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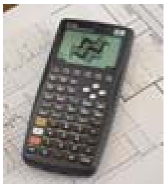
HP Solve invites you to read and share your favorite stories for a chance to win a HP calculator.



» **HP 48 One Minute Marvel - No. 8, Prime Numbers**

Marvel in these One Minute Marvels from HP. This month, learn how to define prime numbers.

» **Are we there yet?**

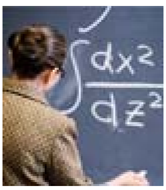
Jake Schwartz

Jake provides his unique perspective on some fundamental aspects of HP calculators and examines their trends, both positive and negative over time.

» **HHC MMX report**

Richard J. Nelson

Read Richard's full report on another successful gathering at the 37th HP Handheld Conference, HHC, held in Ft. Collins on September 25-26, 2010.



» **Calculating before Calculators**

Richard J. Nelson

The fourth installment in the 'Fundamentals of Applied Math Series' explores and explains how calculations were done before personal electronic

» **The PROOT Gem**

Namir Shammas

The advent of the HP-48GX/G+/G family of calculators introduced a new function, PROOT, that replaced the Solver when dealing with polynomials.

Issue 21
November 2010

Welcome to the twenty-first 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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From the Editor

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

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Customer Corner

» **Meet an HP Calculator user**

Meet Mark Ringrose, a UK calculator user involved in the finance world in an unusual way. Read all about it and the machines he uses.

calculators were commonplace.

Learn how this new function provides users with multiple advantages.

Math Education around the World

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Math Education around the World

Math may be one of the most universal subjects on Earth but math instruction and calculator use vary widely from country to country. Even the simplest activities like learning to count can be handled differently across cultures. A grade school student in the US would say that he could use his fingers to count to ten while an Indian child would use the individual joints on his fingers to count to 28 without having to remove his shoes.

As parents, teachers, and students with curious minds, we benefit by learning from one another about current trends in math education throughout the world. Children of today will likely find themselves competing for jobs with students on the opposite end of the globe. In this borderless society, job markets will become increasingly competitive. So what is it that schools in Hong Kong are doing that holds their position in the top 5 math performers worldwide while the US trails behind in 21st place? This answer will not be found within the context this 900-word article, but we can begin with a brief exploration of the programs HP has initiated in several countries around the world.

Let's begin in Australia where students completing primary school are required to take an exam called NAPLAN, which stands for *National Assessment Program--Literacy and Numeracy* to demonstrate their readiness for high school. HP facilitated the development of a NAPLAN prep kit, which includes a class kit of HP-10s calculators, a prep book with 10 weeks of daily lessons, a virtual book with solutions for an interactive whiteboard, and emulator software to project the 10s calculator on a large screen. What is most interesting about this solution is that it incorporates several technologies. The calculator is perhaps more relevant than before because teachers can use other technologies to incorporate the calculator directly into their lessons. Students can follow along with their teachers to learn interactively. The best way to commit a lesson to long-term memory is to engage as many of the senses as possible. When we watch, repeat, and take notes, we increase our chances of remembering. The interactive lessons of the NAPLAN prep kit engage multiple senses and compel students to take an active role in their own learning. See appendix A.

Now we will travel back to the United States where interactive learning is spreading through our education system via web 2.0. A few years ago, HP and Microsoft collaborated to create the Teacher Experience Exchange, [http://h30411.www3.hp.com/], a free forum where teachers can share or download lesson plans posted by other teachers. Under the math category, nearly all lesson plans are interactive, and many incorporate the HP 39gs graphing calculator in activities that allow students to conduct their own experiments and analyze data. The days of the dry lecturer and his dusty chalkboard are fading into the past. What we see today on the Teacher Experience Exchange, [http://h30411.www3.hp.com/], and in the classroom are teacher facilitators who briefly provide a conceptual base and then walk students through a learning experience. Because this style is more consistent with the on-the-job training we see in today's working world, there is hope that this learning approach will better prepare US students to transition to the work-force.

Today's tour concludes with a trip to Brazil where HP is the clear market leader in calculators. Brazilian administrators in higher education are working towards establishing a world-class education system. As one of the fastest growing economies on the planet, Brazil has quickly established itself as a major player in the sophisticated industries of aerospace, energy, and banking. This creates a need for the Brazilian education system to cultivate high performing talent in the engineering and finance disciplines. However, the high-tech classrooms we see in developed countries are not yet a reality across Brazil. As an affordable alternative to 1-to-1 computing with specialized software programs, HP calculators have become vital tools for Brazilian students. McGraw Hill has even published two new textbooks this year in Math and Finance that link their lessons to HP calculators so that students can make the connection between textbook theory and practical application.

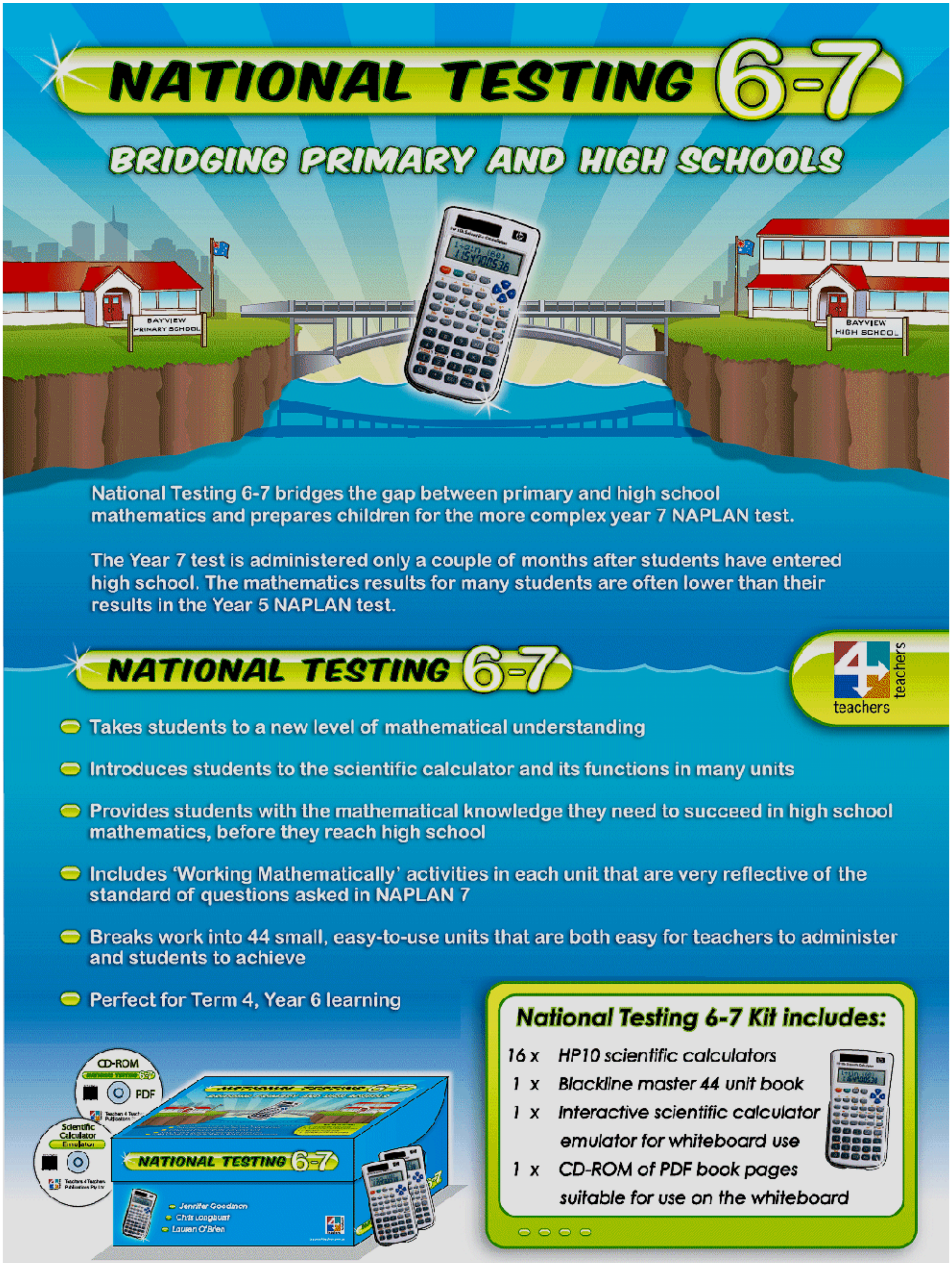
Reflecting on Brazilian math education, one might even go so far as to argue that using a calculator for finance and engineering exercises keeps a student more engaged with the mathematical concepts of his projects and fosters a greater understanding of the material. Three examples of a Successful Mc Graw Hill partnership for back to school include the following titles:

- Linear Algebra by Grossman with HP 50G Technology
- Financial Mathematics by Zbigniew Kozikowski with 17 BII technology.
- Physics by Tippens including HP 50 G Technology

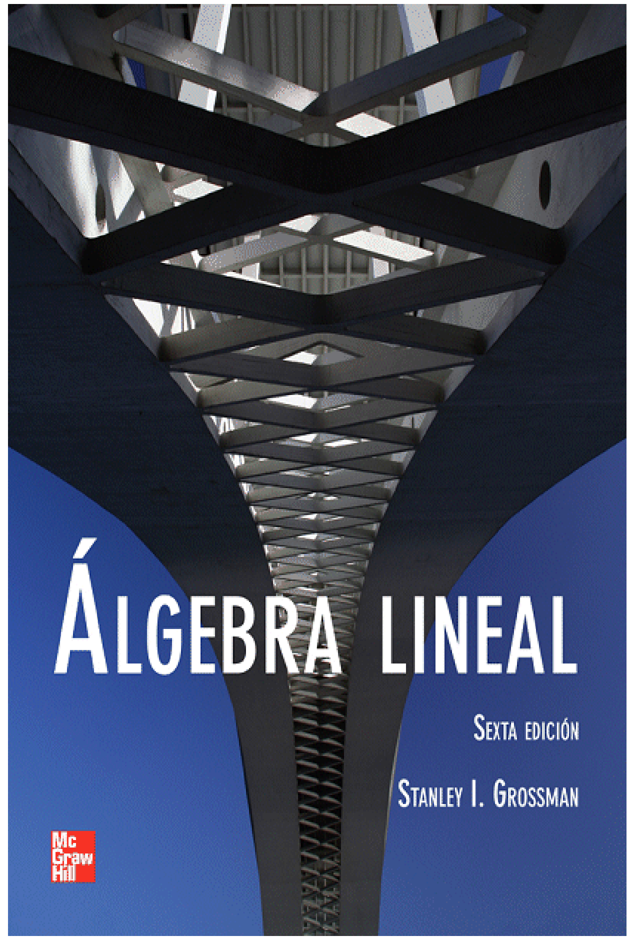
See appendix B for additional information.

