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In what hopes to become a regular column, here's an opportunity to showcase your ability to solve problems.



» **HP 48 One Minute Marvel – No. 5, Electronic Stopwatch**

Marvel in these One Minute Marvels from HP. This month,



» **Fundamentals of Applied Math Series #1**

Richard J. Nelson

This new series looks to

Issue 18 May 2010

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From the Editor

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From the Editor

Hey *HP Solve* reader,

Welcome to the 18th issue of *HP Solve*. As you may have noticed this issue has a new editor, me, Richard J. Nelson. This is my fifth HP calculator newsletter to edit, and the seventh HP calculator news letter to have published my articles. One of the most important lessons that I have learned from this experience is that the reader is the most important part of any publication. This means that I (and the HP calculator staff) want to hear from you, and that I will promptly respond both in person and in the newsletter. Send me email at: hpsolve@hp.com.

HP Solve, as I would like to see it, is of, and about you – the student, the teacher, the business person, and the technical person (engineer, surveyor, etc.). Since we are HP calculator based the range of topics should be related to the purchase, support, analysis, use, and the future of HP Calculators.

Some topics may not be appropriate simply because they are addressed by other resources that HP offers. These resources are also a topic of the newsletter and I hope that eventually this publication will be the first resource to check for HP calculator usage. At least that is one of my personal goals. Examples of this approach are described below.

You will notice some changes in this issue, and there will be more changes to come. The basic structure remains the same for now because of system limitations. It is more complicated than you might expect simply because the systems were not designed to be good at newsletter publishing. The content, however, is what is most important - and that is very much up to you.

It will take a few issues to reach our stride, as I hope to we will. This issue will illustrate these goals so let me briefly mention the articles.

HP 82240B IR Printer. This somewhat specialized HP accessory is described in an article that covers it in detail and it will illustrate what I said above in terms of serving as a reference or starting point on the subjects we will address in these pages. First, the product is fully described in all of its glory and short comings. Second, it is well photographed so you really know what it looks like. Thanks to Eric Rechlin for his photos. Third, it provides a fair amount of detail in terms of what it is and how it works. Forth, it provides the current resources - links – for additional information. If you search the Internet you will find lots of fluff, but not nearly as much stuff as this article provides. The list of 24 HP calculator models that uses the printer is an example. It seems that that there is a lot of copying among the web sites that include the HP 82240B IR printer. The problem is that so many are incorrect.

The HP 30b Business Professional is the newest HP business calculator and it is reviewed in detail by Gene Wright. Gene is an experienced finance professional and his detail and insight provides a close look at the HP30b. A link to an extensive list of HP Learning Modules is included.

RPN Tips. This popular “regular column” has appeared in all issues of *HP Solve*. Since I have written these I can use them as an example of what I mean by providing information not found elsewhere. I challenge even the most experienced HP user to send me the answers to the questions asked about ENTER in that article. What was the first HP-35A ENTER key color? Why was it changed to blue?

Cutting a Circle problem. Here is an opportunity to show your ability to solve problems. That is what calculators do, right. I also hope that Problem Solving becomes a “regular” column.

One Minute Marvels. This relatively new “column” is an example of RPL programming. How many readers are finding this topic of interest? If you don’t express your approval or disapproval we can’t change or improve.

Math Review Series. Again you have to let me know if you find this approach to explaining the math that we use with our calculators. The approach I would like to use is defined in this first of many future (I hope) articles on the Fundamentals of Applied Math Series. Part II will really illustrate the point.

I hope that you find this issue interesting reading. From this simple beginning, with your help, we will continue to provide serious (in technical content) articles to enhance your HP calculator experience.

X <> Y,

Richard

About the Editor



Richard J. Nelson is a long time HP Calculator enthusiast. He was editor and publisher of *HP-65 Notes*, *The PPC Journal*, *The PPC Calculator Journal*, and the *CHHU Chronicle*. He has also published articles in *HP65 Key Note* and *HP Key Notes*. As an Electronics Engineer turned technical writer Richard has published hundreds of articles discussing all aspects of HP Calculators. His work may be found on the Internet and the HCC websites at: <http://hhuc.us> He proposed and published the PPC ROM and actively contributed to the UK HPCC book, *RCL 20*. His primary calculator interest is the User Interface.

HP 82240B IR Printer

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HP 82240B IR Printer

Introduction

The HP 82240B Infrared printer is a portable thermal printer that works with 24 HP calculators. This oldie but goodie HP accessory is a battery powered wireless printer that was specifically designed for printing graphics. An example is the printed calendar shown in figure one.

Often called a “whistle printer” by users, see figure two, the 82240B printer may also be AC power line operated. The HP F1011A (a small and light switcher adapter) or the HP 82241A (larger and heavier linear adapter) may be used. See figure five. Also see the **Printer & Paper Specifications** section below for other power options. The 82240B is also called a strip printer.

The 82240B is suitable for use with the current HP 17bII+, 39gs, 48gII, and 50g. It works well with the older models: HP 17B, 17BII, 18B, 19B, 19BII, 27S, 28C/S, 38G, 39G, 42S, 48S/SX/G/G+/GX and 49g+. It also works with the HP-41C/CV/CX with an HP 82242 IR module. See figure six.



Fig. 1 – HP 82240B IR Printer is able to print graphics and text from 24 HP calculator models.

The primary IR Printer users are students (math and technical), and commercial users. These users need a small portable printer that is practical to be carried with the calculator. This is important because of the many other things that are also carried around such as text books, smart phone, eBook reader, mini computer, etc.

The primary use in these situations is printed results for homework and confirmation of input and output data such as long equations and complex math representations involving fractions, exponents, and integrals. The commercial user will print receipts, business cards, and invoices for deliveries. Game playing, while a popular use of the calculator, usually does not require a printer. An exception might be board games such as checkers or chess. Another consideration is the ability to rotate the printed material down the paper as well as across as needed. The 82240B has the ability to print a large graphic in strips which may be assembled into a much larger image. See example in figure nine.

Very few users write programs. For those that do, the use of a printer is a very good debugging aid and it provides a fast easy means of documenting the program. Documenting a program is vital if the program is used at a later time and the details are forgotten.

Do you need a portable wireless printer for your calculator? Here is a list of 11 reasons why you might buy an HP 82240B IR printer.

1. To document your machine. Printing all the variables in your machine provides you with a printed record of programs, variables, and data.
2. To print outputs of programs. Some programs output large digit numbers, detailed text, or large quantity of outputs that makes a printer essential. The inputs printed with the outputs are important.

3. To print large tables in multiple strip form. This is useful if another printer is not available.
4. To print screens from your calculator that are difficult to capture any other way.
5. To illustrate articles, books, class lessons, technical notes etc.
6. To speed up your programming. By being able to list your programs you may more easily "pencil" edit them and reduce errors when making changes on the machine. Program development time is easily cut in half.
7. To print plots, especially large plots. See figure nine.



Fig. 2 – The IR Printer looks like a big “whistle.”

8. To print banners and other large special graphical signs.
9. To print bar codes.
10. To print receipts, business cards, and invoices.
11. Printing special graphics is a fun programming exercise and this is good way to better understand how “computers” work.

IR Printer: "A" Vs. "B" Model

The HP 82240A IR Printer was first introduced in late 1986. Because it is a graphics printer the bottom of characters with descenders (lower case g, j, q, & y) touch the character below it. An improved model, the HP 82240B was introduced in late 1989. The "B" printer model has four improvements.

1. The "B" printer has an improved character set. The "A" version uses the Roman8 character set. This was modified to reduce the height of most upper case letters from seven dots high to six dots high. This improved readability with most character combinations providing two dots of interline spacing.
2. The "B" printer added a second (default) character set called ISO 8859-1, renamed ECMA 94. The "A" default character set is Roman8.
3. The "B" printer added a ten minute auto shutoff to conserve batteries. Leave the "A" printer on for two days and your batteries are completely DEAD!
4. The "B" printer added a red power-on indicator on the left front panel near the IR detector. See figures one and three.

Either model may be used with any of the five HP 48 series machines. The HP 48, if used with the "A" printer should have its character set remapped to match the "A" printer character set by executing the HP 48 OLDPRN command. This changes the PRTPAR list that shows up in your HOME directory. If you switch back and forth between "A" and "B" printers you must remember to purge PRTPAR to use the "B" printer and execute OLDPRN to use the "A" printer. If you have a "B" printer there is little to worry about. Just turn it on and start printing.

Printer Basics

The three printer sloping panel controls are arranged in a horizontal row. The left control is a sliding switch to turn power on (to the right). The center control is a slider control for print darkness. The right most position is the darkest. The right control is a push button that advances the paper. Paper advance speed is one inch (25.4 mm) in ten seconds or 1/10 inch (2.54 mm) per second.

