is also a centered hexagonal number (http://en.wikipedia.org/wiki/Centered_hexagonal_number).
8. There are seven frieze groups (http://en.wikipedia.org/wiki/Frieze_group), the groups (http://en.wikipedia.org/wiki/Group_%28mathematics%29) consisting of symmetries (http://en.wikipedia.org/wiki/Symmetry_group) of the plane whose group of translations (http://en.wikipedia.org/wiki/Translation_%28mathematics%29) is isomorphic (<http://en.wikipedia.org/wiki/Isomorphic>) to the group of integers (<http://en.wikipedia.org/wiki/Integer>).
9. There are seven fundamental types of catastrophes (http://en.wikipedia.org/wiki/Catastrophe_theory).
10. Seven is the sum of any two opposite sides on a standard six-sided die. When rolling two standard six-sided dice (<http://en.wikipedia.org/wiki/Dice>), seven has a 6 in 36 (or 1/6th) probability of being rolled (1–6, 6–1, 2–5, 5–2, 3–4, or 4–3), the greatest of any number.
11. The Millennium Prize Problems (http://en.wikipedia.org/wiki/Millennium_Prize_Problems) are seven problems in mathematics (<http://en.wikipedia.org/wiki/Mathematics>) that were stated by the [Clay Mathematics Institute](http://en.wikipedia.org/wiki/Clay_Mathematics_Institute) (http://en.wikipedia.org/wiki/Clay_Mathematics_Institute) in 2000. Currently, six of the problems remain unsolved (http://en.wikipedia.org/wiki/Unsolved_problems_in_mathematics).

(1)

We learn our numerals (numbers) at a very young age. Any parent will be exposed and sensitized to this by the many books and materials that are available just about anywhere. Most children learn to count at

age two as they learn to talk. The critical aspect of this process is learning (by rote) the order of

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(2)

the numbers. We are able to automatically, mentally, order numbers⁽⁵⁾. Without thinking you will check the completeness of a deck of cards by arranging them by suit and numerical value. Ask any multilingual person to do a simple number problem or do something related to counting. Next ask this test subject what language he or she used for the numbers. The odds are very high that it will be the subject's native, first learned, language e.g. the speaker uses English but counts in German.

N1. Cardinal and Ordinal Numbers

Cardinal numbers are the numbers we have been talking about. They are the regular or normal numbers we use for counting. If, however we wish to indicate the position of a set of numbers we may use ordinal numbers such as the first, third, fifth, six hundredth, etc. These terms have strict definitions in Number theory and these aspects are best studied from a Number Theory reference..

N2. Counting Numbers

Counting Numbers are Whole Numbers, but without the zero. Because you can't "count" zero.

Computer and some calculator related "systems" do count starting from zero. This is done for convenient electronic implementation reasons. The first memory location of a program or series of registers is one not zero. Using zero as the "first" register is justified to maximize the number of registers with a single digit key designation/keystroke. See N7 below.

N3. Odd or Even Numbers

If a number (integer) cannot be divided evenly into two (equal) groups it is an odd number. The remainder will be 1. Odd numbers end with 1, 3, 5, 7, or 9. The oddness (an attribute) of a number is called its parity, which is most commonly used in computer science. An odd number has parity 1. The numbers -5, 17, and 153 have the same parity, 1. Numbers that are not odd are even.

Adding, or subtracting two odd numbers will always result in an even number.

If a number (integer) may be divided evenly into two (equal) groups it is an even number. Even numbers end with 0, 2, 4, 6, or 8. An even number has parity 0.

Adding, subtracting, or multiplying two even numbers will always result in an even number.

All combinations for adding, subtracting, or multiplying odd and even numbers are shown in Table two.

Table 2 – Math Operations of Odd and Even Numbers

Adding Even and Odd	Subtracting Even and Odd	Multiplying Even and Odd
even + even = even 2 + 6 = 8	even - even = even 6 - 2 = 4	even x even = even 6 x 2 = 12
even + odd = odd 8 + 3 = 11	even - odd = odd 6 - 3 = 3	even x odd = even 2 x 5 = 10
odd + odd = even 7 + 3 = 10	odd - odd = even 9 - 3 = 6	odd x odd = odd 3 x 7 = 21

Division of odd and even numbers that result in a fraction cannot be classified as odd or even because fractions are not odd or even numbers. The terms “odd number” and “even number” are only used for whole numbers and their opposites (additive inverses⁽⁶⁾).

N4. Negative or Positive Numbers

As we get older we learn to do arithmetic and typically by the 7th grade (age 13) students learn about negative numbers. One of the easiest ways to understand negative numbers is by visualizing a number line as shown below in figure five. The line extends infinitely⁽⁷⁾ in both directions. At the center is zero. The numbers to the left are called negative numbers. The numbers to the right are called positive numbers. Increasing positive values go to the right from zero. Increasing negative values go to the left from zero.

From a value perspective a negative three is equal to but “opposite” of a positive three. You may think about the result of comparing a positive and a negative number as two teams in a tug of war. If both sides are equal there is no movement along the line. If a positive (team) has a value of four and the negative (team) has a value of five the positive team are not able to with stand the extra value of one and the result is movement in the negative direction by one value.