When using a calculator, a student is more likely to understand what the numbers are telling him and where they come from, but when he becomes too accustomed to plugging commands into a software program, it's easy to lose touch with the meaning of the numbers. What happens when the finance leaders of tomorrow lose touch with the concepts upon which they build statistical models for forecasting and risk management? Toxic assets are assigned AAA ratings and snatched up by banks and pension funds. As humans, we've come to rely on computers to spit out scores, and we hope that someone else in the chain of command knew how to do the math.

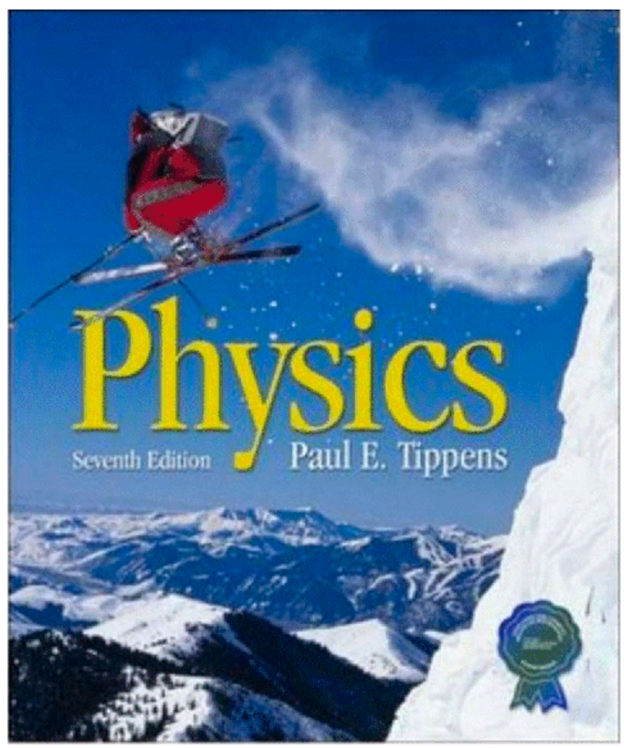
Appendix A – Australia's NAPLAN



Appendix B – HP-McGraw Hill Partnership Books



- *Linear Algebra*, 6th Edition by Stanley I. Grossman with HP 50G Technology
  ISBN 0387728287
- *Financial Mathematics* (*Matemáticas financieras*) by Zbigniew Kozikowski *w*ith 17 BII technology.
  ISBN: 970106061X
  ISBN-13: 9789701060612
- Physics, 7th Edition by Paul E. Tippens including HP 50 G Technology
  ISBN 9780073222707



Every Calculator has a Story

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Every Calculator has a Story

Last week at a commercial real estate conference, a veteran 12c user approached the HP table and asked, "Do you know how HP won its first big government contract for calculators?" He reported that Bill Hewlett and Dave Packard went into this government office to do their sales pitch. They showed all the functions and processes that made the HP calculator a better and faster engineering tool. But at the end of their pitch they said, "Now that you've heard what we have to say, if it's alright with you, we'd like to briefly demonstrate the real reason why our product is better than the competition." They brought in a board to prop against the wall on the opposite side of the room. First they threw the competitor's calculator at the board and watched it shatter. Then they did the same with the HP calculator, picked it up, brushed it off, and showed that it was still in fine working condition.

For a product line with such a devoted fan following, there are many stories about the ways loyal HP colleagues and customers have tortured their beloved calculators. Perhaps the most famous is the story of a zoo keeper who called HP a few years ago to report that his calculator had been eaten by a hippopotamus. Concerned for the safety of the animal and the fate of his calculator, the zookeeper waited for the calculator to pass through the hippo, cleaned it off, and found that it still worked perfectly.

Then there is the story of a man who inadvertently left his HP calculator outdoors in Montana for an entire winter. When he returned to the site the following spring, he found his calculator waiting for him. With a new set of batteries, the calculator worked just fine. Undeterred by rain, sleet and snow perhaps the HP calculator should apply for a job with the US Postal Service.

As you can see the stories told here come from HP calculator owners and loyal fans. If you would like us to share your HP calculator story with our newsletter readers, send an e-mail about your experience to

hpsolve@hp.com

Disclaimer:
HP offers a one year warranty on our calculators. Despite the accounts we've heard from some of our customers, HP does not recommend that you drop, pour liquid on, step on, run over, or otherwise torture your calculator. If you love your HP calculator, please take good care of it.

HP 48 One Minute Marvel

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HP 48 One Minute Marvel – No. 8 – Prime Numbers

One Minute Marvels, OMMs, 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.

Let's first define a prime number. The following is taken from an article in the last issue of ***HP Solve*** **,** #3 in the Fundamentals of Applied Math Series, Numbers III.

N13. Prime Numbers

Numbers may be broken into various groups. Examples are even numbers and irrational numbers. Another group are those numbers that have two distinct natural number divisors, 1 and the number itself. If you examine the numbers from 1 to 100 you will find 25 of these are prime. You may put any of these primes into Wikipedia by entering "number N" (N = number) to learn some interesting numerical tidbits.

2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47, 53, 59, 61, 67, 71, 73, 79, 83, 89, and 97

Prime numbers have fascinated people for centuries. Euclid demonstrated that an infinite number of prime numbers exist in approximately 300 BC. The number 1 is by definition not a prime number.

Looking at the small sampling of primes above a few observations and questions jump right out. Except for the first prime number, 2, prime numbers are always odd. How are the primes distributed? Are the prime numbers random? You naturally want to enter them into a list and use your RPL graphing calculator to apply various list functions on the primes. First you want to take the difference. What is the smallest prime number that has substantial difference between it and next prime? Do the differences of sequential prime numbers form a series? Next you may want to take the square root. Are the roots of all prime numbers irrational?

One way to look at prime numbers is to list "the numbers" indicating which ones are prime as shown below in Table 1. The shaded values are primes.

Table 1 – Prime numbers (shaded) in a table of numbers 1 to 200.

	1	♦	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171	181	191
⇒	2		12	22	32	42	52	62	72	82	91	102	112	122	132	142	152	162	172	182	192
	3	♦	13	23	33	43	53	63	73	83	93	103	113	123	133	143	153	163	173	183	193
⇒	4		14	24	34	44	54	64	74	84	84	104	114	124	134	144	154	164	174	184	194
⇒	5		15	25	35	45	55	65	75	85	95	105	115	125	135	145	155	165	175	185	195
⇒	6		16	26	36	46	56	66	76	86	96	106	116	126	136	146	156	166	176	186	196
	7	♦	17	27	37	47	57	67	77	87	97	107	117	127	137	147	157	167	177	187	197
⇒	8		18	28	38	48	58	68	78	88	98	108	118	128	138	148	158	168	178	188	198
	9	♦	19	29	39	49	59	69	79	89	99	109	119	129	139	149	159	169	179	189	199
⇒	10		20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200

⇒ indicates a row in which no prime numbers will be found, ♦ indicates a row in which some prime numbers will be found.

The challenge is to "process" a number to determine if it is prime. Essentially you must perform a lot of trial divisors to insure that the number is only divisible by 1 or itself. Actually you only need to test the number up to its square root. Still this is a lot of arithmetic for very large numbers and because it involves division that is one of the most "expensive" of the normal arithmetic operations. The excessive number crunching to determine weather a number is prime is often used as a bench mark program to test a machine.

Often the process of exploring prime numbers is to test the number and then continue "looking" at larger numbers testing them until a new prime number is found. While the arithmetic is being performed there are useful results other than just knowing if the number is prime. You may also want to know the prime factors of the number.

Here are two HP 48 programs, both with contributions from Joseph Horn (CA) and Brian Walsh (IL).

Next Prime

Enter any integer n (greater than 0) and press '**np'**. The original n will be raised to level 2, and the first prime factor of n will be placed in level 1. To find the next prime factor, you can press / and then run '**np'** again. If the input number is returned (same number on levels one and two) the number is prime.

You may write the factors down or you may type in a second OMM, **Prime Factors**.

```
'np' << DUP √ → s << DUP 2 MOD { 3 WHILE DUP2 MOD OVER s <
        AND REPEAT 2 + END DUP s > { DROP DUP } IFT } 2 IFTE >> >>
```

31 commands, 108.5 Bytes, #A114h.

Prime Factors

If you want to find all the prime factors of n, run '**pf'**. It replaces n with a list of its prime factors. (Calls '**np'** above.)

```
'pfa' << { } SWAP DO np ROT OVER + ROT ROT / DUP 1 SAME UNTIL END
         DROP >>
```

16 commands, 55.5 Bytes, #2E8h. Timing: 27 ⇒ { 3 3 3 } in 161_ms.

The following values may be used to illustrate and test the **Prime Factors** program.

Table 2 – A few examples of finding prime number factors

pfa input	Result	pfa input	Result
199	{ 199 } *Prime*	99,990	{ 2 5 29 241}
200	{ 2 2 2 5 5 }	99,991	{ 99991} *Prime in 2.6 sec.*
1,326	{2 3 13 17 }	982,451,652	{ 2 2 3 7 13 899681 } in 7.4 sec.
1,327	(1327 } *Prime*	982,451,653	{ 982451653 } *Prime in 14:29*
5,572	(2 2 7 199 }	78,643,581,288	{ 2 2 2 3 2287 1432801} 23 sec.
5,573	{ 5573) *Prime*	78,643,581,289	{ 7 13 17 23 31 37 41 47 } 2.3 sec.
7,918	{2 37 107 }	961,748,942	{ 2 7 11 6245123 } 23.4 sec.
7,919	(7919 } *Prime*	961,748,941	{ 961748941 } Prime in 14:25
69,888	{ 2 2 2 2 2 2 2 2 3 7 13 }	977,777,808	{ 2 2 2 2 3 7 307 9479) 4.3 sec.
69,889	{ 47 1487 }	977,777,809	{ 977777809 } *Prime in 14:55.5.*

When the numbers get very large (hundreds of digits) the run time for any computer program becomes significant and computers are used around the world to look for new largest prime numbers.

More modern machines such as the HP20b or HP30b are much faster and they could be programmed to find prime factors at significant speed improvements.

Patrice Torchet from France recently gave a presentation at HHC MMX in which he described his method of determining if a number is prime. Do the rows of Table 1 with numbers ending in the digits indicated by the ⇒ symbol mean that numbers ending in the digit cannot be prime[(1)]? Testing the input, n, may be done by examining these digits to eliminate 60% (6 of 10 rows) of the numbers involved. Here is how he compared the classical method and his approach in terms of the number of steps.

Classical algorithm complexity:

- O(N) is for every factor until the square root
- O(N/2) is for every odd factor

New algorithm complexity:

- O(N*2) is for every factor until the square root with the twist that it is a tree and not a simple list. The 2 comes from the number of nodes in a binary tree to have n leafs.
- O(N) is for every odd factor
- O(N/2) is because the multiplication is commutative

For each step.