Installing the paper is a bit troublesome the first time. The paper will only print on one side because of the special thermal coating. To verify the side you think will print rub your fingernail hard against the paper to make a mark. If you don't see a mark, use the other side. The paper must be "pressed" coated side down into the paper feed slot 1/2 inch below the top of the paper well. To start the paper, unroll about 12 inches, cut it square, and place the roll into the open paper well cover with the paper coming from under the roll. The 12-inch loose end is long enough for you to hold in your fingers and apply a little feed pressure as you insert the paper into the slot. While pressing the paper into the slot, hold down the paper advance until the paper is gripped and the paper advance feeds the paper through. When the paper exits the tear bar you may roll up the excess and close the paper well cover.

Perform a self-test once the paper is feeding properly. Turn the printer off. Press and hold down the paper advance button when you turn the printer on. The self-test will start when you release the paper advance button. All printable characters (9-1/3 lines) are printed except the vertical broken rectangle that only prints when the print buffer overflows. See figure four and the Print Buffer entry in the **Printer & Paper Specifications** section.

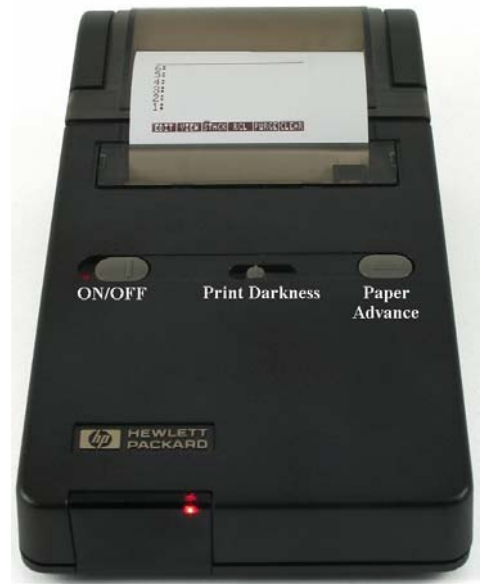


Fig. 3 – The HP 82240B IR Printer has three controls shown by the added white labels.

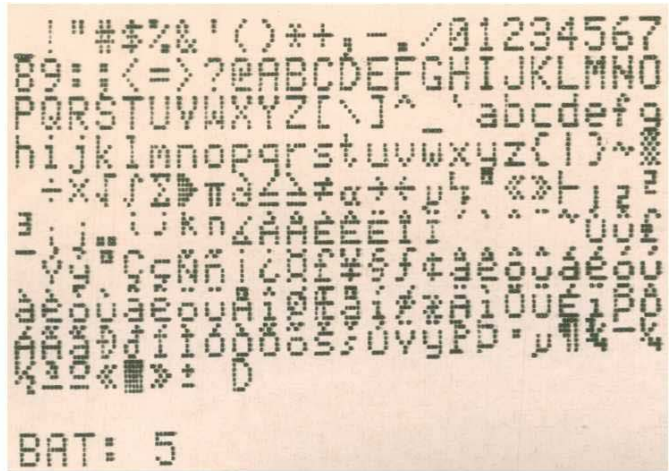
After the full character set is printed a line is skipped and a line “BAT: N” is printed where N is an indication of the printer supply voltage. The numbers range from 1 to 5. One indicates low voltage and five indicates normal voltage. The last character, after a space, of the character set is a version letter. Printers tested from June 1990 thru March 1995 all show "G". A 1987 "A" printer is a "D."

Printer & Paper Specifications

- Size. 7.25 in.(184 mm) long, 3.5 in. (89 mm) wide, 2.5 in. (63.5 mm) high (tapered).
- Weight One pound (0.4545 Kg) with full roll of paper and batteries.
- Column Width 24 columns of alphanumeric characters per line.
- Graphics Width. 166 dot columns of continuous graphics per line.
- Paper. Black print thermal paper, 58 mm wide (2.3 in.) 80 feet/roll. Use HP 82175A; a Box of six rolls.
- Printed Area. 9 lines per inch (25.4 mm) vertically, 1.825 inches (46.4 mm) wide centered.
- AC Adapter HP F1011A (small and light with folding plug) world wide adapter or HP 82241A (big and heavy wall transformer that is much less expensive). See figure five.
- Power Four AA alkaline cells will print about 6,000 lines (nearly a full roll of paper). AC or DC may be used as input to the 5.5 mm OD/2.1 mm ID coaxial power connector. A Radio Shack Cat. No. 274-1569A is a suitable coaxial connector if you use your own power source such as a 6 volt auto cigarette lighter plug and cable. Use a “stiff” 9 to 12 Volts AC_{RMS} or DC, 1,500 ma. peak, 500 ma nominal.
- IR Input Unidirectional Infrared (wireless) at a maximum data rate of 78 characters per second. The maximum rate from an HP 48 is about 24 characters per second. The IR printer CAN NOT tell the data source (calculator) if it is out of paper, the buffer

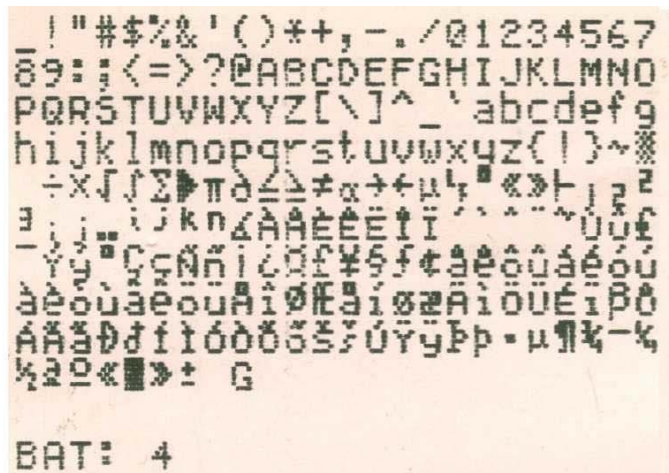
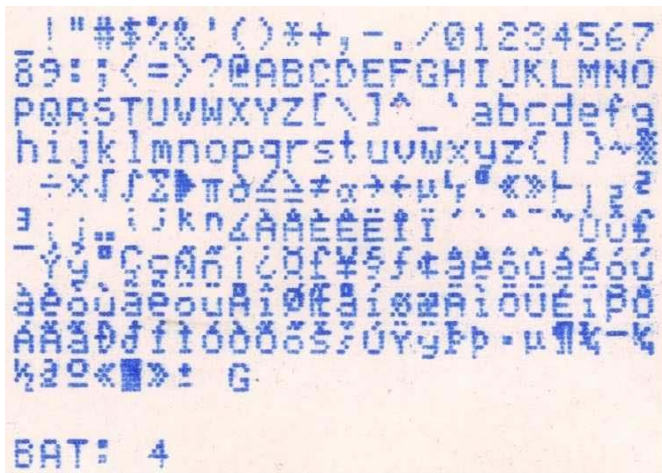
is full, etc. The IR range is normally about 18 inches, but it is up to 31 inches with some HP 48/IR printer combinations with fresh batteries.

Printer Modes Normal, Double wide, Underline, Continuous Graphics (no space between lines).
The IR printer uses a Seiko print mechanism designed for continuous graphics. It does not have a (mechanical) line feed between printed lines.




HP 82240A Self Test using blue and black paper.

Fig. 4a – Here is an unprocessed printed “A” version self test enlarged 1.8 times using blue and black HP paper.



HP 82240B Self Test using blue and black paper.

Fig 4b - Here is an unprocessed printed “B” version self test enlarged 1.8 times using blue and black HP paper.

Print Buffer. Print buffer capacity is 200 characters. A special broken vertical rectangle character, e.g. , is printed if the print buffer overflow occurs. Printing continues with the start of the next line and some data is lost.

Motor The printer motor speed is power supply sensitive; it slows to half speed at the end of battery life. IR timing is especially important to avoid loss of print information under low voltage conditions (four volts). Fresh batteries will start at 6+ volts.

Using the 82240B Printer

Consult the user's guide that came with your calculator. It will provide the basics of using the 82240B with its various features and functions.

The following tips are practical suggestions for using the IR printer. They are in no special order.

1. HP doesn't recommend pulling the paper through the printer. Holding the paper advance button to feed paper to tear it off takes so long that only the most patient user actually does this. After ten years of "pulling" there are no signs of problems actively using the printer. Pull gently. After tearing off the paper press the paper advance button to advance the paper one line to prevent the next two lines from overlapping. Add the following RPL code at the end of your programs to automatically advance the paper six lines for tear off (1 6 START CR NEXT).
2. The IR printer is not recommended to be used on AC without batteries. The "A" and "B" version printers will work directly from the AC adapter. The reason is that under the worst-case conditions of low temperature and low line voltage the high peak motor current may not be adequately supplied by the AC adapter alone. Most users don't have any problems under normal conditions.



Fig. 5 – HP 82241A AC Adapter is useful for 82240B.

3. When testing printed output spacing it is handy to print a "scale" above the printed line to check spacing. A scale suitable to check centering is (RPL functions)
"123456789012210987654321" PR1 DROP.
Place this sequence in your program during the debugging phase and remove it after everything is working properly and it is thoroughly tested.
4. The thermal paper is rolled onto a small diameter spool. This will give the paper a curl when it emerges from the printer, especially from the last half of the roll. Use a ruler or square corner to pull the paper over to reverse the curl and make the paper lie flat. This is more easily done with long printouts. You can cut afterwards.