We may visualize the addition of numbers by superimposing the values on the line. Adding +2 and +3, for example, extends the line value of +2 with the line value of +3 to get +5 as shown in figure six.

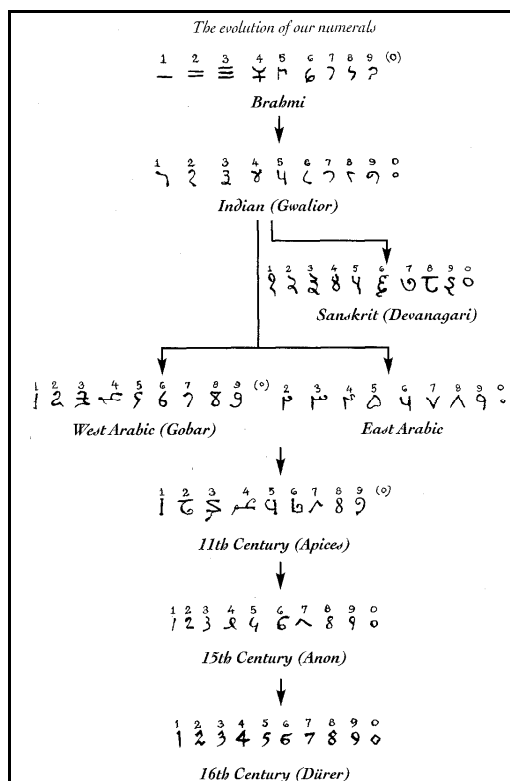


Fig. 4 – Evolution of our numerals.

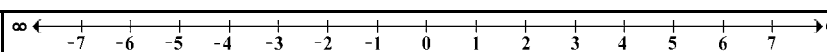


Fig. 5 – Numbers arranged on a line with zero in the center.

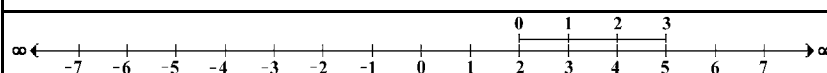


Fig. 6 – Adding positive numbers, +2 added to +3 has a value of +5.

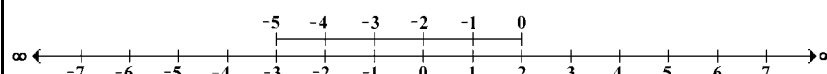


Fig. 7 – Adding -5 to +2 has a value of -3. See text.

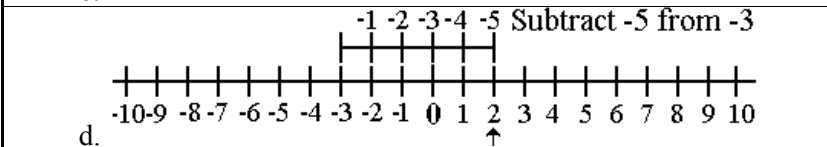
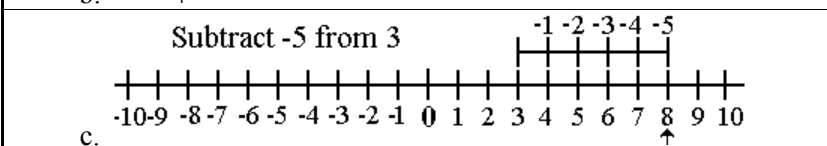
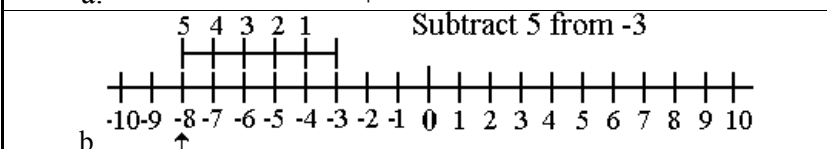
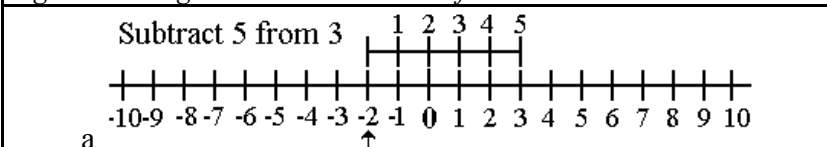


Fig. 8 – Subtracting examples. See table three

Negative numbers may seem confusing, especially if a larger negative number is subtracted from a smaller positive number. See figure eight of the four possibilities of positive and negative numbers. Zero is neither positive nor negative.

Adding and subtracting positive and negative numbers may be summarized as shown in table three.

Table 3 – Adding And Subtracting Positive And Negative Numbers

(a = 3 b = 5)

Variables - a & b	Adding	Add Result	Subtracting	Subtract Result
a b	$3 + 5$	8	$3 - 5$	-2
a -b	$3 - 5$	-2	$3 - (-5)$	8
-a b	$-3 + 5$	2	$-3 - 5$	-8
-a -b	$-3 - 5$	-8	$-3 - (-5)$	2

The sign rule is: Subtracting a negative number (two negatives, e.g. $3 - (-5)$) is the same as adding.