Classical algorithm:

- It is a division
- O(log(N)*log(N)) in base 2
- O(log(N)) subtractions and shifts

New algorithm:

- O(log(N)) in base 2, each step is about a subtraction and a shift
- O(1) subtractions and shifts

If you are interested in his approach to testing for prime numbers you may contact Patrice at: torchet.patrice@orange.fr

HP 48 One Minute Marvel – No. 8 – Prime Numbers Notes:

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(1) You may use word to get a "very good feeling" about this speculation. Down load a large batch of prime numbers from: http://primes.utm.edu/lists/small/millions/. These will be provided as single numbers without spaces or commas in columns across the page. Using 12 point Times New Roman font, for example, the last choice to down load is fiftieth million (**) which will down load 2,501 pages of 400 numbers per page (except the first and last pages) of 999,976 prime numbers between 961,748,941 and 982,451,653. Each number is separated by a space.

Use the Word function "Find" using "6 ", for example, to find such a set of characters. If the cursor is at beginning of the numbers on page 1 Word will instantly search the 2,501 pages of 999,976 prime numbers and not find a single occurrence of a prime number in this range ending in "6."

You may search for any number to quickly find it in this range. For example, what prime has 7 7's in this range? 967,777,777 is one. Is there a number with 8 7's? No. Starting with 97? No. The prime numbers in this range are: 977,777,701; 977,777,719; 977,777,737; 977,777,767; 977,777,809. If you search this Word database of primes for just about any sequence of 5 or 6 digits such as 31415, 12345, 24680, your address, etc. you will find a prime number that contains them. For example a series of 5 of the digits 0-9 will be found. The same series of 6 will be found except "5" and a sequence of 7 of the same digits for "6" & "7" will be found, but none of a series of 8 of the same digit.

Are We There Yet?

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Cupertino to Corvallis to Singapore to Melbourne to San Diego: Are We There Yet? (9/2007)

Jake Schwartz

On this 35th anniversary year of HP handhelds, I would like to briefly touch on some fundamental aspects of HP calculators and examine their trends over time. In order to declare whether these are positive or negative trends, one should probably consider the point of view of the examiner. As an outsider who is trying to understand the historical forces being exerted on the calculator products, my focus is on whether the machines increase capability and increase (or at least maintain) ease of use without much regard for cost. However it is beneficial at least to consider the basic steps required for a calculator to evolve from napkin sketch to shipped product.

An Outsider's View of the Development Cycle

Initially, one must create a machine design based on inputs from a team of one or more individuals. Once the design is firm, the specifications are communicated to the manufacturer. (From the days of the Advanced Products Division in Cupertino through the Corvallis Division, the designer and builder were both HP, so the manufacturing facility may have only been a short walk from the engineer's drawing boards. In more recent times, an outside manufacturer has been utilized.) If the manufacturer is unfamiliar with many of the criteria evolved over years for successful HP hardware, these specs might have to be spelled out in excruciating detail so nothing is overlooked.

Following the manufacturing process, product is packed and shipped to distributors and vendors. There might also be some concurrent marketing and publicity to make the buying public aware of the release of the new product. (Lately there has been way too little of this for HP calculators, in my opinion.) Calculators are sold by mail, retail and on line and (hopefully) everyone in the chain starting with HP make some profit in the sales. With this profit, designers get paid, more designers may be hired and with feedback incorporated from the users, perhaps additional calculators may be conceived, allowing the process to repeat itself.

The Eternal Struggle

During the development cycle, many factors come into play which participates in the "tug of war" between maximizing profit and sales versus improving technical capabilities. A device which is primarily designed for students might sell better to them if it looks "cool", but this obviously doesn't make the device work any better. A fixed budget might be allocated such that significant dollars are funneled away from design engineering in order to support marketing, and thus an inferior machine supported by lots of ads might outsell a superior machine about which few people have been informed. Often times, a company decides it wants to "get a foot in the door" in a certain market and the quickest and least expensive way to achieve this might be to utilize an existing generic (and not necessarily well-thought-out) third-party calculator design and affix their company logo on the case. The ultimate effect on the company's reputation becomes anyone's guess in this case.

When HP's Australian Calculator Operation (ACO) in Melbourne resurrected the business from Singapore (where it seemed to lay dormant for a few years), it appeared that the pendulum had swung over from technical excellence to more of a focus on profitability. Perhaps this was intended to be a temporary way of jump-starting the group again with some much-needed cash. In any case, the release of the 6S, 6S Solar and 30s calculators were unlike any HP machines before them, where virtually all of the legacy "family jewels"-type characteristics (such as high-contrast function lettering, tactile-feedback buttons, RPN-logic capability, concern for minimizing keystroke counts, etc.) were de-emphasized. Since the 6S and the 30S physically and functionally resembled other manufacturers' units already in the marketplace, one was led to conclude that these had not been designed in house. Whether the hoped-for cash streamed into ACO at that point is any outsider's guess. In any case, the veteran HP users pretty much scratched their heads. Meanwhile, soon after, the entire group was disbanded and all projects (including the promising educational Xpander and Linux-based PDA the Jornada X25) were cancelled or put on hold.

Around 2002-03, when the San Diego group was attempting to restart calculators again, they also had designs on generating some quick cash (as far as we can tell) and put out the hp9s and hp9g. These two machines resembled the 30S so much, we outsiders concluded this was another pair of rebadged machines from the same vendor. The new-fangled term for the San Diego group's initial approach to calculators was "Strategic Touch Model", which we interpreted to mean that HP attempts to only provide detailed specs and perhaps technical support information while relying on the third-party manufacturer to completely implement the hardware and firmware. This can work if the specs are clear and complete and the vendor does not attempt to sneak in any short cuts which might jeopardize quality or reliability. When the 10BII and 17bII+ were released, we saw legacy firmware in a new case and hardware design, presumably to reduce cost. The results were mixed from a user-feedback standpoint; with the 10BII experiencing some issues with its keyboard and the 17bII+ appearing like an "economy model" compared to its Pioneer-Series ancestors. Since the professional business user has been considered HP's "bread and butter", you would think that they would desire to provide a more acceptable look and feel to this community which traditionally would be willing to purchase a more expensive machine in exchange for prestige and reliability. Later, in an attempt to enter the Asia-Pacific educational and basic-scientific market, they produced the hp8s calculator, a machine similar in functionality to the 6s and 30s and again (as far as we know) with firmware basically selected off the shelf and bearing no resemblance to any legacy HP scientific machines. Hopefully, these strategic moves have generated the cash which the organization required in order to sustain itself while planning more substantial homegrown designs.

Meanwhile ACO's hp49g, which had greatly improved functionally over the 48 series but presented compromises in other areas, was given a hardware upgrade by San Diego in the 49g+. After a handful of iterations attempting to return the key feel to that of the 48, they began to get it right. More recently, the 50g refreshed the 49g+ and the keyboard feel is extremely good.

Considerations and Trade Offs

The purpose of this paper is to discuss specific changes which have occurred recently in the calculator models which either extend features considered to be beneficial to the user or those which reduce usability in one way or another. Back in the Corvallis days of 1978 through 1994, for the most part, functionality and capabilities seemed to improve from one generation to the next. Display sizes grew in order to provide more and more information at a glance, keyboard quality was maintained at a high level, flexibility and ease of use was retained or improved, programming power improved, memory sizes grew and costs fell. Certain features did come and go, but in general, the direction of the business seemed clearly headed towards better, faster, less expensive. After Corvallis, things changed, however. Perhaps the ubiquity of the personal computer made the calculator less important to technical professionals and the student market seemed the only viable place to pursue significant sales. Also, the changing of personnel from the Corvallis team to Singapore, Australia and now San Diego caused an erosion of the knowledge of what was considered the most important qualities of HP calculators to long-time loyalists. Each time a new team arrived, the users attempted to remind the next group of the importance of certain traits and features. This effort has begun to pay off in returning to some of the best capabilities and qualities of the Corvallis past. In other areas, more work is needed.

Issue 1: Long Live the Large ENTER Key

Since the HP35 in 1972, we have seen a large ENTER key in some form or another. Even when pure algebraic machines were first released starting with the HP18C in 1986, the large INPUT key at the middle of the keyboard represented the HP brand more than anything else. However in 1999 with the hp49g, there was an attempt to appease the algebraic users by shrinking ENTER and relocating it down at the bottom right like the other manufacturers. In the flagship RPL models and algebraic student models from 2000 on, this positioning has remained, much to the dismay of the traditional HP users. Another example of this was the release of the hp33s, which was a 2004 refresh of the 32sII Pioneer unit. However, recently the San Diego group did another upgrade with the hp35s and the large ENTER has returned in this mid-line scientific model. From the excitement generated in the experienced-user community, this has been a very positive step.

Issue 2: Key-front functionality and Controlling Keyboard Clutter

Starting with the HP65 in 1974, when the number of functions on the keyboard was rising steadily but increasing keyboard clutter was a liability, HP found a way to control this clutter by placing functions on the fronts of the keys as well as on the key tops. This continued up through the mid 1980s but was inexplicably discontinued with the release of the Pioneer-Series machines in 1988. Suddenly, if more than three functions were required per key, that keyboard got really crowded with function names labeled above and to the side of keys. Despite the implementation of soft-key menus, keyboards got “busier”. Somehow, this change began to be reversed with the 10BII and 17bII+ on the business side and more recently with the 35s on the scientific side By adding this key “plane”, layouts do not seem as intimidating.

Issue 3: A Little Bit About Color Choices for Calculator, Keyboard and Keys

For the most part, from the Corvallis designers, we counted on and received a set of machines which had a consistent look and high key-color to key-label-color contrast. There typically was no issue with reading markings on any keyboard in this era. Then starting with the Singapore group, some things began to change. The HP48G series machines received teal and lavender shifted key functions which were somewhat difficult to tell apart. A second version of the hp32SII was produced with a change in the key colors from the clearly-differentiated Corvallis blue and gold shifts to the same 48G-series teal and lavender. The hp6S was later released by ACO with a blue metallic case and blue shifted function names which became almost invisible under varying lighting conditions. The hp49g, with its odd combination of green, red and blue functions on a light blue case was puzzling. This was followed by the 30S with its set of switchable faceplates to supposedly suit varying student color preferences. Again, traditional users saw more emphasis on style but not necessarily on substance. This trend does seem to be reversing lately, with higher-contrast and more easily readable function and key color choices in the 35s, 50g, 39gs and 40gs.