5. Almost ANY liquid will cause the paper to discolor. Exposure to gasses from chemicals and solvents will also discolor the paper and make it unreadable. This includes physical contact with other papers, some plastics, manila folders, etc. that outgas over time. Coin collectors are familiar with this issue.

Not all papers outgas and if you use them make a simple test. The outgas property of most materials is unknown and you won't realize that your materials will cause trouble until it is too late. Printouts not touching surfaces that outgas will last ten or more years in room temperature storage. Exposure to sunlight will cause the paper to fade in a matter of a few months. Business users tape their outputs to standardized forms and photocopy or scan them. Make sure that the clear tape does not touch the printing. The tape adhesive will turn the paper black in a few weeks. Photocopy toner will last a long time. Note, however, that toner tends to stick to smooth plastic surfaces and may pull off.

6. Consider the following tips when writing HP 48, 49, or 50 programs that provide a printed output.
 - A. Start your program by setting/clearing system flags, using the RPL PRTPAR, etc. so the user won't have to worry about the printer working properly. Use the 'Irset' escape code at the beginning of the printer use program. You can't assume the condition of the machine when the program runs. Use the RPL RCLF at the beginning and STOF at the end to restore the machine to preprogram run status.
 - B. If your program prints a table be sure to allow for inputs (prompted) that may be changed easily. This makes the program more useful. If you take the time to format the outputs your return on invested time will be much appreciated later when you need a table of different values.
 - C. Test full printed outputs for the minimum DELAY. You don't want to be running the program with a bunch of broken rectangles printed down the paper because your DELAY was too short. Likewise you don't want to wait too long for the output. A good starting point is a DELAY of 1.1 assuming the printer is plugged into the AC adapter. If the printer is running on batteries use the default value of 1.8.
7. Printer control characters in programs will also control the printer when the program is listed. For example, a doublewide escape code sequence early in the program may cause most of the listing to be printed double wide. The print mode will change when the program contains the singlewide escape code sequence.
8. Old paper vs. fresh paper. Paper stored in high temperatures, as in the trunk of a car in summer, may turn gray, and reduce contrast. The paper is usable, but it won't look as nice and may fade more quickly. Years ago HP offered blue print paper, HP 82145A. See figure four. This was more sensitive to fading. The current paper is much nicer than even the black print paper of a few years ago. It is whiter and the print looks sharper. Use your oldest paper first for debugging and testing. Switch rolls for the final printouts.
9. If you are using the graphics calculator models you may easily make up a series of short programs and use a custom menu or key assignments to send mode change escape sequences to the printer. A single key press will put the printer into the mode you need to debug printer related programs.

Normal printing may be enhanced by sending what are called escape codes to the printer. The ability to do this varies with each calculator. The graphing calculators provide the greatest capability; especially with their program-mability. Figure seven shows the escape codes that control the 82240B IR Printer.

There are many methods of creating and using the escape codes (strings) sent to the printer to print graphics "characters." The "long" method is used in Jim Donnelly's HP48 program on page 218 of his book. A shorter method uses ASCII characters directly in the string in the program. Program techniques dealing with printer control codes are complete subjects in themselves and there is plenty of room for creativity. See figure eight.

When you are creating graphics "characters" it is helpful to use a grid to draw the "dots" as you want them. An "ideal" form would have 166 columns across to represent a full printed line. The Wt. column is the binary weight given each dot. The data sent to the printer must be in a dot column format. This is in contrast to a dot row format used by some printers.

An excellent graphics resource is *Graphics on the HP 48G/GX* by R. Rey Depew which also includes a chapter on Plotting, Equation Writer, and Solver. Some of the ideas and information also apply to the HP



Fig. 6 – HP-41 IR Module.

49 and 50. Once you understand how the printer works you will want to try all kinds of graphics.

Technical References

1. *EduCALC Technical Note 64*. describes the 82240B printer in greater detail. Request a copy from: rjnelsoncf@cox.net.
2. *Hewlett-Packard Journal*, October 1987 issue. See the CD (and now DVD) series, #2, by Jake Schwartz at <http://www.pahhc.org/ppccdrom.htm>
3. *PPC ROM User's Manual*, 500 pp, © PPC 1981. See 85 pages of printer applications listed on page 6 under Peripherals. See the CD (and now DVD) series, #2, by Jake Schwartz at <http://www.pahhc.org/ppccdrom.htm>
4. *HP 82240B Infrared Printer Technical Interfacing Guide*. This HP document contains technical details describing the printer, its circuitry, and software. This is especially needed for third parties to use the printer with their equipment. You may obtain a free copy from: <http://www.hpcalc.org/details.php?id=4742>

Printer Command	Control Codes*
Carriage right	4
Carriage return/LF	10
Column graphics	27 n C ₁ ... C _n †
Roman 8 character set ‡	27 248
ISO 8859-1 character set	27 249
Underline off ‡	27 250
Underline on	27 251 DSP PRT
Single wide print ‡	27 252 ■ ü
Double wide print	27 253 ■ ý
Self-test	27 254
Reset	27 255

*Decimal value †1<=n<=166 ‡Default mode

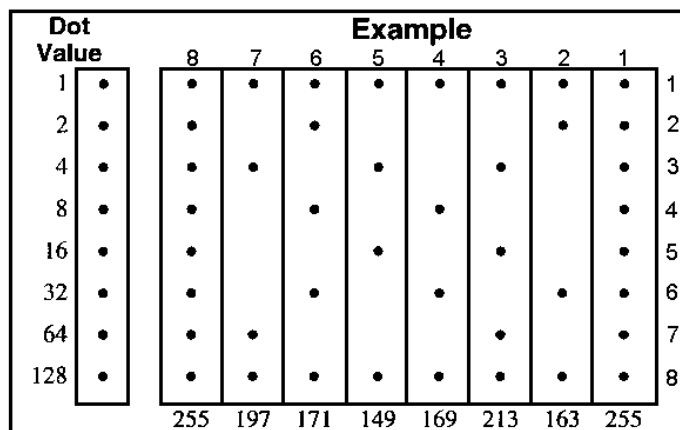


Fig. 7— IR Printer Escape codes. From The HP 48 Handbook, 2nd Edition, by James Donnelly.

Fig. 8 — Graphics control code format. From The HP 48 Handbook, 2nd Edition, by James Donnelly

Conclusion

This article provides the HP calculator user with a brief outline of information needed to select and use the HP IR printer. The 82240B is suitable for use with 24 HP calculator models, the current HP 17bII+, 39gs, 48gII, and 50g. It works well with the older models: HP 17B, 17BII, 18B, 19B, 19BII, 27S, 28C/S, 38G, 39G, 42S, 48S/SX/G/G+/GX and 49g+. It also works with the HP-41C/CV/CX with an HP 82242 IR module. See figure six. Consult the calculator user's guide of your calculator for additional printer use information.

Eleven reasons why you may need a printer are provided. Applications such as printing bar codes, using a business card printing program, assembling a collection of special symbols e.g. copyright, foreign language characters, various fonts including script, italics, etc., or a collection of special purpose shapes such as hearts and stars would make a book in itself.

Printer Basics are provided with a Technical References list for the reader to easily obtain a great deal of additional technical information on the HP 82240B IR printer. Here is one last example. The plot below, figure nine, shows all six trigonometry functions simultaneously plotted using an applications program

from the PPC ROM manual. Five strips were attached together. The functions are Sine, Cosine, Tangent, Cotangent, Secant, and Cosecant.