N5. Integer or Decimal Numbers

Integer numbers are natural numbers (defined in a strict rigorous mathematical sense is beyond the level of this fundamental review) include the whole numbers both positive and negative.

The definition of an integer is consistent with usage so when in doubt say "integer", and if you only want to include positive integers, say "positive integers". This is more accurate and being specific makes you sound intelligent. Zero is (normally) neither positive nor negative.

Two numbers that form a fraction with a normal remainder, e. g. $1/4$, may be represented as a decimal; 0.25. Two divided numbers that form a remainder that that does not repeat or terminate are called irrational numbers. See **N9**. below.

Some fractions result in a decimal number that repeats a series of digits. These are called repeating decimals. Examples are $1/7 = 0.\underline{142857}1428\ 571\dots$ with 6 repeating digits immediately after the decimal point; $1/17 = 0.\underline{0588235294117647}0588\ 23529\ 411760\dots$ with 16 repeating digits starting in the hundredths place, $1/19 = 0.\underline{0526315789473684210526}315\ 78947\ 36842\ 10\dots$ with 18 repeating digits. Note that the last two examples would not be noticed as repeating decimals on your average calculator.

Many high end scientific and graphing calculators have functions that separate the integer and decimal parts of a number. These functions are especially useful when formatting and converting numbers into various forms. See **N8** below.

N6. Real Numbers

In computing, a "real number" often refers to non-complex floating-point numbers.

In practical mathematics (vs. number theory), the real numbers include both rational numbers, such as 42 and $-23/129$, and irrational numbers, such as e and $\sqrt{2}$ or, a real number can be given by an infinite decimal representation, such as 2.48717 73339 ..., where the digits continue in some way; or, the real numbers may be thought of as points on an infinitely long number line.

N7. Being Consistent

Not all number users are consistent. This may be confusing, and some people say that whole numbers can

also be negative, so that would make them exactly the same as integers. Sometimes people say that zero is NOT a whole number. How strict you are will depend on your college major, e.g. mathematics or engineering.

Calculator convenience is often balanced with consistency. It is the nature of people to avoid being boring by adding variety which often leads to being inconsistent. While this quality has no place in mathematics, science, or engineering, people are involved, and they will naturally be inconsistent regardless of their training or education. Table three provides examples of the various kinds of basic numbers.

Table 3 –Numbers

Number Type	Examples
Whole Numbers	0, 1, 2, 3, 4, 5, ...
Counting Numbers	1, 2, 3, 4, 5, ...
Integers	... -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, ...
Negative Integers	..., -5, -4, -3, -2, -1
Non-Negative Integers	0, 1, 2, 3, 4, 5, ...

N8. Formatting and Expressing Numbers

Calculator numbers are floating point, or optionally on high end graphing models, integer. A few models have a special fraction mode. Floating point numbers include a fixed number of decimal digits displayed, usually 8, 10, or 12 digits. The separator used between the integer part and the decimal part is called the radix. In the US and many other countries the radix is a period. Many European countries use a comma radix.

When very large (long) numbers are involved there are two common methods for grouping the digits to allow the eye to more easily discern (count) the number of digits.

The method used with a period radix is to add a comma separator every three digits. An example is 35 million⁽⁸⁾ dollars. In the US the radix is a decimal point and the 1,000's separator is a comma. 35 million dollars is \$ 35,000,000.00. In Europe this same number is expressed and calculator displayed as \$ 35.000.000,00. If you are used to seeing one format the other seems very strange and confusing. Most HP calculators may be set to display the numbers in either format.

The second common method for conveniently dealing with long strings of digits uses a space inserted every five digits. Table one on the first page uses this method. Calculators do not use this format – unless specifically user programmed to display numbers in this way.

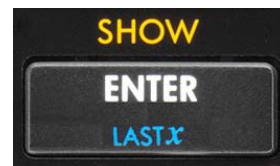
HP calculators have various display modes to show the number in a format that is most suitable for the application. The most common modes are fixed, scientific, and engineering. Each mode requires you to specify the number of digits. The display mode setting does not change the number, it only changes the way it is shown in the display, and you may change the display mode at any time. The display value is rounded to the number of display mode set decimal places⁽⁹⁾. Some machines have a display mode called ALL which may be also found on the HP35s.

Fixed mode is most popular with business users and this is usually the default mode. A fixed two mode shows dollars and cents. The \$35M example in fixed two mode displays as 35,000,000.00. If the display was set to fix 5 it would show 35,000,000.00000 in a 12 digit display because the display limits the number of decimal digits shown. Divide the number by 10 and the display shows 3,500,000.00000. Divide again by 100 to show 35,000.00000.

Scientific mode shows the number as a multiplier of a power of ten. 1,000 is shown as 1×10^3 . Most calculators use “E” in the display for the “10”. The 35 million example in SCI 1 would be displayed as 3.5E7. Multiply by 10 to see 3.5E8. Change to SCI 2 mode to see 3.50E8.

Engineering Mode displays the number similar to Scientific mode in such a way that the exponent is always a multiple of three. The 35 million example in ENG 1 would be displayed as 35E6. Multiply by 10 to see 350E6. Multiply by 10 again to see 3.5E9. The 3.5 part is called the mantissa and the “E” part is called the exponent. These values may be positive or negative. Note how the mantissa is changed until the exponent reaches a multiple of three and then the mantissa will show the number of digits based on the number entered when the Engineering mode was set.