Issue 4: The Re-definable Top Row of Calculator Keys

Hewlett-Packard began making the top row of calculator keys re-definable on its flagship programmable scientific calculators starting with the HP65 in 1974. With this model, along with the HP67 in 1976 and the HP41 in 1979, the user could mark five (or ten with shifted) functions on the writeable side of a magnetic program card and mount that card either directly above or near the top row of keys in order to label their functions as assigned by the program. Later, starting with the HP18C business calculator in 1986, HP began an effort to allow the LCD itself to be the identifier of the functions on the top key row. This relationship between the LCD and the top row of keys appeared in several forms throughout the Clamshell machines, the Charlemagne series and in Pioneer 1-line and 2-line LCD machines and continues up to the present day with the 39gs, 40gs and 50g graphing products. It was especially clever how HP Corvallis managed to keep this feature intact with single-line-display HP32S and HP32SII Pioneer units. When a menu is activated, it is displayed in place of the value in the X register and when a menu selection is made by pressing the corresponding top-row key, the menu is removed. The elimination of the need to hunt for specific keys on the keyboard below the top key row is a big advantage over other menu methods such as (1) requiring pressing of up- or down-arrow keys to navigate the entry in the display to the selection of choice, or (2) having to press a number on the keypad corresponding to the selection of choice. In the two-line Pioneer models, the menu labels could be displayed in the bottom row of the LCD while other information remained in the top row. The San Diego group also maintained this feature when repackaging the HP17BII into the hp17bII+ hardware and case.

Later, in 2004, when they refreshed the HP32SII with the release of the hp33s, the top key row and LCD were suddenly and inexplicably decoupled. Despite the fact that the 32SII functionality was maintained (and even enhanced somewhat), the new case and key arrangement did not permit the soft-key menus to be retained. So now, if a user wished to change the current base to OCTAL from within the Base menu, he would either have to press the down-arrow to reach the Octal selection and then press ENTER (which increases the keystroke count unnecessarily), or go down to the keypad and select “3” since this choice was listed in the LCD as the third menu selection. Unfortunately, although with the release of the hp35s last July, the top row of keys was more suitably situated adjacent to the LCD again in order to facilitate a return to the soft-key menu scheme of the Pioneer machines, it was not restored. This could be considered the converse of the proverb regarding those who don’t remember the erroneous ways in past history being doomed to repeat them – this goes something like “those who forget the successes of the past are doomed to abandon them”.

There actually would be a way that the current 35s LCD and key layout could support soft-key menus via a firmware change if HP chose to implement them. Please refer to the paper “Soft-Key Menus for the hp35s”, located at: http://www.pahhc.org/2010/Articles/HHC2007_Soft_Key_Menus_for_the_hp35S.pdf for some ideas in that realm.

Issue 5: Keyboard Overlays for Fully-Re-Definable Calculator Keyboards

With the introduction of the HP41C in July of 1979, HP took keyboard customizability a large step forward by extending the capability to assign user functions not only to the top row but to any key on the calculator keyboard. After assigning a function to a key, a user could turn on “USER” mode and then identify the customized key function by attaching over top of the keys an overlay which was physically marked with the new function name. Cleverly, the calculator edge around the keyboard had slots cut in it to allow overlay tabs to be snugly set into them. In addition, HP allowed pre-programmed functions provided by some of their own plug-in ROM modules to redefine the HP41 keyboard and they supplied preprinted overlays for those functions. With this technique, the requirement to press the keystrokes required to spell a custom function out letter-by-letter, was supplanted by a key assignment. This USER-mode capability continued with the HP48 S- and G- series machines and with their own overlays and again, slots were in the outer edge of the machines to allow overlay attachment. For those third-party software providers (and also for individual users who wrote programs which assigned many keyboard keys), this was a convenient way to keep keystroke counts to a minimum by redefining multiple key positions.

In 1999 when the hp49g was released, it represented a direct descendant from the HP48 series and retained USER mode to redefine keys, however no provision was made in the plastic case to allow the attachment of keyboard overlays. We have heard HP explain this rationale a few times, whereby since the sales of blank overlays for the HP48 series machines were extremely low, they saw no benefit in continuing the overlay capability. However from my standpoint, if modifications to the calculator case added almost no cost, then had they been present, some outside vendor or enterprising user could potentially manufacture overlays for that small group of people who chose to continue to use them. The attitude of choosing to withdraw support for advanced users despite the cost being minimal is one of concern, but that is a topic for another time.

Issue 6: Full-Keyboard versus Soft-Key Menu-Based Alphanumeric Entry Capability

The HP41 brought many innovations to calculator design, not the least of which was the capability to include alphanumeric strings, prompts and labels in calculator programs. The user interface provided the alphabet spread out on the keyboard so when “ALPHA” mode was entered, the keyboard would be redefined such that each primary key function was an upper-case letter. Thus, with the exception of entering and exiting ALPHA mode, each single keystroke allowed for the addition of a letter to the calculator program or ALPHA display register. In 1988, when the HP42S was released in the Pioneer series as a successor to the HP41 series, the ALPHA mode and alphanumeric text and labels were retained, but the method by which ALPHA entry was achieved was radically changed. Instead of placing the letters on the keys, an ALPHA soft-key menu was presented. Since only the top row of keys get defined for this purpose, the user was faced with a two-level menu scheme whereby the initial menu grouped as many as 5 letter choices on a single menu key. After that menu key was selected, a secondary menu would appear, spreading the 5-or-so keys from the initial menu choice across the row of soft keys. Under this method, each letter required no fewer than two key presses. Although the absence of the alphabetic letters on the keyboard contributed to the reduction in keyboard clutter, the increased number of keystrokes to enter alphabetic information seems to be a regression in user ease.

In 1990 with the release of the HP48SX, the alpha entry was restored to distributed characters over the entire keyboard again and keystroke counts went back down to reasonable levels. This method has been continued to the present day with the hp50g and although the keyboard does have high clutter, it is tolerable.

Issue 7: Base Conversion, Base Arithmetic and Bit Manipulation

Hewlett-Packard’s first foray into the world of base arithmetic happened in 1974 when the HP65 was given decimal-to-octal conversion capability. The pinnacle of this functionality occurred with the release of the HP16C Voyager-Series machine, which was dedicated to base manipulation for computer science applications. Had the demand for such a machine continued to the levels that the HP12C business calculator experienced, perhaps we would still be able to purchase a new 16C to this day. However despite its demise, a subset of base conversion, arithmetic and bit-manipulation functionality survived within a handful of the Pioneer scientifics, the 33s and 35s, the HP48 S- and G-series and 49g/g+ and 50g graphing units. However the depth of capabilities such as double-word arithmetic, bit shifting and rotating and carry and overflow-bit functions were lost. (Rick Grevelle and I produced in 1993 an HP16C

Emulator Library for the HP48 S and G series machines, which attained and exceeded the 16C functionality. This utilized a custom keyboard overlay which distributed all the HP16C functions throughout the HP48 keyboard. However, when the 49g came out and there became no way to attach a overlay, we abandoned any attempt to port it further.) Perhaps some day this full capability could be restored to some scientific or graphing machine of the future.

The Prognosis: The Future Is Still Bright

Despite the issues with some of the current line of HP calculators, there is hope for a brighter future. With the release of the hp35s, we were treated to the return of the wide ENTER key, put back in its rightful place at the middle of the calculator rows. The fronts of the keys are being utilized more and more in order to help keep keyboard clutter minimized. Reliability and key feel has been getting better over the past few years as the manufacturer is being educated on how important it is to present a physically superior keyboard. The displays on recent models have been very readable and with higher contrast than those in the past. Color schemes appear to be getting more sensible, with key labels becoming easier to read. The 35s represents a direction toward home-grown calculator functionality like what has been ongoing with the 50g. Perhaps if the 35s has a market success like it deserves, HP will consider two additional things: (1) adding RPN to an entry-level scientific so as to give new students at least a chance to try RPN for themselves; and (2) following up the 35s with an even more capable RPN-based keystroke programmable in order to continue where the last RPN "king-of-the-hill" – the HP42S, from almost 20 years ago - left off.

Epilog October, 2010 - San Diego to Fort Collins: Still on Track?

It has now been three additional years since this article was first presented at the HHC2007 conference, after which the calc-team "headquarters" shifted again from San Diego to HP's Fort Collins, Colorado facility this time. Calculators keep chugging along, with the focus having seemingly changed primarily over to refreshing and/or enhancing the financial machines. In early 2008, we saw new cases and keyboards for both the HP10BII (returning to a more professional look as in its 10B predecessor) and the 17BII+ (with the reinstatement of the familiar double-wide INPUT key like its ancestors). In June of that year, the 20b was introduced, being the first of a new series and designed essentially from scratch. With a hardware platform based on a modern CPU, the possibilities opened for machines many times faster than anything in that class. This platform bore fruit again in early 2010 with the release of the HP 30b financial calculator, which includes many more functions plus basic keystroke programmability whose speed allows it to run rings around all predecessors, including the non-graphing scientific machines. Also, this CPU was adapted for the 12C, with revised units recently appearing on the store shelves this year. Again, the speed is an order of magnitude higher than any previous machines in the Voyager (10C/11C/12C/12C Platinum/15C/16C) series. Without question, the financial user has been treated to fantastic speed improvements.

On the key/function front, it does seem that HP has continued to prefer control of financial-machine keyboard clutter at the expense of increasing function keystroke counts. While the 10BII continues to provide dual shift keys in order to place all its functionality in plain view, the 17BII+ and 20b/30b have maintained (or adopted) a single shift key and shifted-function plane while embedding a huge number of functions in menus. While it would not be possible to bring all the functions out to the keyboard on any of those units, at least a few dozen additional popular ones could have been made immediately accessible. In addition, with respect to the 20b and 30b with their "sequential" menu system, only one function is accessible at a time and the up- and down-arrow keys must be used in order to navigate to the function desired. Despite this being the same system that is employed by the competition's calculators, it requires many more keystrokes to get a job done and also may leave the less-experienced user hunting more for embedded items. At least in the 17BII+ soft-key menus, at many as six functions are visible simultaneously.

While no new machines have appeared in the scientific or graphing lines recently, it is hoped that eventually, those families will also adopt more modern hardware and enjoy the speed improvements now available in the financial calculators. A 35S scientific sporting the speed of the 30b would increase its programming usefulness significantly. With those prospects, the future remains bright.

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.

HHC MMX

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HHC MMX

Richard J. Nelson

What do you call it when the weather is ideal, you enjoy fantastic fellowship, you have great fun, and you go home with more than you came with? I call it the 37th Hewlett-Packard Handheld Conference, HHC.

Forty-three HP enthusiasts converged in Ft. Collins Colorado from around the world. We started at the HP facility at 7:30 AM on Saturday September 25, 2010 and continued on Sunday. The 37th HHC was unusual in that it was the first time that an HHC was held in the same location[(1)] two years running. The most popular proposed location for HHC 2011 is Nashville Tennessee.

HHCs are international conferences with HHC MMX attendees from the US, Canada, the UK, Germany, and France. The greatest distance traveled to Ft. Collins was by Pavneet Arora flying in from Prague, a Distance of 5,164 miles or 8,311 km.

Fig. 1 – Group photo taken after lunch on Saturday. Four other attendees are missing.