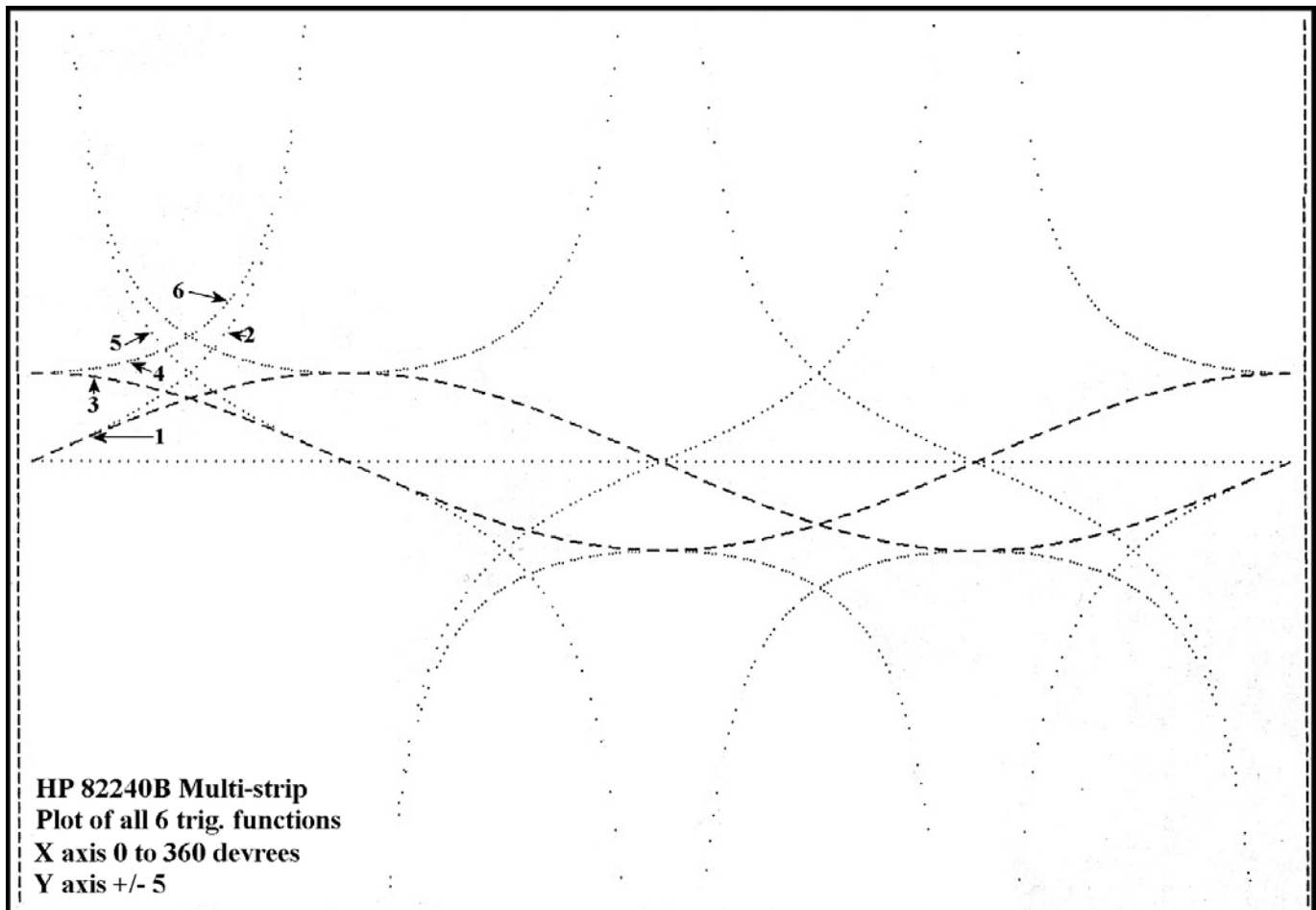


Fig. 9 – Five strip plot using the PPC ROM Manual super plotting program SHP.

The HP 82240A/B IR printer is very reasonable in cost compared to other strip, half, or full page portable printers. The 82240B's small size makes it a useful portable accessory for many student and commercial applications.

The HP 30b Business Professional

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The HP 30b Business Professional

Gene Wright

What is it? The HP 30b is Hewlett Packard's new mid-range financial calculator. This machine is a very welcome addition to HP's financial calculator line. The HP 30b comes with a very small printed manual, which certainly seems to be the continuing trend. A larger PDF manual is available online as well as 40 learning modules that go into greater detail on how to use the HP 30b. This review will focus on the new features found on the HP 30b and differences between it and the HP 20b.



Fig. 1 – HP30b introduced in January 2010



Fig. 2 – HP20b introduced in June 2008

Physical differences. First off, the HP 30b uses rotate and click keys. This is a welcome improvement over the HP 20b keys, which many found to be inadequate. While the author never had any real problems with the HP 20b keys, it certainly is nice to have a good click when pressing a key. Secondly, the HP 30b comes with a metallic-looking faceplate compared to the shiny black faceplate on the HP 20b. Some of the pictures do not quite do the real color justice – the real calculator color is more bronze/copper than pure silver as the picture would suggest. The back of the HP 30b is the same black plastic as on the HP 20b. The HP 30b comes with a slip case to protect it.

Bond calculations. The HP 30b includes two bond duration calculations – the modified duration and Macaulay duration. These measure a bond’s price sensitivity to fluctuations in interest rate movements by giving what is essentially a time value of money weighted average time to maturity. While the modified duration has been in other manufacturer’s calculators before, this may be the first time the Macaulay duration has ever been on a preprogrammed calculator.

MIRR and FMRR. The HP 30b extends the usefulness of the HP 20b’s cash flow analysis tools by including Modified Internal Rate of Return and, for the first time ever in a financial calculator, the Financial Management Rate of Return. Both of these tools address a problem with the basic IRR that occurs when the signs of cash flows switch from negative to positive to negative, etc. – there can be multiple interest rates that make the present value of the cash flows equal to the cost, which is the definition of the IRR. That’s a particular problem if you’re trying to use IRR to make a decision. MIRR and FMRR provide one rate of return that more accurately reflects the return an investor receives. They differ on how they manipulate any negative cash flows after the initial cash outlay.

Black-Scholes. The HP 30b includes a menu that computes put and call option prices for European options using the Black-Scholes method. While Tony Hutchins (New Zealand) provided the programs to compute these for the presently shipping HP 12c calculator manual, this is the first preprogrammed financial calculator from HP to have Black-Scholes built-in. This menu is invoked using the shift+hold method and is labeled on the keyboard above the BOND key.

Canadian Mortgages. A new Mode menu setting allows the choice of TVM Standard or TVM Canada. When TVM Canada is chosen, the compounding periods per year can be a different value from the payments per year. Canada is the name given since Canadian mortgages compound interest semiannually while having monthly payments, but any combination of compounding and payment frequencies per year can be specified.

Other. The Probability sub-menu in the Math menu has been extended by including the binomial probability distribution. There is also a choice in the Stats menu for frequency statistics, which is quite useful for analysis of grouped data. The Math menu has two new functions: IP for integer part and FP for fractional part.

Still missing? In an earlier HP 20b review, several things were functions were listed as missing. Of these, the shift key position being more centrally located and the lack of a primary key for storing numbers remain on the wish list.

Found? Programming. Yes, that’s correct. The HP 30b contains programming abilities that are a mixture of several things: key recording macros, RPN and RPL too. Programming commands are mapped to the shift-hold positions of the top 4 rows of keys. These commands are not printed on the faceplate and will not execute in run mode, but only in program editing mode. To help the user who wants to write programs more easily remember the command locations, a clear, thin, sticky overlay is provided which lays over the top four rows of keys.

The program catalog is entered by pressing shift and then the close parenthesis key. There are 10 program slots available in

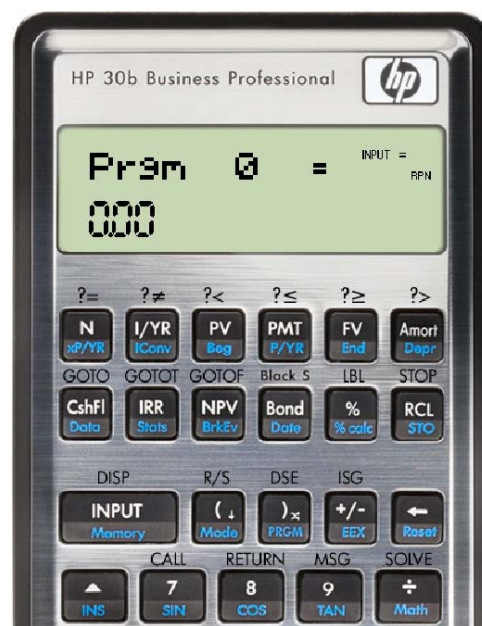






Fig. 3 – Programming designations.













the program catalog (Prgm 0 through 9) and 290 bytes of programming space available on the machine. Note however that program memory cannot be backed up to any external device.

Programs can be assigned to primary keys, shifted keys and shift-hold key positions. Six conditionals are present comparing two values. Each comparison pushes a 1 if true or 0 if false to the stack. Conditional transfers are goto if true (displayed as GT in a program, but GOTOT on the keyboard overlay) and goto if false (displayed as GF in a program, but GOTOF on the keyboard overlay), but note that these conditionals consume the argument on the stack. A quick test for $x=0?$ and a branch to a label if true is (of all things) merely to place a GF XY instruction in a program and if the value in X is equal to zero, a branch to label XY will occur. This works because a zero is a false argument and GF will branch to the indicated label if the display contains a zero. An unconditional goto is also provided. Destinations for these gotos are any of 100 global numeric labels, 00 through 99. Four levels of subroutines are available using the CALL and RTN commands. Values can be displayed while a program is running using the DISP command. Even a short prompt of letters can be displayed using the MSG command. This has been put to good use to make a “high – low” number guessing game more fun.

If viewed as primarily a “macro recording” ability then some of the operating characteristics of HP 30b programming will make more sense. For example, to access the inverse sine function in the Math menu, the program steps will look like this:    , which will take four program steps, take four bytes, and show as Math Input Down = on four lines in the program listing. Each key press required to navigate through a menu is recorded as a separate step and uses a byte. Some commands are merged and shown as one step. Examples are store, recall, and gotos.