ALL Mode displays all that it can with commas. Our 35 million example is displayed as 35,000,000 without a decimal point. If the number of digits is too high it reverts to displaying in scientific mode.



There is also a SHOW “display mode.” If 35 million, or any number, is in the display you may also press the left shifted SHOW key, see figure nine, to display the full precision of the number in the machine. The SHOW key must be held down to display the view. This display mode makes maximum use of the display and may or may not show the decimal point. Table four shows how selected number examples will appear in the HP35s display using each of its four display modes plus SHOW. The high end graphing models have an additional display mode called standard. It is similar to ALL.

Table 4 –Example Numbers Shown in Each Display Mode Plus SHOW

Number & (setting)	FIX	SCI	ENG	ALL	SHOW
-123.45678910 (3)	-123.457	-1.235E2	-123.5E0	-123.34567891	123.3456789100
2.71828182846 (5)	2.71828	2.71828E0	2.71828E0	2.71828182846	2.71828182846
2.71828182846E-6 (4)	2.7183E-6	2.7183E-6	2.7183E-6	2.71828182846E-6*	271828182846
-3.14159265359E-4 (4)	-.0003	-3.1416E-4	-314.16E-6	-3.14159265359E-4*	314159265359
0.121869343405 (9)	0.121869343	1.218693434E-1	1218.693434E-3	1.21869343405E-1	121869343405
-0.000000765532 (3)	7.655E-7	7.655E-7	765.5E-9	7.65532E-7	765532000000

* indicates that the number exceeds the width of the display and the display must be shifted to the right with the right cursor key.

Numbers may be represented in various ways. For example:

- $15 = 1 \times 3 \times 5$ showing the factors of 15.
- $15 = 3 * 5 = 15$ using the asterisk symbol for multiplication.
- $15 = 2^4 - 1 = 15$ as expressed as powers of two.
- $15 = 1.5 \times 10^1$ as expressed using scientific notation.
- $15 = 15.00$ may be expressed to imply two decimal places of precision.
- $15 = 30/2$ as expressed as a fraction.
- Half a minute past noon as a time may be expressed as 12:00:30 using the form HHMMSS
- Dates are another example of the variability (to deal with boredom) of using numbers. Most readers have experienced the “set up” process with most hand held devices that have a built in calendar. In the US the format is MMDDYYYY. In Europe the format is DDMMYYYY. If you spell out the month and use numbers for the day and year you must insert a separator between the day and year to avoid confusion.

If you may abbreviate the year to two digits the format YYMMDD provides a nice six digit date that may be easily and correctly sorted by date. The beginning of the year is 100101, mid year is 100701, and the last day of the year is 101231. This is the Japanese custom to display dates.

N9. Precision, Accuracy, and Rounding

Calculator displays will display a resolution of 8, 10, or 12 digits. Most users expect that the answer they see in the display is correct, i.e. accurate. If the display is 12 digits and the answer of $\sqrt{2} = 1.41421\ 3562\ 373095 \dots$ what should the last digit in the 12 digit display be? Based on the answer above it should be a 7 and most machines will show a seven for the 12th digit.

The 12 digit calculator will perform its calculations to more digits than you see in the display. The extra digits, typically a total of 15 for a 12 digit machine and 13 for a ten digit machine, are called guard digits.

Two questions should immediately come to mind.

- (1) Should the guard digits be retained and used for additional calculations, and
- (2) should the display show the number truncated (simply cut off at the last digit) or rounded?

The vast majority of HP calculators do not use the guard digits for the next calculation. What you see in the display when the machine stops running is what you get. This is not true of most other brands of calculators. A favorite “test” many students will make is to take the square root of a number ten times and then square the result ten times and compare the result with the input number. The results will greatly vary and surprise you.

Let’s use $\sqrt{3} = 1.73205\ 08075\ 68877 \dots$ as a test number. Begin with the number 3 and take the square root ten times. On most current HP machines and you will see 1.00107343828. Square this answer ten times and the display will show 3.00000000835. Is this answer wrong? It should be 3. Is it possible to have a 12 digit calculator “be accurate enough” to produce 3? The answer is NO! Accuracy describes how close the result calculated by a calculator is to the true value, as opposed to how close the displayed result is. The reason is beyond the level of this math Review. The most important question to ask is: Do other calculators get a “better” answer. In order to make a test your self you must take the square root, clear the machine, and enter the result for each calculation because many other machines retain the guard digits and the error propagates.

The accuracy aspect of a calculator is a topic beyond of this brief numbers review⁽¹⁰⁾.

Rounding is another complicated and confusing issue.

Suppose you have the following three numbers, examples A – C, to round to two decimal places. I have added two spaces at the point where the number is to be rounded.

- A. 13.98 132411
- B. 13.98 532411
- C. 13.98 932411

In the first case the result is clearly 13.98 because the following digits are very small so they are dropped. In the last case the result is clearly 13.99 because the following digits are very large so 1 is added.