HHC MMX was typical of most previous HHCs with presentations, demonstrations, a programming contest, HP Q&A session, best speaker voting, and door prize drawing. We spent Saturday and Sunday taking our meals and breaks together to maximize our time usage efficiency and fellowship time.

Door prizes, http://holyjoe.net/hhc2010/Door-Prizes.pdf, more than twice as many as attendees, are popular so everyone went home with an HP calculator related goodie. Laura Harich, HP Calculator Marketing drew the prize tickets and was asked to present Gene the Best Speaker Certificate. The voting was very close with so many speakers doing an excellent job. Gene made several presentations so we are not sure which one especially appealed to the attendees.

Fig. 2 – Gene Wright receives best speaker award, voted by attendees, from Laura Harich, HP Marketing.

We had two talks presented by HHC Committee members representing people who could not attend. One was by Jake Schwartz with the title of An HP30b Repurposing Project from Walter Bonin & Paul Dale. This project is well defined and it proposes to use the HP 30b platform to make it a very fast and very powerful advanced scientific calculator dubbed the 34s. Paul Dale said in an email to Jake: “Everything is pretty much complete except the actual port to the hardware. I know that the current code will fit having built it for the ARM platform. However, being laid off from work earlier this year has removed ready access to the tools needed to finish the port." Jake made an appeal to the community for help in finishing this project. Eric Rechlin has posted four HHC videos at: http://www.youtube.com/user/hpcalcorg.

A second presentation was by Gene Wright with an update on the NEWT project of Monte Dalrymple. Here is how Monte describes this incredible project. "The NEWT (Nut, Expanded, With Turbo) CPU is

an upgraded version of the Hewlett-Packard Nut microprocessor, which was employed in a number of HP calculators, including the HP-41 series. Only publicly available documentation was used to create this design so there may be minor differences where the public documentation is misleading or lacking. The instruction set and register architecture are identical between the two designs."

If you have an HP-41 you will soon be able to replace the circuit board with one that Monte is having made to make your HP-41 faster, better, and technologically modern with nearly every capability that is currently available from the HP User Community in terms of RAM boxes, ROM's etc. Everything will be on the circuit board. See the list starting on page 161 of the document link below. Even Synthetic programming will work. This is an excellent example of how the well-thought-out features of HP's machines are appreciated by its User Community.

You may get the NEWT technical details at: http://www.systemyde.com/pdf/newt.pdf

One of the more important aspects of an HHC is the opportunity to "Ask HP" any questions you may have. Fig. 3 shows the Q & A HP panel. Laura Harich is Calculator Marketing, Tim Wessman is R & D, Jason Smith is Product Manager, and Scott Nedringhaus General Manager.

We missed HP's Cyrille de Brebisson who is now living in France. He has attended many HHCs, but he could not make the trip this year. Tim Wessman did a super job in working with the HHC Committee to make the Conference so very interesting, effective, and complete.

Fig. 3 – HP Q & A panel answers questions. L to R. Laura, Tim, Jason, and Scott. See text.

Fig. 4 - The Sunday hiking group at sun set. We all felt the affects of the altitude.

The days before and after the Conference are often used for additional technical and fun activities. A group rushed to the Rocky Mountain National Park after the Conference ended to catch the sunset at 12,200 feet, 3,718 meters.

Many of the attendees also toured NOAA and NIST for small group tours of the leading US research in quantum computing and atmospheric research. These specially arranged tours were organized by Mark Ringrose of the UK HPCC.

The Hotel was great and went out of their way to make us feel at home with our "strange hours."

All HHC activities and events are always conducted entirely by volunteers of the HP User Community.

You may follow HHC activities at: http://hhuc.us
These websites are useful for articles, reports, Conference Activities, HP News, and photos.

You may sign up for the HHC email list at: http://lists.brouhaha.com/mailman/listinfo/hhc
The HHC email list is most active a month or so before and after the Conference.

You may get HHC Videos at: http://www.pahhc.org/video.htm
This website is a good source for historical material in that nearly all HP Calculator newsletters and conferences have been preserved on CD's and DVD's by Jake Schwartz.

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 that 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 also has 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.

1. We have actually held two consecutive conferences in one city – Vancouver WA in 1998 and 1999, but we used two different hotels and we had the actual Conference at HP in 1998 and in the hotel in 1999. See the Conference list at: http://holyjoe.net/hhc2010/conflist.htm

Calculating Before Calculators

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Calculating Before Calculators

Richard J. Nelson

Introduction

Numbers – Parts, I, II, & III as discussed in the last three issues of ***HP Solve,*** have given us a basis for starting our Applied Math Series. Before we can review the various calculations involving calculator functions we will now make a quick review of a few methods of making calculations before the electronic calculator.

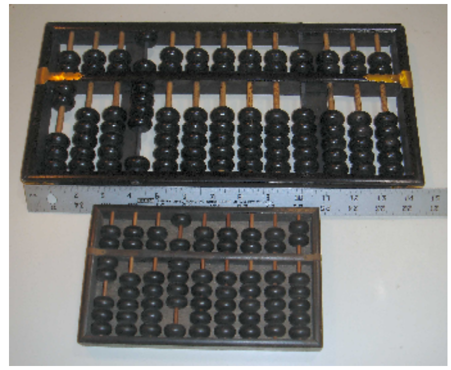


Fig. 1 – The abacus was used before electronic calculators.

Fig. 1 shows one style of a "mechanical" calculator called the abacus. This version is commonly called the Chinese abacus. In Japan it is called a soroban.

Note that there are two rows of beads that are used to represent numbers. The larger (top) abacus is a "13 digit" model. The bottom version is a "9 digit" model. Each vertical rod holding the beads represents a digit. There are five beads on the bottom representing the digits 1 – 5.

The numerical value is determined by the position of the beads. When five beads are moved up, the abacus is intended to be used held as if flat on a table, the value of five may also be represented by a bead positioned (down) in the top row. If you are interested in how the abacus is used you may refer to the many links on the Internet to learn the techniques of adding, subtracting, and multiplying.

The soroban is simpler with only a single bead in the top row and four beads in the bottom row. There is a Russian version called the Schoty. It's beads are moved left to right instead of up and down. The abacus has been used in various forms since 500 BC.

The more modern western version of a more powerful mechanical calculator is the slide rule as shown in Fig. 2. The slide rule will be explored in more detail in our next installment when logarithms are reviewed. The slide rule is able to do much more complex math (with a limited number of digits, typically three to five) and has been used in various forms since about 1625. The slide rule is a very popular collector's item.

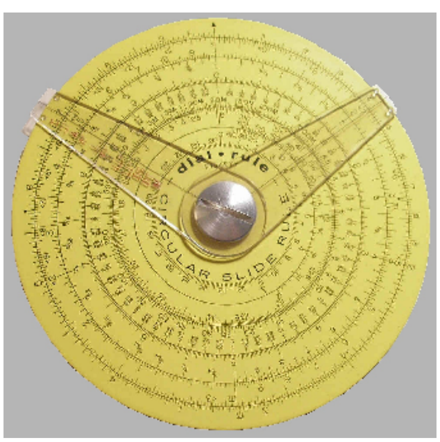


Fig. 2a – Circular slide rule.

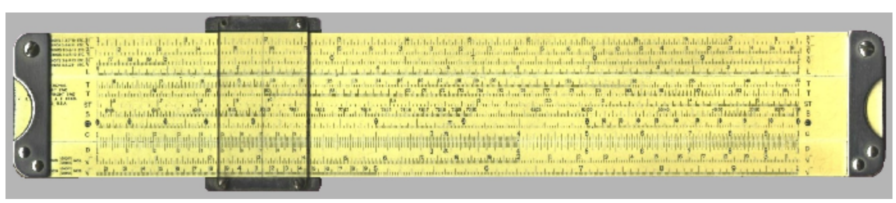


Fig. 2b – Conventional slide rule.

Fig. 2c – Cylindrical slide rule.

A more recent personal mechanical calculator is the so-called German "coffee grinder" Curta. It was conceived in 1902 and was in production until 1988. Its history is an incredible story and very much worth your time to read about on the Internet.

There have been many designs of mechanical personal calculating devices in the last 100 years. Additional examples may be seen in Figs. 4 and 5.

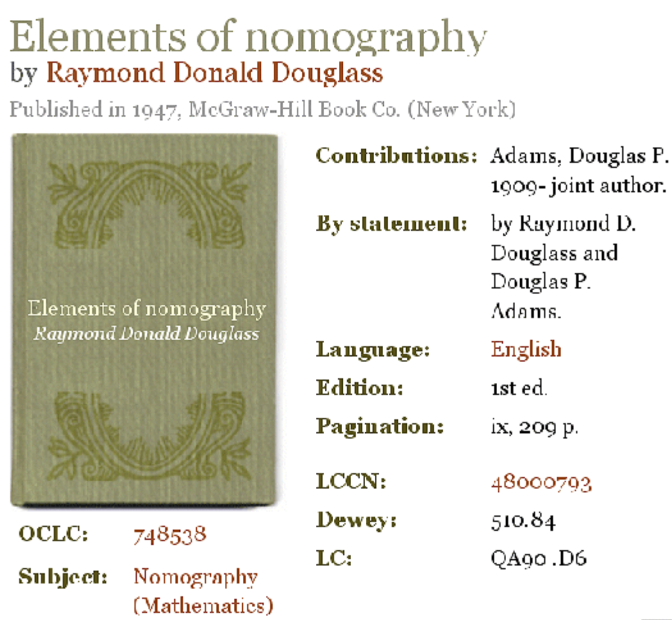
Making calculations involves more than the simple addition, subtraction, multiplication, and division. Calculations involving trigonometry, powers and exotic functions need to be performed by engineers and technicians everyday and doing these calculations long hand is very time consuming and prone to error. This need has stimulated inventors and the examples shown in this short essay shows only a few examples.

Fig. 3 – Famous Curta

Fig. 4 – Magic-Brain mechanical calculator.

Fig. 5 – Low cost German Addiator.

The mechanical devices, batteries not required, shown above are used for general problem solving. When a specific calculation needs to be done there is a very powerful and low cost method that uses a nomograph. An example is the Body mass index, BMI, equation shown in Fig. 7. Carefully designed scales provide the inputs and a ruler is used to align the input scaled values to provide an intersection of an answer scale. The dotted line in fig. 7 illustrates. What makes this nomograph so useful is that it works (converts) using both English and metric values. You can calculate BMI values using the nomograph much faster and at a considerably lower cost than any calculator[1].



Elements of nomography
by Raymond Donald Douglass
Published in 1947, McGraw-Hill Book Co. (New York)

Contributions:	Adams, Douglas P. 1909- joint author.
By statement:	by Raymond D. Douglass and Douglas P. Adams.
Language:	English
Edition:	1st ed.
Pagination:	ix, 209 p.
LCCN:	48000793
Dewey:	510.84
LC:	QA90 .D6
OCLC:	748538
Subject:	Nomography (Mathematics)

Fig. 6 – Excellent book describing nomographs.