How useful are 290 bytes? More than you might think. It is very easy to use these abilities to bring functions buried in menus out to the keyboard for much easier access. If you find yourself needing access to the inverse trig functions, short programs can pull them out of the Math menu and be assigned to the shift-hold locations for sine, cosine and tangent. If you find the need to use the built-in probability distributions, they can be brought out of the Math menu and assigned to keys. This is a great time saver. Short programs have also been written for things such as a prime factor finder, a translation of the HP 25 lunar Lander game, base conversions for bases 2-10 and more.

Found? HP Solve. The solver is accessible by first writing a program that evaluates an equation such that it would equal zero, using memory registers to represent variables in the equation. For example, an equation of $X - Y = Z$ would be rewritten as $X - Y - Z = 0$ and entered as a program like this: RCL 1 RCL 2 – RCL 3 – RTN. Memory 1 would represent X, memory 2 represents Y and memory 3 represents Z. Store values into memories 2 and 3 and SOLVE 1 will find the value of memory 1 that makes the equation equal to zero. This forms the basis for the generalized odd days loan solver program found in the HP Solve examples learning module. This program includes conditional tests and branching and is an indication of the usefulness of the included HP Solve functionality.

What other goodies are included? The mode menu settings can now be stored and recalled by pressing store or recall and then  . This key sequence brings up a 12 digit number with each position corresponding to a mode menu item and its setting. The two rightmost digits for example control the number of decimals displayed. Pressing     in run mode or in a program will change the number of decimals displayed to four regardless of the original value. Pressing       will change the operating mode to RPN and since 14 is an invalid value for the number of decimal digits displayed, will not change the display setting. This is described and a table of these values shown in the Programming Reference learning module.

The 100 memory locations used to store up to 50 pairs of statistics or cash flow data can be addressed indirectly using a location stored in memory 0. If 5 is stored in memory 0, the key sequence $\boxed{\text{STO}} \boxed{\text{Data}}$ will store the value in X into the 6th position of the statistics data area, since it is addressed starting with position 0. This allows for the use of a rather large data set and has already been used to compute and store nearly 700 digits of PI on the HP 30b as shown in the Programming Examples learning module.

And, of course, all the existing scientific functions (and other financial functions) from the HP 20b are still present in the HP 30b.

Programming on the HP 30b. 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 learning module will illustrate using HP Solve and writing programs in RPN mode. Other learning modules will show how to enter and edit programs, loop and call subroutines as well as showing several example programs to help get you started.

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 helps 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 $\boxed{\text{L}}$ and, while holding it down, press $\boxed{\%}$. In these learning modules describing programming, this will be shown as $\boxed{\text{L}} + \boxed{\%}$.

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 $\boxed{\text{PRGM}} \boxed{\text{P/0}}$. In the image above, the program catalog is

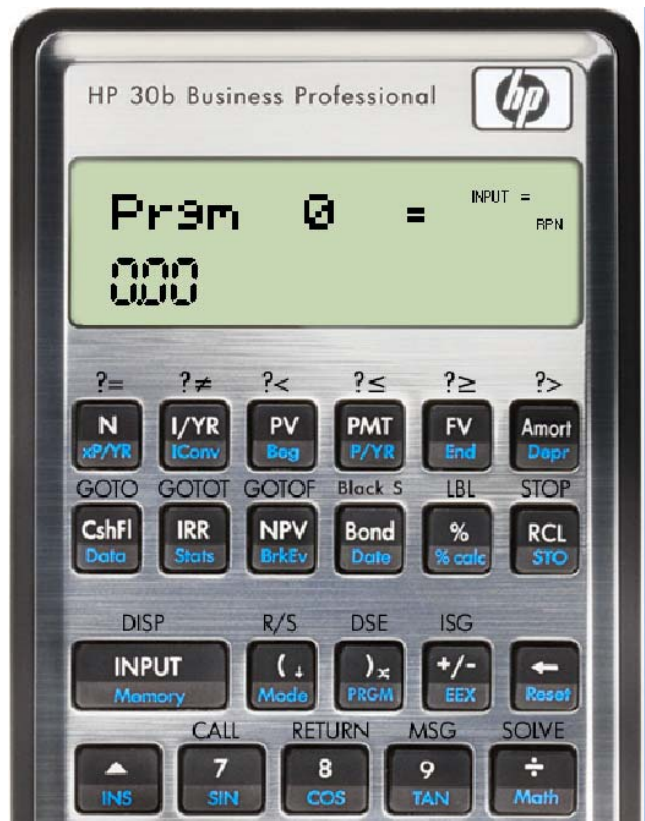










Fig. 4 – HP30b Programming example.

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 .

When a program is displayed, a number will be shown below it indicating how many bytes are used and a checksum, to help ensure the program has been entered correctly. 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. This is shown in the image at right. When viewing a program in the program catalog, pressing  

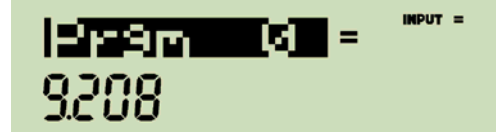









Fig. 5 – Sample Program Catalog Entry.

 will delete the presently displayed program and return you to the calculation environment. To delete all programs, press       while in calculation mode.

At different places within a program, you can insert a Label (LBL) command. A label defines a location 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 with no change made to the program.

HP Solve. The HP 30b contains the incredibly powerful HP Solve feature. No competing business calculator contains such power accessible to the user. HP Solve allows you to key in a program that evaluates a function so that the result is equal to zero and then finds a value for a variable within the function that makes the result equal to zero, called a root. For a very simple example, if you have $X = 5$, this can be rewritten in the form $X - 5 = 0$. Obviously, the value of X that makes this result equal to zero is 5 and HP Solve will find that answer.

The way you use HP Solve on the HP 30b is to write a program that evaluates a function so that the function is equal to zero using the memory registers for the variables. Then you use the SOLVE function and specify the memory register for which you wish to solve.

In this case, the program using memory register 1 for X would be: RCL 1 then 5 then – then STOP. If you then performed a SOLVE 1, the HP 30b would find the root for this function: 5.

Illustration: Generalized odd-days loan solver program. This solver program is general in that it uses memory registers to allow for the solution to the number of odd days, the payment, the present value, the number of periods, the future value and the interest rate. In this example, the following registers will be used for the components of the formula:

- Register 0 for the number of odd days in the first period.
- Register 1 for the value of N .
- Register 2 for the value of I/YR . If solving for I/YR , be sure to store an initial guess.
- Register 3 for the value of PV .
- Register 4 for the value of PMT .
- Register 5 for the value of FV .

Note that if you wish to use values from the time value of money registers in this solve program, they will have to be recalled from the time value of money register and manually stored into the memory registers above before using HP Solve. To enter this equation into the HP 30b as a program, you would press the following keys:

Keys Pressed Explanation

Enters program mode and displays the last program previously viewed in the program catalog. If you wish to enter your program into a different program number in the catalog, press or until the program number you wish to use is displayed. Use Prgm location 3 which is assumed to be empty. Then press:

Enters program edit mode and displays the first line of the program

Recall the interest rate per year and divide by 100.

The X register contains I/YR divided by 100.

Then recall the number of periods per year and divide the previous result by this value. Save I/YR divided by P/YR in memory 9 for later use. This is line 7 of the program.

Recall the number of odd days.

Divide by 30.

Perform the FP function from the MATH menu. Displayed as “Math Up =” and discards integer portion of previous result.

Recall I/YR divided by P/YR and multiply by fractional part of DAYS divided by 30. Add 1 to result.

Recall PV and multiply by previous result. This is line 18 of the program.

Recall I/YR divided by P/YR.

Add 1.

Recall N, the total number of periods. Raise (1 plus I/YR divided by P/YR) to the N power

Divide 1 by (1 plus I/YR divided by P/YR) to the N power

Recall FV, the amount due at the end of the loan and multiply by previous result

Add to previous result. This is line 26 of the program.

Recall the number of odd days.

30 is the comparison point.

Insert ?< comparison test.

If true, goto label 03.

Perform roll down twice. In RPN mode, the key rolls the stack down one level.

Enter a 1 onto the stack

Unconditional go to label 04.

Label 03. This is line 36 of the program.

Perform roll down twice.

Recall I/YR divided by P/YR.

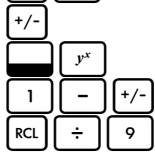
Add 1 to compute (1 plus I/YR divided by P/YR)

Label 04. This is line 42 of the program.

Recall PMT and depending on the outcome of the conditional test above, multiply payment by either 1 or by (1 plus I/YR divided by P/YR)



Recall I/YR divided by P/YR.
Add 1.
Recall N, the total number of periods.



Change the sign of N.
Raise (1 plus I/YR divided by P/YR) to the negative N power.
Computes 1 minus ((1 plus I/YR divided by P/YR) to the negative N power).
Computes (1 minus ((1 plus I/YR divided by P/YR) to the negative N power)) divided by (I/YR divided by P/YR).



Multiply by previous result.



Add to previous result. This has now computed the value of the equation.