It is the middle case, B, where there is an issue. The 5 is right in the middle of 13.98 and 13.99. In other words there is a tie. What is the best method of treating the “5” case? You could argue that since the

decimal digits following the five are so small that you should drop it. You could dream up all kinds of complicated rules to decide this middle “5” case and you will find many rules if you research the rounding issue. When rounding you first consider the number of decimal digits you are rounding to. If it is three digits the fourth digit is all that is considered. You don’t care what the fifth and additional digits are.

Rounding is different from “rounding up” or “rounding down” or “truncating.”

The “rule” taught in most elementary schools (especially in the US) however, is what is often called the 5/4 rule. You always round up if “5” and higher and you round down if 4 or lower. This rule is followed by nearly every calculator made – because it is simple? Since *HP Solve* is read internationally I would love to hear from our non-US readers what they learned in school. **How were you taught to break the tie of the middle five?**

I learned a different rule. I learned what I remember as the Astronomer’s Rule of rounding. If you have a “5” tie situation you round up if it makes the preceding digit even other wise you don’t. The idea is that statistically you spread the “favoritism” around statistically evenly. If you want to delve into the subject of rounding you may find a very good article at: <http://en.wikipedia.org/wiki/Rounding>

N10. Significant digits

The idea of significant digits is to recognize that data and calculations result in a lot of digits in numbers that are not really significant. It is like the links in a chain. The chain is only as strong as the weakest link. The number of digits is only as accurate as the smallest number of known accurate digits involved.

Suppose you have a number of measurements involving instruments of known accuracy. Don’t confuse the number of accurate digits with the number of resolution or precision digits. You may measure the voltage of a battery to five digits, but the accuracy of the measurement may only be good to three digits. The added digits of resolution are useful for trends and comparisons, but not useful for truth (accuracy).

The number of significant digits is the number of accurate digits. You simply round the number of all the other numbers to the number of significant digits.

What are significant digits? Here is one explanation from: http://www.physics.uoguelph.ca/tutorials/sig_fig/SIG_dig.htm

“Non-zero digits are always significant. Thus, 22 has two significant digits, and 22.3 has three significant digits.

With zeroes, the situation is more complicated:

- a. Zeroes placed before other digits are not significant; 0.046 has two significant digits.
- b. Zeroes placed between other digits are always significant; 4009 kg has four significant digits.
- c. Zeroes placed after other digits but behind a decimal point are significant; 7.90 has three significant digits.
- d. Zeroes at the end of a number are significant only if they are behind a decimal point as in (c). Otherwise, it is impossible to tell if they are significant. For example, in the number 8200, it is not clear if the zeroes are significant or not. The number of significant digits in 8200 is at least two, but could be three or four. To avoid uncertainty, use scientific notation to place significant zeroes behind a decimal point:

e.

8.200×10^3 has four significant digits
 8.20×10^3 has three significant digits
 8.2×10^3 has two significant digits”

Understanding and using significant digits and rounding are two vital aspects of dealing with numbers when we use calculators.

N11. Rational or Irrational Numbers

This important topic will be discussed in Part III.

N12. Ordered (Pair) Numbers

This important topic, rectangular coordinate points, complex numbers, polar coordinates, and vectors, will be discussed in Part III.

N13. Prime Numbers

This important topic will be briefly discussed in Part III.

Conclusion

Calculators, by their very nature deal with numbers. We must understand numbers if we are going to correctly and accurately use a calculator to do the hard work of number crunching. Ten aspects of numbers are discussed in part II of a three part series. The short review includes references and links to more advanced aspects of the topics reviewed.

N1. Cardinal and Ordinal Numbers

N2. Counting Numbers

N3. Odd or Even Numbers

N4. Negative or Positive Numbers

N5. Integer or Decimal Numbers

N6. Real Numbers

N7. Being Consistent

N8. Formatting and Expressing Numbers

N9. Precision, Accuracy, and Rounding

N10. Significant digits

The last part, Numbers – III, of the Number series will focus on the following topics.

N11. Rational or Irrational Numbers

N12. Ordered (Pair) Numbers

N13. Prime Numbers

Notes

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- (1) *The photographic calculator display question was actually the basis for a “contest” held on the Internet. The winner was Joseph K. Horn who provided a Meta solution. He wanted very specific restrictions on the number and he decided that he would provide “all solutions” depending on the restrictions you may apply. You may see his “number” answer at: <http://holyjoe.net/hhc2009/contest1.htm>. All seven contest related documents may also be found at this link.*
- (2) *Technically the numeric key pad layout hasn’t been quite as stable as it might first appear. The non-zero digit order has been consistent, but the bottom row containing the zero and decimal point has moved around on the nearly 100 models of HP calculators. Jake Schwartz has extensively analyzed HP’s calculator keyboards and you may find the results in an HP Handheld Conference (HHC), paper titled “HHC 2000 Survey of HP Calculator numeric keypads.” <http://www.pahhc.org/2010/Articles/HHC2000%20A%20Survey%20of%20HP%20Numeric%20Keypads.pdf> The tables in his paper also include model attributes such as usage (business, scientific, etc.), logic system, programmability, solver, CHS, exponent, and ENTER keys.*