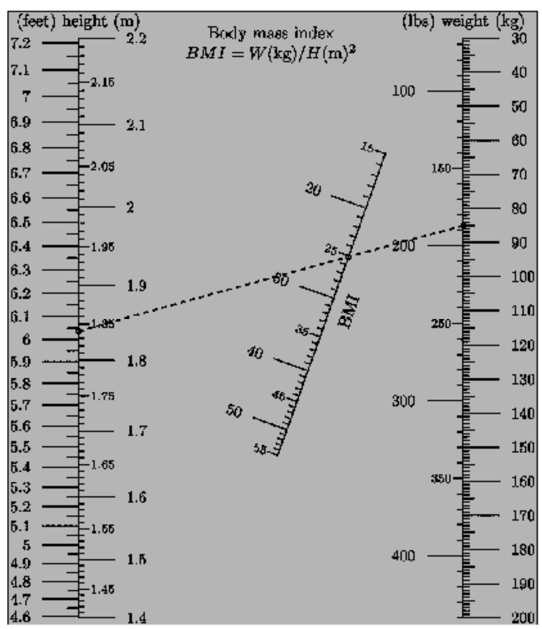


Fig. 7 – Example of nomograph calculating BMI.

An excellent nomograph reference is shown in Fig. 6. Here is a link to an excellent article on the lost art of nomography. http://myreckonings.com/wordpress/2008/01/09/the-art-of-nomography-i-geometric-design/#more-23

Another method for making specific calculations is the use of tables rather than reading the scales of the nomograph. Before the HP-35A calculator appeared in 1972, engineers and scientists used large books of tables for “calculating” trig functions and a host of other math and statistical functions. These heavy books of tables were usually limited to perhaps five significant digits whereas the HP-35A provided ten significant digits.

Another method of “calculating” ratios and conversions is the use of “stretch scales” as illustrated in Fig. 8. Many years ago (mid 60’s) I used this method to calculate my electronics student’s grades in the Philippines. I needed to convert my quiz/exam point values to the standard percentage values for the A through E grades. I used an elastic clothing stretch band with scales marked on them. These bands will typically stretch to twice their length. By having an appropriate set of scales two sets of values may be aligned similar to the BMI height and weight scales shown in Fig. 7. Fig. 8 shows the left range of 15 to 19 aligned to 65 to 86. While this may seem a bit hokey it actually works when you have hundreds (there

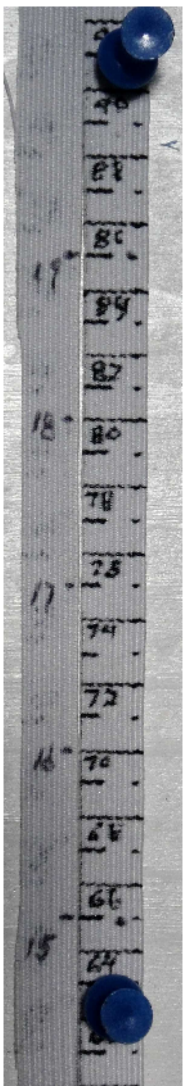


Fig. 8 – Stretch scale conversions.

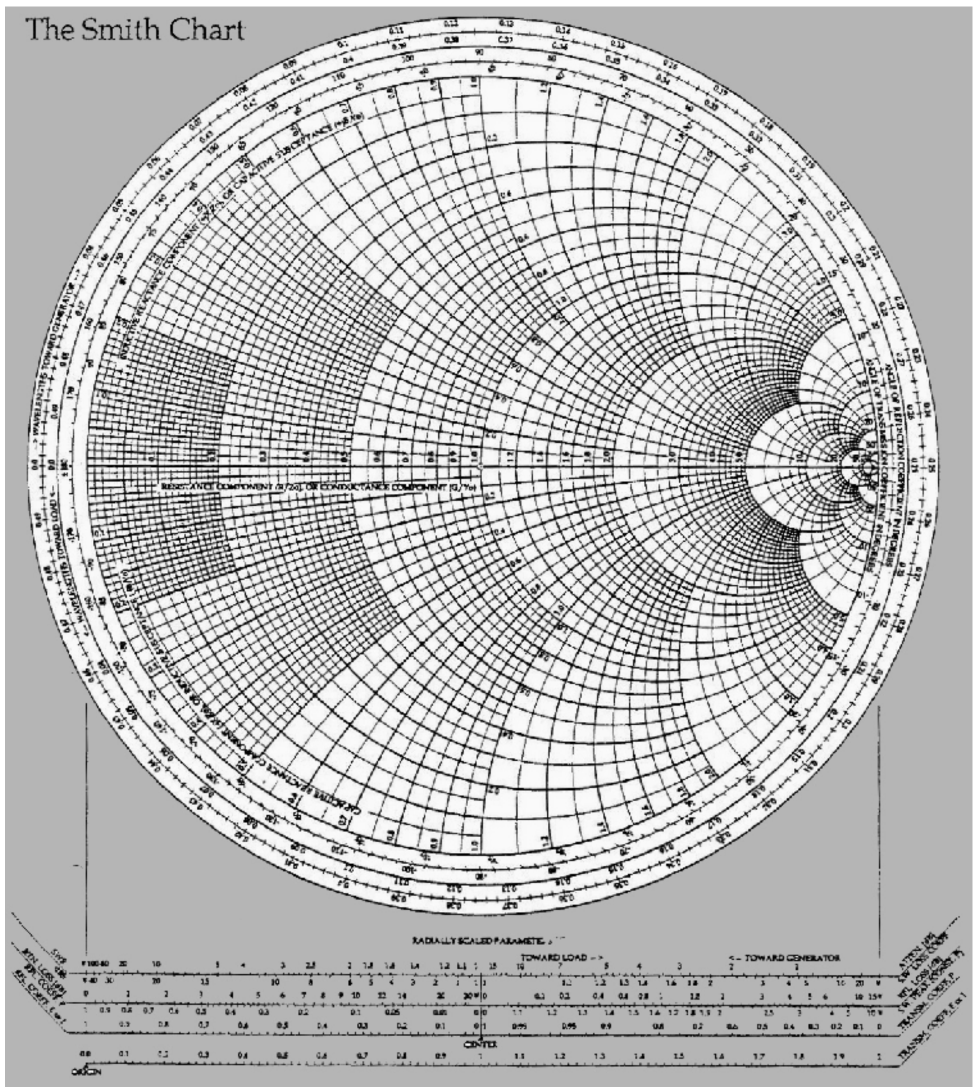


Fig. 9 – The famous Smith Chart[2] is another example of a nomograph that is still used daily by electronics engineers.

were 50 students per class and I had many classes each day) of “conversions” to make in a hurry and calculators didn’t exist. Efficiency is the issue here. Fig. 8 is just a quick example made to illustrate the method.

Even with calculators and computers an engineer will typically use whatever method that gets him what he needs easier and faster. One of the most famous, and perhaps most complex, chart or nomograph is the Smith Chart**(2)** shown in Fig. 9 and taken from the link on the top of the previous page. Computer programs are available to produce charts like the Smith Chart.

Summary and Conclusion

Most students and adults born during the last half of the last century have become operationally familiar with electronic calculators and probably weren’t taught (or don’t remember) how to make calculations by hand. This installment of the Math Review Series is intended to put the calculation issue into perspective by providing a very short review of how calculations were made “in the old days.”

Before personal electronic calculators calculations were divided into two categories: (a) general and (b) specific & repetitive. The former category requires a mechanical calculator of some kind as shown in Figs. 1 – 5. The cost is higher for these devices.

The second category of calculations may be done with tables, charts, and nomographs at a very low cost (5 ¢ printer or photocopy cost). Figs. 6 – 9 show a few examples. These may they may be used on the production line, in class, in the field, etc.

Now that we have reviewed numbers and how they were calculated with before the birth of the personal electronic scientific calculator in 1972 we will start with Logs in the next issue of ***HP Solve.***

Calculating Before Calculators Notes

(1) *A calculator specifically programmed for BMI calculations could possibly compete if it were designed to accept two of four inputs and automatically calculate the BMI. Of course the accuracy is unlimited whereas the nomograph is limited by its practical physical size. The letter sized nomograph value is only accurate to three significant digits. You may better see this by enlarging Fig. 7 using your PDF reader.*

(2) *According to Wikipedia the Smith chart, invented by Phillip H. Smith (1905-1987), is a graphical aid or nomogram designed for electrical and electronics engineers specializing in radio frequency (RF) engineering to assist in solving problems with transmission lines and matching circuits. Use of the Smith chart utility has grown steadily over the years and it is still widely used today, not only as a problem solving aid, but as a graphical demonstrator of how many RF parameters behave at one or more frequencies, an alternative to using tabular information. The Smith chart can be used to represent many parameters including impedances, admittances, reflection coefficients,* S_{nn} *scattering parameters, noise figure circles, constant gain contours, and regions for unconditional stability. The Smith chart is most frequently used at or within the unity radius region. However, the remainder is still mathematically relevant, being used, for example, in oscillator design and stability analysis.*

The PROOT Gem

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The PROOT Gem

Namir Shammas

The advent of the Solver with the HP-34C, in 1978, brought a new and powerful tool for solving single-variable nonlinear equations, including polynomials. The Solver required two initial guesses and went to work to find a root near these guesses. In the case of polynomials, the Solver handled real root of polynomials with real coefficients. The advent of the HP-48GX/G+/G family of calculators introduced a new function PROOT that replaced the Solver when dealing with polynomials. This new function gives calculator users the following advantages:

1. Works with polynomials that have real and complex coefficients (and of course a combination of the two).

2. Solves for all real and complex roots.

3. There is no need to supply guesses for the roots. The function PROOT internally determines the initial guesses.

The function PROOT uses the Laguerre method to find the roots of the polynomial:

p(x) = a(1) x^n + a(2) x^n-1 + … + a(n) x + a(n+1)

Here is an algorithm, based on a version of the Laguerre method, aimed at obtaining the roots of a polynomial:

1. Calculate n = number of elements in the array of coefficients minus one.

2. Create an empty array for the n roots.

3. Internally select an initial guess for a root for the polynomial.

4. Calculate p0 = p(x).

5. Calculate p1 = p'(x) which is the first derivative of the polynomial p(x).

6. Calculate p2 = p''(x) which is the second derivative of the polynomial p(x).

7. Calculate G = p1 / p0.

8. Calculate H = G^2 - p2 / p0.

9. Calculate d = n / {G +/- [(n-1) (n H - G^2)]^(1/2)} choosing the + or - sign that maximizes the absolute value of the denominator.