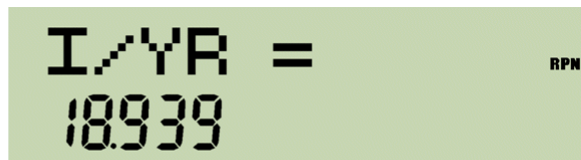
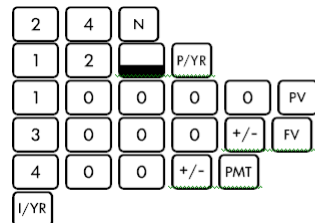


This last key press enters the STOP command. This is line 56 of the program.

Now press [Blank] [2nd] to exit program edit mode and return to the program catalog. If you have entered this program correctly, you should see that program 3 uses 82 bytes and has a checksum of 037.

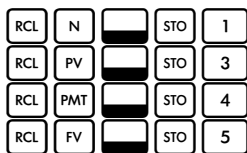
Example: A 24-month loan for 10,000 has a monthly payment of 400 and a balloon payment required at the end of the loan of 3,000. What interest rate, compounded monthly is being charged if there are no odd days in the first period? What is the interest rate if there are 8 days until the first payment?

First solve the time value of money problem.



The interest rate is 18.939%, compounded monthly. This is the interest rate being charged, assuming there are no odd days in the first period and the first payment is due in 30 days.

Now store the actual number of odd days in the first period into memory 0 by pressing [8] [Blank] [STO] [0]. Transfer the time value of money entries to the appropriate registers by pressing:



Store a guess of 2 (most any guess will do – a guess of 55 results in the same answer shown below) into the interest rate register by pressing [2] [Blank] [STO] [2].

Since the last program viewed was the one we wish to run, the interest rate being charged for 8 odd days in the first period can be found in calculation mode at this point by pressing [Blank] + [÷] [2].



HP Solve indicates that if there only 8 days until the first payment, then the loan is being assessed interest at 19.674%, compounded monthly.

In a similar way, the other unknowns in this relationship can be solved using HP Solve, even the odd number of days. HP Solve is an incredibly powerful tool.

The HP 30b Learning Modules may be found at:

http://h10025.www1.hp.com/ewfrf/wc/documentSubCategory?tmp_task=useCategory&lc=en&dlc=en&cc=us&lang=en&product=4031712

Conclusion. This is a good financial machine that addresses many wish-list items left unfulfilled from the HP 20b. In many ways, this is the most powerful financial calculator HP has ever made. It is certain to give fits to the competition's financial calculator designers, since there are a large number of empty spaces next to their models on any comparison chart.

Editor's Note. This article is based on an article by Gene that first appeared in Datafile, the publication of the London-based HPCC user group.

About the Author



Gene Wright is the author of textbook "Quantitative Analysis for Business", a time value of money and statistics textbook using the HP-10BII, HP-12C. He is also a video lecturer for Allen Resources in Rhode Island for the CFA exam. 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.

RPN Tip #18 – The ENTER Key

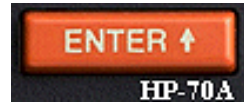
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RPN Tip #18 – The ENTER Key

RPN was defined in RPN Tip #4, and the history of why HP used RPN with a four high stack was documented in RPN Tip #14. The obvious distinctive feature of HP's RPN is the classical double wide ENTER key first seen on the HP-35A scientific



calculator in 1972. The next machine, in 1973, was a finance calculator, the HP-80A. The double wide key served the same purpose, but it was labeled SAVE.



Perhaps HP thought at the time that finance users had a different mind set compared to scientific calculator users and ENTER wouldn't be seen as friendly as SAVE to business users. By late 1974 a second finance model was needed and the last finance machine in the Classic series was added. The RPN "enter" text returned, but the color of the HP-70A was really bright compared to the other seven Classic machines. SAVE was never used again for an RPN machine.

In the early days RPN was in sharp contrast to ALG in terms of the common user interfaces. All of the large manufacturers only produced ALG calculators. HP is not limited to any particular user interface (of the four basic kinds as explained in RPN Tip #4) and many of HP's models have two or three user interface modes. For most calculations RPN is the most effective and efficient user interface and HP still uses RPN for many of their calculators.



The high end calculators (graphing) use a Command Line Interface, CLI, and today most calculator manufacturers use an ENTER key. Most personal computers also use an Enter key and today's HP calculator users don't

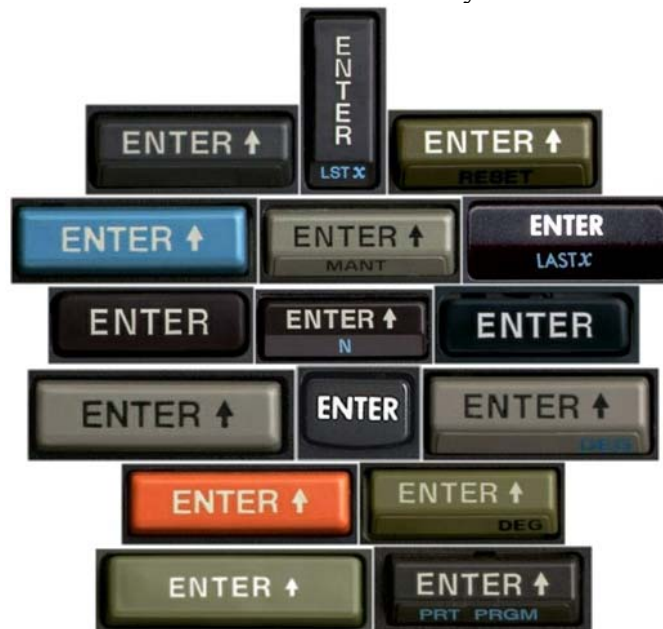


necessarily associate ENTER with RPN.

Here is the question. What do you think? Has the double wide ENTER key lost its meaning? Is there a notation similar to SAVE that would be better and have a deeper meaning for today's student and business users? Send your thoughts, opinions, and suggestions to the editor.

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?

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."



HP Solve Math Problem Challenge #1

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HP Solve Math Problem Challenge #1

Divide A Circle Into Three Equal Parts

Marty decided that he needed to lose some weight. His normal breakfast was a grapefruit and a 6 oz. can of fried turkey chopped with onions and tomatoes. He decided to cut the turkey into thirds. The first thought was to divide the circle into three parts like slicing a pie with each section $360/3 = 120$ degrees.

Since dieting is 50% food intake control Marty cut a pattern from cardboard to help him cut the turkey from the round can. He covered the cardboard with 2" clear tape so it could be wiped clean after use. See figure one below.

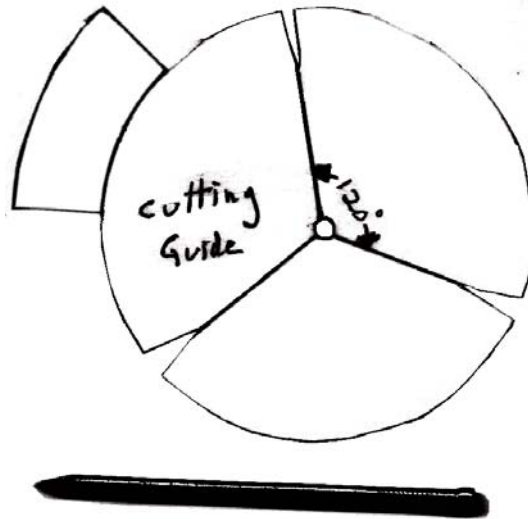
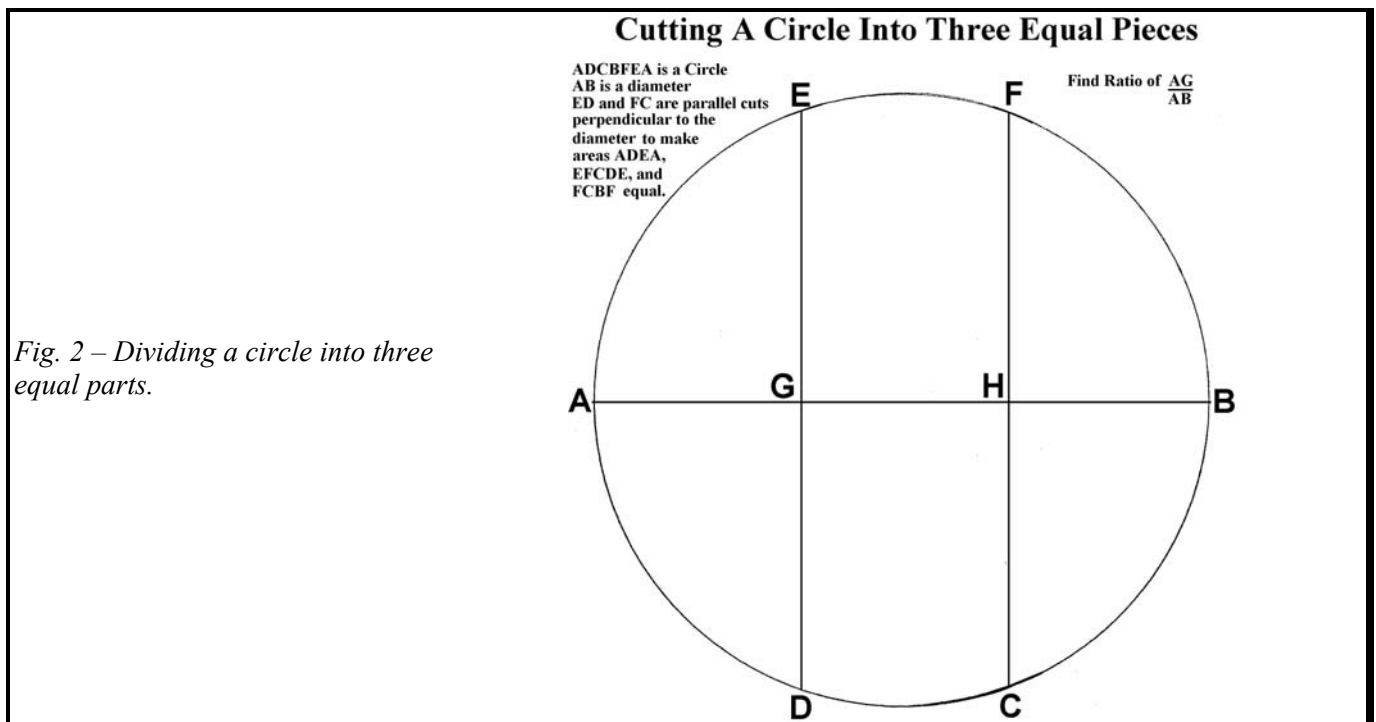