- (3) "ZERO, The biography of a Dangerous Idea" by Charles Seife copyrighted Charles Seife, 2000, and published by Penguin Books, is soft bound, 5" x 8", 248 pages. A review by the Atlanta Journal Constitution puts the book into perspective. "Mathematicians, contrary to popular misconceptions, are often the most lucid of writers (Bertrand Russell won a Nobel prize not in mathematics, but in literature), and Seife is a welcome example. He writes with an understated charm that takes account of human fear, the mistakes of geniuses, and the mind's grandest ambitions."
- (4) "The Rule Of Nine, Simplified and Expanded" by William Wallace Jr. copyrighted 1959 is published by the United States Naval Institute. The booklet is 6" x 9" and 27 pages. ISBN 0-87021-555-8. Library of Congress Catalog Card No. 59-12077, second printing 1970. The essence of the rule is a method (system) of reducing all numbers to a single digit. Is the number 2,835 divisible by 9? Yes, because the sum of the digits $2+8+3+5 = 18$, and the sum of these digits $1+8 = 9$. Addition, subtraction, multiplication, and division operations may be verified by applying the rule of nine. This is an example of accuracy checking math before we had calculators. Now our mistakes are those of entering the numbers into the calculator e.g. pressing the wrong keys. There is a newer version of a similar book by another author.
- (5) I add numbers to images in my article file so I may quickly find what I need. While proofing an article I note the figure number, open and find the image, edit it, save it, and then insert the new version. Working with image names only is less productive, e.g. F01 No. keyboard. Another advantage is that the "F" numbers place the images in the proper order.
- (6) Additive inverses in mathematics is the opposite. A number b is the number that, when added to b , yields zero. The additive inverse of N is denoted $-N$. For example, the additive inverse of 13 is -13 , because $13 + (-13) = 0$, and the additive inverse of -0.5 is 0.5 , because $-0.5 + 0.5 = 0$.
- (7) "Infinity" is not a place nor is it a "number" in the real number sense. Many mathematics teachers will say that the lazy eight symbol represents an "infinitely large value." Most number line representations do not include the infinity symbol and I included it for emphasis. The symbol in MS Word, from the symbol table, is not accurate because the mathematics symbol is symmetrical about the center ∞ VS ∞
- (8) A million is 1,000,000 or 10^6 in the US and a billion is 1,000,000,000 or 10^9 .
- (9) Setting the display mode larger than 9 digits requires a special key sequence. See your owner's manual for details. Using an HP35s, for example, requires you to first press the decimal point key which puts a "1" into the display for 10 or 11. All other digits after pressing the decimal point, and "1" is displayed, are ignored.
- (10) One well-known and respected expert on numerical computation accuracy is William Morton Kahan of the University of California, Berkeley. Check <http://www.eecs.berkeley.edu/~wkahan/abstrcts.txt> for a few of his papers. Readers interested in calculator accuracy must read: <http://www.eecs.berkeley.edu/~wkahan/MathSand.pdf> The HP15C is specifically mentioned and he consulted with HP on this machine. Kahan was the primary architect of IEEE 754-1985 standard of floating point computation. He and his graduate students developed programs to run on most computers and many calculators to determine potential floating-point bugs as avoidable and unavoidable. Especially well known is "paranoia." Kahan is very vocal when computational accuracy is involved and he coined the phrase "The Table-Makers Dilemma." The HP-71B is the only calculator to fully incorporate the standards of IEEE 754.

About the Author



Richard J. Nelson has written hundreds of articles on the subject of HP's calculators. His first article was in the first issue of *HP 65 Notes* in June 1974. He became an RPN enthusiast with his first HP Calculator, the HP-35A he received in the mail from HP on July 31, 1972. He remembered the HP-35A in a recent article that included previously unpublished information on this calculator. See <http://holyjoe.net/hhc2007/Remembering%20The%20HP35A.pdf> He has also had an article published on HP's website on HP Calculator Firsts. See <http://h20331.www2.hp.com/Hpsub/cache/392617-0-0-225-121.html>.

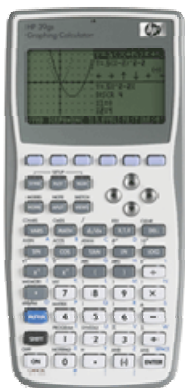
HP - Interactive learning for the 21st Century Classroom

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HP — Interactive learning for the 21st Century Classroom

June 3, 2010



"With other calculators I've tried, I've had to take a few minutes out of every class period to teach the students how to use the calculator on that day's lesson. With the HP calculator, the students just grab their calculators and go."¹



Learning Has Changed

Kids learn differently today, so our technology and teaching methods must adapt. HP designed the affordable, easy-to-use 39gs Graphing Calculator and free calculator projection software (shown above) to enable math teachers to spend more time teaching and less time showing students how to use their calculators.

We also provide learning activities and teacher training so that our calculators can seamlessly integrate into math curriculum. The 21st Century classroom needs more than just technology, so we offer low-cost tools, training, and integrated curriculum.