10. Update the root x using x = x - diff.

11. If |diff| exceeds a tolerance value (which is hard coded in the implementation), resume with step 3.

12. Store the root x in the array of roots.

13. Deflate the polynomial p(x) using the last root to get a new polynomial of the order of n-1.

14. If the order of the deflated polynomial is greater than 2, resume at step 3.

15. Solve for the roots of the current quadratic polynomial, update the array of roots, and return the results.

The core Laguerre method comprises of steps 3 to 11. The remaining steps manage the solution for the various roots of the polynomial. The above algorithm is my own version and is not based on the actual algorithm used by PROOT. I suspect that HP's algorithm has a few more tricks up its sleeve to keep the solution stable and handle a wide range of cases.

To use the PROOT function on an HP-50G graphing calculator, in RPN mode, I suggest that you write the following short program:

<< DUP PROOT ARRY–> DROP >>

Store the above program in the name PAD. The program works by leaving a duplicate of the polynomial coefficients in the stack and then separately listing the roots of that polynomial in the stack—each root in a separate stack level. This kind of output makes it easier to read. To access the program click the VAR button. The name PAD appears in the custom menu list.

Let's start with a simple example. Let's solve for the roots of the following quadratic polynomial:

P(x) = x^2 - 5x + 6

Enter the array [1 -5 6] in the stack and run the PAD program. Figure 1 shows the screen output:

Fig. 1- Solving a simple quadratic polynomial.

Figure 1 shows a copy of your input array in level 3 and the roots of 2 and 3 in levels 2 and 1, respectively.

Here is an example of a cubic polynomial with real coefficients and with a solution that contains both real and complex roots:

P(x) = x^3 - x^2 + x - 1

Enter the array [1 -1 1 -1] in the stack and run the PAD program. Figure 2 shows the screen output:

Figure 2 shows a copy of your input array in level 4 and the roots of 1i, -1i and 1 in levels 3, 2, and 1, respectively. Notice that function PROOT sometimes displays real roots as complex numbers with a 0 value in the imaginary part.

Fig. 2 - The roots of a cubic polynomial.

Here is an example of a polynomial with real and complex coefficients and with a solution that has complex roots:

P(x) = x^3 + (2+2i) x^2 + (-2-4i) x + 5

Press the Mode button and set the number format to FIX 2. Also using the Flags options make sure that the calculator works with complex numbers using the (X,Y) format. Now, enter the array [1 (2,2) (-2,-4) 5] in the stack and run the PAD program. Figure 3 shows the screen output:

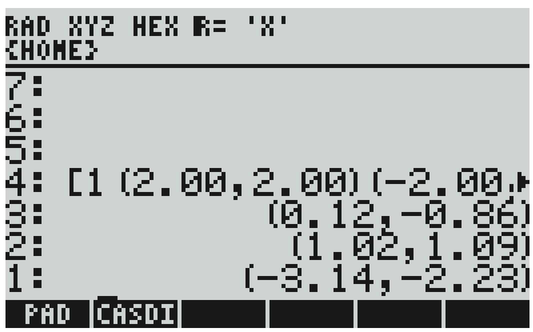

Fig. 3 - Roots of a polynomial with complex coefficients.

Figure 3 shows a copy of your input array in level 4 and the complex roots of 0.12-0.86i, 1.02+1.09i, and -3.14-2.23i in levels 3,2, and 1, respectively. Most of the displayed numbers appear in the FIX 2 number format.

I have kept the examples short, but I encourage you to further experiment with the function PROOT to handle higher order polynomials with real and complex coefficients. For example if you enter the array:

[1 5 -180 -750 10773 34965 -251770 -562700 2055576 2342880 -3628800]

And run the program PAD you get the roots 1, -2, 3, -4, 5, -6, 7, -8, 9, and -10. In another example, enter the array [1 (0,-3) 23 (0,-51) 94 (0,-120)] and run the PAD program. You should get the complex roots 1i, -2i, 3i, -4i, and 5i.

What about dealing with polynomials having duplicate roots? This is a case that causes many algorithms to struggle or even fail. nfortunately, the Laguerre method is no exception. Consequently, the function PROOT does struggle a bit with duplicate roots. Here is a simple example. Enter the array [1 -5 10 -10 5 -1] in the stack and run the program PAD. Figure 4 shows the output:

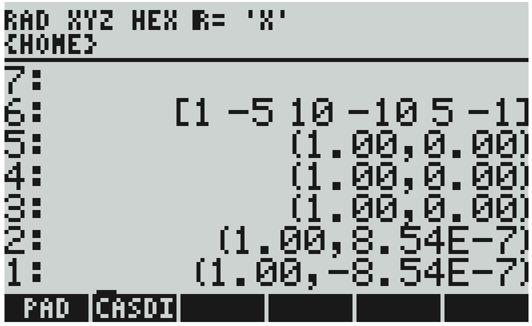

Fig. 4 - Handling a polynomial with multiple roots.

The targeted polynomial has five duplicate roots of 1. The function PROOT gets three roots correctly (albeit as complex numbers with zero imaginary parts) and two root very close to the actual solution (with some minute imaginary parts). As the number of duplicate roots of a polynomial increases, the calculated solutions tend to further drift away from the exact roots.

In conclusion, I find the function PROOT as a gem and a powerful tool to solve all roots of polynomials with real and complex coefficients. This is a task that is not always easy!

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About the Author

Namir Shammas is a native of Baghdad, Iraq. He resides in Richmond, Virginia, USA. Namir graduated with a degree in Chemical Engineering. He received a master degree in Chemical engineering from the University of Michigan, Ann Arbor. He worked for a few years in the field of water treatment before focusing for 17 years on writing programming books and articles. Later he worked in corporate technical documentation. He is a big fan of HP calculators and collects many vintage models. His hobbies also include traveling, music, movies (especially French movies), chemistry, cosmology, Jungian psychology, mythology, statistics, and math. As a former PPC and CHHU member, Namir enjoys attending the HHC conferences. *Email me at: nshammas@aol.com*

From the Editor - Issue 21

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From The Editor – Issue 21

Summer has come to an end here in the northern hemisphere and many ***HP Solve*** readers will be spending more time indoors as cooler weather is at hand. The more active members of the HP User Community, HPUC, have been busy with their annual HP Hand Held Conference, HHC, and they are now back into their routines. Speaking of routines we should be back into a normal publishing schedule with Issue 22.

I have a calculator question for our many calculator expert readers. According to Wikipedia ". . . the first digital electronic calculators were created in the 1960s, with pocket-sized devices becoming available in the 1970s." These machines were very expensive by today's standards and were often called "four bangers." The "four bangers" offered addition, subtraction, multiplication, and division, and interestingly one or two additional functions - **%** and $\sqrt{\ }$. Here is my question. Because so many of these machines from many different manufacturers using different internal designs had the square root function, I am wondering why the square root function is usually included with most "four bangers."

First, what were the technical reasons, and second, what were the marketing reasons? If you have any insight into this please let me know. I have heard various reasons, but I don't have any serious documentation that gives the "real reason." BTW many of the lowest cost four bangers today still include the square root function. Send me your ideas and research on this interesting historical calculator question. Use the email address below.

Here is the content of this issue.

S01 Math Education around the World

As a leader in building calculators for educational use HP partners with others to advance the art of education. This article provides an update.

S02 Every Calculator has a Story

Illustrating with a few stories about HP calculators an appeal is made to ***HP Solve*** readers to share their favorite stories.

S03 One Minute Marvel, OMM, #8 – Prime Numbers

Prime numbers are defined and the numbers from 1 to 200 are shown in Table 1. Two very efficient OMM routines are provided with a table of example inputs for testing and evaluating (Table 2). A non-classical method that was presented at HHC MMX is described and links are provided to down load millions of prime numbers. A Word technique is used to illustrate why numbers ending in 2, 4, 6, or 8 cannot be prime is provided in note 1.

S04 Cupertino to Corvallis to Singapore to Melbourne to San Diego: Are We There Yet? Jake Schwartz provides an HP product overview in terms of seven issues he sees as important for a better user interface based on an HHC 2007 presentation and updated to October 2010. The article is especially interesting reading because it puts so many of HP's calculators into user friendly perspective.

S05 HHC MMX report

The 37th Hewlett-Packard Handheld Conference, HHC, was held in Ft. Collins Colorado on September 25, & 26, 2010. The report describes another successful gathering of members from around the world –

USA, Canada, UK, France, and Germany - to discuss new ideas and developments in HP calculator activity.

S06 Calculating before Calculators

This is the fourth installment in our practical Math Review series. #4 describes how calculations were done before personal electronic calculators were commonplace. The fifth installment in ***HP Solve* issue** 22 will start the more serious part of reviewing calculator functions with Logs. Mechanical calculators, no batteries required, were used as early as 500 BC. Seven mechanical calculators are illustrated to show how general calculations were performed over the centuries. Very inexpensive methods of calculating with tables, charts, and nomographs are also described. An example is calculating Body Mass Index, BMI.

S07 PRoot Gem by Namir Shamas

The advent of the HP-48GX/G+/G family of calculators introduced a new function, PROOT, that replaced the Solver when dealing with polynomials. This new function provides calculator users 15 advantages which are described in the article.

S08 Regular Columns

This collection of repeating columns fills out the issue.

- **From the editor.** This column provides feedback and commentary from the editor.
- **RPN Tip 21.** We are running out of RPN Tips so this column will provide an index and description of all 20 previous RPN Tips since ***HP Solve*** Issue #1.
- **One Minute Marvels.** This OMM delves into Prime numbers and is featured as a full article as described in S03 above.
- **Community News.** What is happening in the HP User Community? Readers are encouraged to provide inputs to this column. NEWT and the repurposing HP20b and 30 projects are described.
- **Did You Know?** The results of a legacy machine survey are provided with a link to the full survey tally.

S09 Customer Corner – Meet Mark Ringrose

Periodically ***HP Solve*** Interviews an HP Calculator user under the title of Customer Corner. Mark is a UK calculator user involved in the finance world in an unusual way. Read all about it and the machines he uses.

Here is a "correction" for the last issue. The article titled "**All of HP's Calculators** 200722" provided a list of HP's calculators. Three machines need to be added to the list.

1. The HP OfficeCalc 100.
2. The HP CalcPad 100
3. The HP Calcpad 200.

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

Also tell me what you liked, and what you would like to read about.

X < > Y,

Richard Email me at: hpsolve@hp.com

RPN Tip # 21

Unless ***a reader*** is able to suggest an RPN Tip, this, or perhaps #22, concludes the RPN Tips Column. Legacy RPN involves a 4 high stack, its automatic rules of operation; 5 stack commands (ENTER,↑; X⇄Y; Roll down, R↓; LAST X ; & Roll up, R↑); and the Last X register. RPN is quite simple and there are a limited number of Tips and techniques to optimize its use. A Word file, with cover, of all RPN Tips is a 34-page file.