Fig. 1 – Cardboard cutting guide. The nail locates the center.

After a couple of uses Marty decided that this was not a practical solution. Cutting the circle with two slices seemed a more practical way of cutting the meat. Measuring in from the circle on a diameter (AG as shown in the figure two below) is a bit easier.



Marty quickly realized that this was an interesting problem. What he wanted to do was to determine the ratio of AG to AB as shown in figure two.

This problem is the first 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 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 AG is equal to HB? The winning solution is based on the “rules/guidelines” listed below

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

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 trying to loose weight and he needs to be able to cut the circle accurately into three equal (area) pieces.

HP 48 One Minute Marvel – No. 5, Electronic Stopwatch

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HP 48 One Minute Marvel – No. 5, Electronic Stopwatch

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.

Have you ever wanted to time something? Perhaps you wanted to know how long were the TV commercials or how much time you spent doing something? An electronic stopwatch program is a quick and easy one minute marvel to answer such questions.

A single key press starts and stops. The machine does not run while “timing” and it is usable for other tasks. The start time is stored in user variable ‘t’. Create this variable with anything stored in it. Move this variable out of the way to the far right of your menu.

‘SW’ uses Flag annunciator 5 (because looks 5 like “S”) to indicate the stopwatch is “running”. The time is tagged with “Sec”. Note: The fastest time possible is 0.2 seconds due to the user and calculator (debounce) response. Since this response time occurs when you start and stop the stopwatch it does not need to be subtracted from the run time.

```
‘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.

The timing accuracy is the same as the calculator and is suitable for most applications. The “Sec” text string and →TAG commands are underlined to indicate the location of changes that could be made (in OMM #6) to convert the seconds value to minutes or hours.

Here is how the program works. The first two commands set the display to show a single decimal value after the decimal point. The program leaves the machine in this FIX one mode. TICKS brings the internal running clock value to level one. The IF command tests flag 5. If it is set it clears the flag and executes the THEN clause. If the flag is clear it executes the ELSE clause.

The THEN clause places the variable ‘t’ on level one and RCL recalls the previously stored value to level one. At this point the start ticks value is on level two and the stop ticks value is on level one and the minus command subtracts them. Level one now contains the difference in ticks. The ticks value is a binary object and it is converted to a real by the B→R command. Since there are 8,192 ticks per second the ticks value is divided by 8192. The time in seconds is tagged with “SEC” and displayed on level one.

The ELSE clause is executed if the stopwatch is not running because flag 5 is not set and the start ticks value is stored in ‘t’. Flag 5 is set and the program stops with END. When the program is run a second time the IF command will execute the THEN clause as described in the previous paragraph.

The value in ‘t’ is always a binary number as indicated by the leading # symbol.

Fundamentals of Applied Math Series #1

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Numbers - Part I


Richard J. Nelson

This issue of *HP Solve* starts a series of articles on applied mathematics topics related to calculator usage and functions. Since calculators primarily deal with numeric calculations it is appropriate to start with numbers. The more capable machines also deal with symbolic math, but that topic will have to be covered by other articles. *HP Solve* Readers are encouraged to provide feedback on topics of interest, or to possibly contribute, by contacting the editor.

Because this is the first of the series it is appropriate to provide a few guidelines.

HP Solve Fundamentals of Applied Math Series Guidelines

The plan is to have serious math content with the calculator in mind in terms of application and use. Here is a list of guidelines for future articles.

1. The article should flow from a non-math opening with real world applications and historical descriptions of the subject if appropriate.
 2. There should be at least one graphic, photograph, or other visual on every page.
 3. Show a photo of one or more specific HP calculator keys to illustrate the related keys that may be used.
 4. Include general statements with respect to the topic and HP calculators and their use, e.g. Most HP scientific calculators have LOG and LN keys. The HP35s example is shown.
- 
5. Include a program related to the subject or to some aspect of the content. Calculating values for a plot, for example.
 6. All parts of the article should be easily referenced. All figures must have numbered captions. Equations should be numbered. Shadow boxes should be numbered, Copy and paste the example.
 7.

Use a shadow box (top & left 1.5 pt.; bottom & right 3 pt.) similar to this one for important points, rules, etc.

 (1)
 8. All plots should have at least major value lines for both axis. Use a colored or shaded background for greater visual punch. Be sure the axis has practical units and the plot has a title. Make the plot a complete stand alone graphic. The editor will help in improving plots.
 9. Since this is a review series there is no need for detailed proofs or derivations. An exception to this might be an article dedicated to e , a multipart “numbers” series, or π .
 10. Relate the topic to the real world - specifically mentioning the various fields that a student may relate to. For an example an article on the Average, Median, and Mean might point out how the news media often confuse these popular statistics.
 11. Include a historical element that positions the topic historically in perspective with current thinking.
 12. The range of topics is very broad. A multipart article on numbers might describe the number line, reals, irrational numbers, complex, ordered pairs, etc. relating them to HP calculators. Include a few "interesting" numbers such as, 42, π , 153, the "best" display number for a calculator photograph,

numbers that don't change when a function is applied (a few could be given with the reader asked to come up with others).

13. Use 0.7" margins all around and number the pages at the bottom (in the footer) in the center.
14. Avoid Internet links. Just provide the information. If you need a link use the actual URL and not a "hidden" link named similar to [click here](#).

Numbers in the Calculator Display

Everyone has had the experience of turning on a calculator and keying in a number. This process is both easy and difficult/confusing at the same time. It should be easy because with the many different designs of calculators, literally thousands, the relative layout of the keys are as shown in figure one. All calculators use the same numeric keys layout. The difficult/confusing aspect is that the calculator keyboard layout is arranged to have the larger digits at the top row and the lower digits on the bottom row. This is the opposite of the digit layout on cell phones which has the lowest row of digits across the top. If you make numeric entry errors on either your phone or calculator you might be surprised to learn that many errors is because of the two different keyboard arrangements.



Fig. 1 – HP35s keyboard

Let's suppose you have just received your new calculator and you are taking a photograph of it with your cell phone to send to a friend. You decide to turn the machine on and put a number into the display. What number do you key? HP has this question every time they have a new model and they have to show the calculator in photographs for their website, etc.

This is going to be your photograph of your calculator so you take a few minutes to think about this question. A non-blank display is desirable, but an informative display requires considerable thought, planning, and effort. What number do you use? To answer this question I made a list of practical requirements.

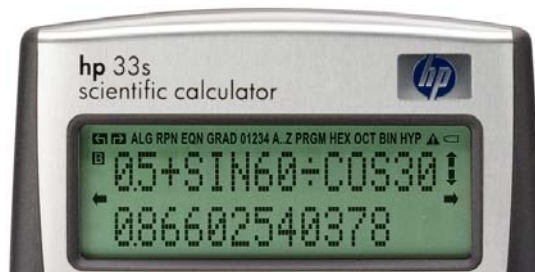
- i. A simple, mathematically interesting, and informative number to be used for 8 to 15 digit displays.
- ii. The number should include as many of the 0 to 9 digits as possible.
- iii. The number must be easily and quickly input with one or two keystrokes, i.e. function produced.
- iv. A general method of generating the number should not require extensive knowledge of the machine.

If you look at HP's literature over the 38 years of producing and advertising 97 models (January 1972 to March 2010) you could make the following observations about what is commonly shown in the display.

1. **Many displays are simply blank.** I have an old HP color photo (14" wide x 9-3/4" high, given to me by Henry Horn in the early eighties that shows all machines made to that date. It shows 27 machines from the HP-35A to the HP-41C. The HP-41C has a 14 segment LCD and all the other 26 machines are seven segment LEDs. All of the calculator displays are blank. The professional photographer simply didn't want to bother with having something meaningful in each display. He was primarily concerned with layout and lighting. Besides, the machines will turn off after ten minutes, and the displays would have to be re-entered in each machine – they would have to be AC powered. This is very troublesome.