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HP provides educators with complimentary software versions of our calculators. Send your request to: emulators@hp.com

*Products may qualify for use of Title I Funds

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¹Quote courtesy of Joel Gaines, mathematics teacher, South San Antonio Independent School District.

HP Solve Newsletter

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Interested in Joining the HP Calc Club and Receiving *HP Solve*, our Free Bi-monthly Calculator Newsletter?

As a member of the HP Calculator Club, you will have access to HP Discounts and Special Offers as well as to free applications (applets) for your HP calculator. You will also receive our bi-monthly calculator newsletter, which is full of helpful tips and learning activities for professionals, educators, and students.

It only takes a few minutes to sign-up. Follow the instructions listed below use the detailed instructions on the next page.

Step 1: Go to www.hp.com/calculators and click on the link that says “Newsletters” on the right-hand side of the page under the “Calculator Community”

Step 2: The following page will tell you a little bit about the HP Calculator newsletter and prompt you to click the link that says, “Click Here to Sign UP”

Step 3: Fill out the HP Passport form. Passport allows you to enter all HP passport-enabled websites with one universal username and password. Think of it as a simple, secure portal to HP. It also allows you to choose what information you wish to receive from HP and how you would like to receive it (ie. e-mail, postal mail, or phone, or not at all). Passport is the HP way of ensuring that you can access all the HP material you want but never have to receive information you don’t want.

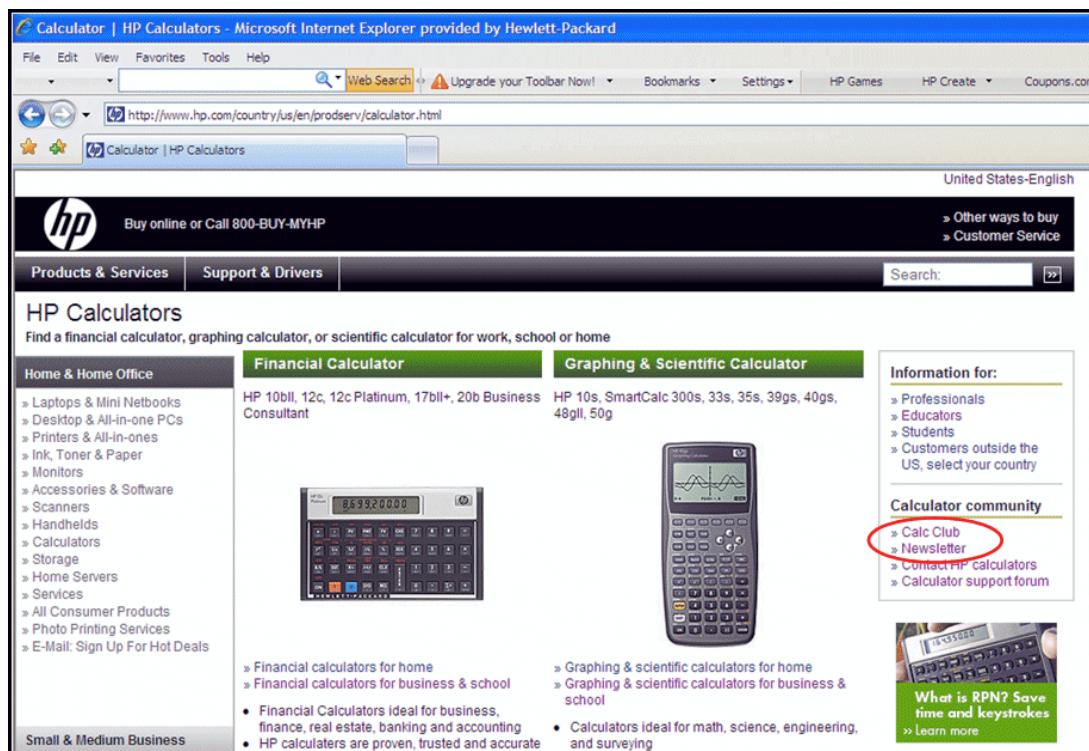
Step 4: You may be prompted to fill information about your HP calculator, such as model and serial number. If you don’t have the serial number, just enter “000000000.” This just lets us know what calculators our HP fans are using so that we can better tailor our offers and newsletters to your needs.

Step 5: Welcome to the HP Calculator Club!

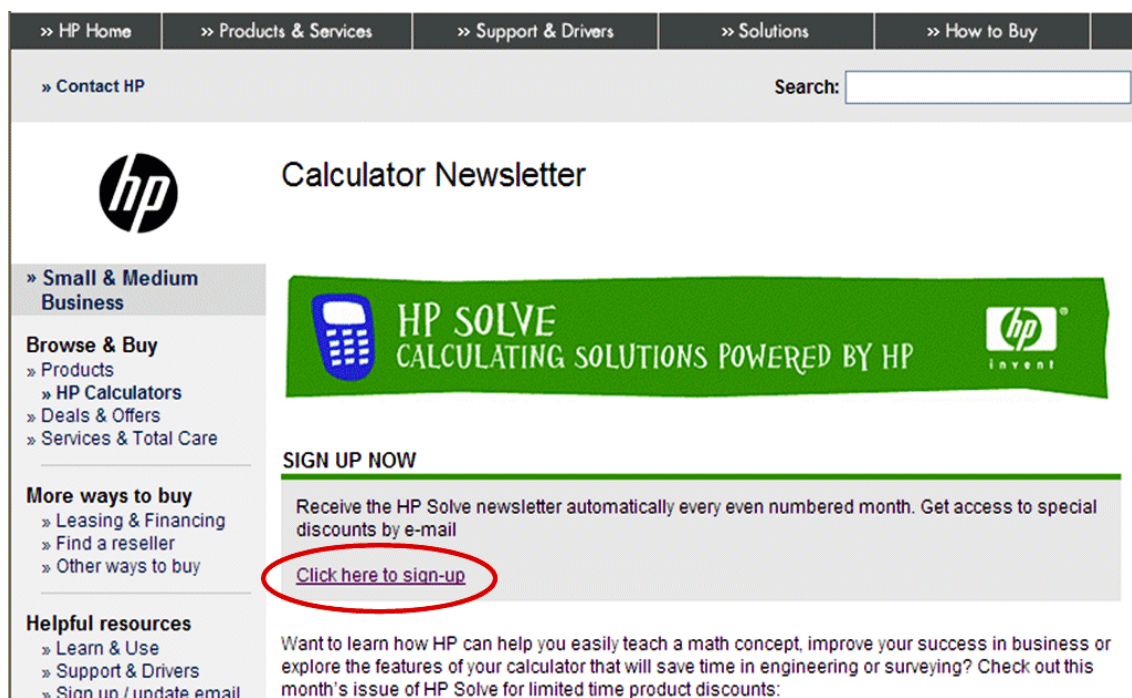
You will now receive our bi-monthly newsletter, and you will also have access to HP discounts, special offers, and complimentary applications (applets) for your HP calculator. You can give us feedback about our calculators through the HP Calculator Forum. Please feel free to let us know what you would like to see from us on the HP Calculator Club site and we will do our best to oblige.

How to Join the HP Calculator Club and Sign Up to Receive HP Solve, our Free Bi-monthly Calculator Newsletter:

Step 1: Go to www.hp.com/calculators and click on the “newsletter” link on the right side of the page.



Step 2: Click on the link that says, “Click here to sign up.”



Step 3: Fill out the HP Passport form as shown below. Passport allows you to access all HP passport-enabled websites with one universal username and password. Think of it as a simple, secure portal to HP. It also allows you to choose what information you wish to receive from HP, if any, and how you would like to receive it (ie. e-mail, postal mail, or phone).

The screenshot shows the 'HP Passport new user registration' page. On the left is a sidebar with the HP logo and links: '» Contact HP', '» Back', '» New user registration' (highlighted), '» Forgot password', '» Forgot user ID', and '» About HP Passport'. The main content area has a title 'HP Passport new user registration' and a description: 'HP Passport is a single login service that lets you register with HP Passport-enabled Web sites using a single user identifier and password of your choice.' Below this is a legend '* = Required field'. The form is divided into three sections: 1. 'Sign-in information' with fields for 'User ID*' (hpCalcFan), 'Password*' (masked), and 'Confirm password*' (masked). 2. 'Personal information' with fields for 'Title (Mr., Ms.)' (Mr.), 'First name*' (John), 'Middle name' (empty), 'Last name*' (Doe), 'E-mail address*' (john.doe@noname.com), 'Preferred language*' (English dropdown), and 'Country/Region of residence*' (United States dropdown). 3. 'HP Privacy policy' with a paragraph of text and a link to the 'Online Privacy Statement'. Information icons (i) are present next to the User ID, Password, Title, and Privacy policy sections.

Step 4: Sign in using HP Passport

The screenshot shows the 'HP Passport sign-in' page. The sidebar is identical to the registration page, with '» New user registration' highlighted. The main content area has a title 'HP Passport sign-in' and a description: 'HP Passport single sign-in service lets you use one user ID and password of your choice to sign-in to all HP Passport-enabled Web sites.' Below this is a legend '* = Required field'. The form is divided into two sections: 1. 'Sign-in to HP Passport' with fields for 'User ID *' (hpCalcFan) and 'Password *' (masked). 2. A checkbox for 'Remember my User ID on this computer'. Below the checkbox is a link '» New users - please register'. At the bottom right, there is a security icon and the text 'HP Passport is secure' next to a 'Sign-in »' button.

Step 5: Fill in information about your HP calculator, if you own one, and Click “Register”
This should take you to the following page:

[» HP Home](#) | [» Products & Services](#) | [» Support & Drivers](#) | [» Solutions](#) | [» How to Buy](#)

[» Contact HP](#)

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☒ Calculators site ☐ All of HP US



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Related links

- » Register your product
- » Register for information
- » Reseller locator
- » Press releases

Support

- » Product comparison
- » Calculators Support (includes retired models)
- » Contact HP

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Welcome to the HP Calculator Club! You will now receive our bi-monthly newsletter, and you will also have access to HP discounts, special offers, and complimentary applet downloads for your HP calculator. You can give us feedback about our calculators through the HP Calculator Forum. Feel free to let us know what you would like to see from us on the HP Calculator Club site and we will do our best to oblige.