2. **Some displays are chosen for marketing purposes.** Many of the finance machines, especially the multi-line models will show numbers or text that represents a major feature of the machine. Simple one line displays that are dot matrix will show mixed text and numbers, e.g. an HP 14B (12/89 brochure) display has "PROF%=14.14." Graphing models will often show a plot in the display and

one brochure of the Business Consultant II (11/88) shows a sine curve in the display. The Computer Scientist HP 16C shows 11100010 b in an 11/84 brochure. An HP 48GX 4/93 brochure shows a wire frame plot in its display.

3. **Some displays simply show the model number.** This was popular for many years, especially for numeric only models. Examples are: An HP-41CX calculator display showed * HP-41CX * in a 3/88 brochure. The HP 10B shows 10.010, and the HP 12C shows 12,000.00 in the display of a November 1992 brochure. An HP 20S machine shows 20.020 in its display in a 4/93 brochure.
4. **Some displays show technical display information.** If you are going to show the display you might show as much display information as possible. An LED calculator might show all the digits: 1234567890. While this is a boring display it is technically informative. This was used in the HP-15C display (segmented LCD) in a march 1988 brochure. The more recent HP 33s display (from HP's website) is a good example that is technically informative.



From these examples it is clear that a non-blank display is desirable, but an interesting and informative display requires considerable thought, planning, and effort.

With the above examples in mind I wondered what would be the simplest, easiest calculator display to use if I had to photograph a calculator. To answer this question I decided on a list of practical requirements.

- i. A simple, mathematically interesting, and informative number to be used for 8 to 15 digit displays.
- ii. The number should include as many of the 0 to 9 digits as possible.
- iii. The number must be easily and quickly input with one or two keystrokes, i.e. function produced.
- iv. A general method of generating the number should not require extensive knowledge of the machine.

What makes a number interesting? Two ideas come to mind. Normal numbers are either rational or irrational. Irrational numbers (see part II in the next issue of *HP Solve*) are much more interesting. Certain numbers are well known and easily recognized because they show up frequently in mathematics.

Another “interesting” number may be one that “begs to know what it means.” One such number (6.0030000004) appeared on the case of the HP38g some years ago, and it drove everybody nuts because it was assumed to have meaning. Many in the HP user Community searched for the function. It turned out that this number was an “artistic creation” (chosen because it had “balance”), and it had no mathematical meaning and no function generated it.

With these considerations in mind here are a few numbers that could work. Keep in mind the non-conventional processing of (guard) digits that HP traditionally uses. Bold bracket numbers indicate the number of missing digits.

The most popular and very easily entered irrational number is Pi, π

1. $\pi = 3.14159 \mathbf{26535} \mathbf{89792}$. This number provides all but three of the digits 0 – 9.
 - 8 digits: 3.14159 27 are missing 0, 6, & 8. [3]
 - 10 digits: 3.14159 2654 are missing 0, 7, & 8. [3]
 - 12 digits: 3.14159 26535 9 are missing 0, 7, & 8. [3]

Another popular well recognized irrational number is e (which deserves its own dedicated article in this *HP Solve* series), but from a digit perspective it falls considerably short.

2. $e = 2.71828\ 18284\ 59045$

8 digits: 2.71828 18 are missing 0, 7, 3, 4, 5, 6, & 9. [7]

10 digits: 2.71828 1828 are missing 0, 7, 3, 4, 5, 6, & 9. [7]

12 digits: 2.71828 18284 5 are missing 0, 7, 3, 5, 6, & 9. [6]

A very popular and easily recognized irrational number is the square root of two.

3. $\sqrt{2} = 1.41421\ 35672\ 373095$ This number provides all but three of the digits for the longer displays.

8 digits: 1.41421 36 are missing 0, 5, 7, 8, & 9. [5]

10 digits: 1.41421 35672 are missing 0, 8, & 9. [3]

12 digits: 1.41421 356724 are missing 0, 8, & 9. [3]

A less recognizable irrational number is the square root of three.

4. $\sqrt{3} = 1.73205\ 08075\ 68877$ This irrational number provides all but three of the 8, 10, 12 display digits 0 – 9.

8 digits: 1.73205 08 are missing 4, 6, & 9. [3]

10 digits: 1.73205 0808 are missing 4, 6, & 9. [3]

12 digits: 1.73205 08075 7 are missing 4, 6, & 9. [3]

The digit count for the above single digit number/function combination is not especially impressive. What about another function that is found on most scientific calculators, perhaps a trigonometric function?

5. $\tan 7$ (degrees) = $0.12278\ 45609\ 02906$. This number provides all but one of the digits 0 – 9 for a 12 digit display.

8 digits: 0.12278 46 are missing 3, 5, & 9. [3]

10 digits: 0.12278 4561 are missing 3, & 9. [2]

12 digits: 0.12278 45609 0 are missing 3. [1]

Probably the most interesting, but least recognized irrational number, is the golden ratio, ϕ , $\frac{1+\sqrt{5}}{2}$.

However ϕ takes six keystrokes to put it into the display. The 12 digit ϕ display is digit competitive only missing three digits.

6. $\phi = 1.61803\ 39887\ 49894 \dots$

8 digits: 1.61803 40 are missing 2, 5, 7, & 9. [4]

10 digits: 1.61803 3989 are missing 2, 4, 5, & 7. [4]

12 digits: 1.61803 39887 5 are missing 2, 4, & 9. [3]

What makes ϕ interesting and perhaps the-most-interesting-display number?

1. It's reciprocal has the same decimal digits. $1/\phi = 0.61803\ 39887\ 49894 \dots$

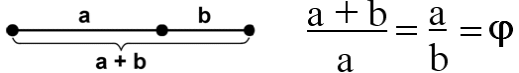
2. It's square is the same as adding 1. $\phi^2 = 2.61803\ 39887\ 49894 \dots$

3. Solving for ϕ using #2 as a quadratic equation has the same + and – solution decimal digits.

$$\phi^2 - \phi - 1 = 0$$

$$\phi = 1.61803\ 39887\ 49894 \dots \left(\frac{1+\sqrt{5}}{2} \right)$$

$$-\phi = -0.61803\ 39887\ 49894 \dots \left(\frac{1-\sqrt{5}}{2} \right)$$

4. ϕ has been known since at least 300 BC when the Greek mathematician Euclid described it (its construction) in *Elements*.
5. ϕ may have been a factor in the design of the Great Pyramid in circa 2540 BC.
6. ϕ and $1/\phi$ are irrational numbers. Its value has been calculated: to 10 million digits in December 1996 and to 1.5 Billion digits in May 2000.
7. ϕ expressed in any base does not have any ultimate repeating pattern in their digits.
8. ϕ and the Fibonacci numbers are related and it may be shown how the Fibonacci number (ratio of successive Fibonacci numbers) arise from ϕ .
9. ϕ cannot be expressed as a fraction because it is irrational.
10. Geometrically the golden ratio may be expressed as:  $\frac{a + b}{a} = \frac{a}{b} = \phi$
11. ϕ has artistic value in that it is used to hang paintings and size rectangles because these proportions are aesthetically pleasing and have been used since the renaissance period. In #10 above if length ab is unity, $a = 61.8\%$, $b = 38.2\%$.
12. An alternate name for the golden ratio is the golden section.
13. Da Vinci, during the renaissance, claimed that there were a number of applications of the golden ratio in the human body. He found that a perfectly structured human body would have the golden section between:
 - first finger joint and second - second joint to both
 - hand to lower arm - both hand and lower arm
 - many proportions creating the perfect face
 - so on, all over the body
14. The Pearl Musical company of Japan positions the air vents on its four Masters Premium drum models based on the golden ratio. The company claims that this arrangement improves bass response and has applied for a patent on this innovation.

This very simple question of entering an interesting number into the calculator display just to take a photograph should illustrate the simple fact that numbers are more than the digits zero through nine and a decimal point.

Numbers may be described as cardinal or ordinal, odd or even, rational or irrational, positive or negative, real or complex. These will be described in detail in the next part of this series. For the moment let's describe what is called the natural numbers. Wikipedia describes natural numbers as follows.

“In mathematics, there are two conventions for the set of **natural numbers**: it is either the set of positive integers $\{1, 2, 3, \dots\}$ according to the traditional definition or the set of non-negative integers $\{0, 1, 2, \dots\}$ according to a definition first appearing in the nineteenth century.”

“Natural numbers have two main purposes: counting ("there are 6 coins on the table") and ordering ("this is the 3rd largest city in the country"). These purposes are related to the linguistic notions of cardinal and ordinal numbers, respectively. (See English numerals.) A more recent notion is that of a nominal number, which is used only for naming.”

“Properties of the natural numbers related to divisibility, such as the distribution of prime numbers, are studied in number theory. Problems concerning counting and ordering, such as partition enumeration, are studied in combinatorics.”

This will get us started in our math review series. Now if I can only get that E or EEX key to work as I expect it to.

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>.