Table 1 - Summary Table of *HP Solve* RPN Tips – 1st , 2nd, & 3rd Years

		2 0 0 8
VOL[1]	**Date**	**Description**
1	FEB	Pressing an extra ENTER.
2	MAR	Enter numeric values only once.
3	APR	Using T register to calculate compound interest.
4	MAY	*****HP RPN and automatic stack is defined (Introduction to RPN Tips).
5	JUN	RPN foot ball game stack counter. Improved version Tip #11.
6	JUL	Parallel resistor solution avoids numeric entry error.
7	AUG	Correcting a divide input order mistake.
8	SEP	Solving the Linear Interpolation Problem. **(monthly)**
9	OCT[2]/NOV	*****Solving the Quadratic Equation Problem. **(start bi-monthly)**
10	DEC/JAN	*****RPN operation and numeric entry shortcuts.
		2 0 0 9
11	FEB/MAR	RPN Foot ball game counter alternate. Improved Tip # 5.
12	APR/MAY	Constant multiplier uses LASTX. Also preserves Z & T registers.
13	JUN/JUL	*****Efficient stack ordering; The "RPN" Stack - Future & Past (Part I)
14	AUG/SEP	*****How RPN was started at HP; The "RPN" Stack - Future & Past (Part II)
15	OCT/NOV	Scanned HP booklet *Solving Problems With Your Hewlett-Packard Calculator* four pages to a page in gray scale to reduce file size. Total pages: 15. PDF file size: 3.184 MB.
16	DEC/Jam	How to perform X-Y while preserving Y, Z, & T.
		2 0 1 0
17	FEB/MAR	Calculating $A = \sqrt{X^2 + Y^2}$ using R→P. (HP35s example).
18	APR/MAY	The ENTER Key, 35A, 80A, 70A, 49g+, 50g.
19	JUN/JUL	*****RPN vs. RPL, 1st 35A Color, RPN Books.
20	AUG/SEP	20 Hints and Tips for an RPN Programmer Moving to the HP 30b Calculator by *Gene Wright.*
21	OCT/NOV	Table of all ***HP Solve*** RPN Tips.

1. The RPN Tip number is the same as the volume number.
2. ***HP Solve*** changed from a monthly to a bi-monthly starting with volume nine.

* Indicates a longer article of importance.

Community News

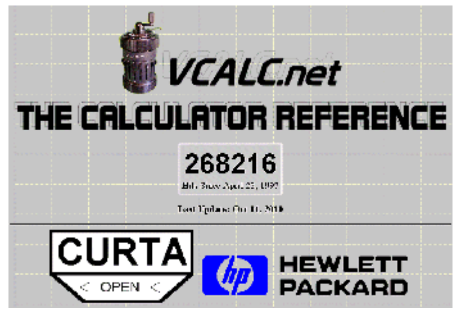
Two especially interesting user Community projects were reported at HHC MMC.

The first is an on going project to design and build a more modern HP-41 microprocessor. The idea is to fabricate the famous HP 1979 nut processor equivalent from the public domain specifications. You may get the details in the HHC MMX report, including links. The built-in ROM list is extensive. NEWT is a very unusual project by Monte Dalrymple.

The second project involves the latest machines from HP, the HP20b and HP30b. Walter Bonin & Paul Dale have designed an advanced legacy RPN scientific calculator they call the 34s. See the HHC MMX report for additional details.

What is not mentioned in the HHC MMX report is the winner of the programming contest. The details should soon be posted at: **http://holyjoe.net/hhc2010/index.htm**. The winner was Bill Butler from Canada.

Rick Furr is thinking about updating his famous and popular HP Calculator poster. If you haven't seen this poster check his website at: **http://www.vcalc.net/** You will find lots of fun stuff at this site.



Where do you get spare calculator parts or have your HP machine repaired? Where do you get some of the books still available related to calculators? Where do you find other technical posters? Where do you find mock up photos of user envisioned calculators, e.g. HP 32C

Did You Know?

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

Have you ever visited HP's website? You probably have since you are reading this newsletter – at least to the extent that you have visited http://h20331.www2.hp.com/Hpsub/cache/580500-0-0-225-121.html - and you have downloaded a copy of ***HP Solve.*** HP has one of the largest websites and they work on it continuously. If you have gone to the link above have you signed up for the newsletter? Are you concerned that you will be overwhelmed with spam and you haven't signed up? HP has one of the strictest and most confidential websites in the industry and you are always "in control" of your involvement. The calculator group is relatively small, compared to, say computers, so calculators don't get "first billing."

I mention this because I received an email from the Home & Home Office Store regarding a 12 year "Anniversary Sale." After exploring – and calling the phone number in the "Ad" - I came to learn that HP Calculators were also on sale. The sale is now over, but you may want to be told of the next one. I didn't have an HP SmartCalc 300 in my collection of about 150 HP calculators so I ordered one because the sale terms also included free shipping. The sale special even included two calculators in one package (a four banger, the HP EasyCalc 100). You may just want to sign up using the HP Passport option on the HP website to get an emailing every once and a while of "HP News."

In Issue 20 I mentioned the HP-15C emulator with this note:
Editor's Note. The HP-15C is a very popular legacy calculator. See the link below for an HP-15C emulator for the iPhone.

This reminded me of another HHC MMX activity. It was an attendee Survey that asked what machine the attendees would like to see HP make as a special run of a legacy calculator. Here is the Conclusions and Observations of the six page tally.

Conclusions and Observations

It is very clear that the HHC MMX respondents wanted the HP-15C at $75 to be the first legacy machine if HP were to undertake such a project.

The HP-42S at $95 is a fairly close second.

The relative rating of each of the five models is tallied giving three points for first choice, two points for second choice, and one point for third choice. The average of the three choices and prices is also given.

HP-15C	96 points	HP-15C	$ 78
HP-42S	51 points	HP-42S	$ 95
HP-16C	22 points	HP-16C	$ 88
HP-27S	10 points	HP-27S	$ 82
HP-71B	4 points	HP-71B	$ 120

The HP-71B didn't seem well represented. Perhaps this is explained because it would require extensive tooling and the respondents felt that the additional engineering wouldn't allow this model to ever see the light of day again as a legacy machine. The respondents checked 61 boxes of the machines that they owned or used. Of these boxes 14 were for the HP-71B, the same number as for the HP-15C. This most accurate of all HP calculators could be a candidate to seriously consider.

Wlodek made a similar survey a month ago at HPCC in London with similar results. The HP-15C was by far the most popular legacy model with the HP-42S coming in second.

Get all the details at: http://www.holyjoe.net/hhc2010/HHC-MMX-Legacy-Machine-Survey.pdf

Meet Mark Ringrose

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Meet *Mark Ringrose*

Customer Corner has appeared in past issues of ***HP Solve*** where we interviewed worldwide users of HP's calculators. Past interviews have been of users who live and work in the US, UK, Canada and Germany. We now go to London for our next interview.

Mark Ringrose

***HP Solve*: What is your background?**

Mark: I grew up mostly in the UK. My favourite subject was always mathematics.

***HP Solve*: What did you study at school?**

Mark: I studied for a degree in Electronic and Electrical Engineering, but I never practised as an engineer - neither of these areas held much interest for me. Fortunately software for the calculations in engineering was becoming increasingly important and my final year project was done on my own BBC micro. Being able to write software on your own computer was a great leap forwards for students at the time, because prior to that, we had to wait for time on a shared mainframe. It was a very slow process to get anything done. Note that a BBC micro was cheaper than an HP-41 series calculator with peripherals at the time.

***HP Solve*: What is your occupation?**

Mark: I work in a technical pre-sales role for a company called Thomson Reuters in London. I sell software and services to deliver, distribute, process and store real-time and historic pricing information and news from the world's financial markets (exchanges) to customers such as financial institutions, hedge funds, brokers and others.

***HP Solve*: Do you do much traveling?**

Mark: No, not really. My job is based where my customers are. London is a major financial centre and most of my customers are on "my doorstep" in Canary Wharf or in the City of London.

***HP Solve*: When were you first exposed to HP calculators?**

Mark: A neighbour in 1978 had an HP-25C. I had a TI-57 (programmable) at the time. RPN puzzled me at first, but what I liked was the continuous memory of the HP-25C and the quality of the manual.

***HP Solve*: When did you first see or use an HP calculator?**

Mark: I tried out my neighbour's 25C, which I liked, but I was much more taken with the high-end model at the time, which was the HP-67. I had my first summer job in 1978 and saved enough to buy the 67 because my neighbour, the one who had the 25C, went on a trip to New York and kindly bought me one there for about £190 instead of the £320 it cost in the UK. So some things haven't changed much in thirty-odd years.

***HP Solve*: What machine did you buy after your first?**

Mark: My second HP calculator was the 15C. I was in San Francisco in 1982 and went to a store intending to buy a 34C. Luckily the salesman in the store directed my interest to the new models, the Voyager series. This series remains in production today as the 12C. This is my favourite form factor of HP calculator.

The purchase of the 15C coincided with the start of the second year of my degree course and was almost invaluable in electrical engineering. The ability to do complex numbers and matrices (and even complex matrices) plus numerical integration and the famous HP solve was functionality unmatched by anything else at the time. My fellow students were amazed. The manual was very good too, and what was outstanding was the advanced handbook for the 15C, which included detail on errors and accuracy of chain calculations. This type of book should be a standard text for science and engineering students everywhere.

***HP Solve*: What HP calculators have you used since?**

Mark: Many. Too many. When I discovered HPCC in 1995 (the HP calculator user group in London, www.hpcc.org) I went crazy and bought many older models from members of the HPCC group, simply to enjoy some classic models that I could never afford when they were in production - a good example is the 41CX, and the 29C. I also took a trip to California in November of 1995 especially to visit Educalc. I had planned to trade in some older models for updated versions, such as the 200LX for my old 100LX (HP's handheld PDA) and a 48GX for my old 48SX, which Educalc allowed you to do back then. However, when I got there I couldn't bring myself to let go of my old ones, so I ended up with my old ones and all the new ones. I also bought many more than I originally intended, including a 75C and a 71B. I had never seen so many different HP calculators in one place. It was a very heavy suitcase that I returned with from that trip.

***HP Solve*: What have you used your calculators for?**

Mark: My most frequently used model for the last 15 years has been the 12C. I always take it with me to the bank or mortgage lender to check their figures on my monthly payments. I sometimes use a 48GX or 50g to calculate the number of working days between dates to help calculate resources and timescales for project implementation.

***HP Solve*: Do you frequently travel?**

Mark: No. In fact the longest trip I do each year is to the HHC, which I started doing in 2007. I love visiting the U.S., and this is the perfect excuse.

***HP Solve*: Have you noticed anything interesting about calculator usage during your travels?**

Mark: I don't see many HP calculators anywhere, other than the 12C, which still sits on the desks of a few traders and other financial professionals in London and elsewhere. I sit next to an ex-Bond Trader at work, and he still uses his 25-year old 12C every day. The 12C became a kind of badge of honour for Fixed Income people in the financial markets, and it still holds a place on the desks of some. It is still on the approved calculator list along with the 17BII+ for financial market examinations, so I don't think it will disappear.

***HP Solve*: Does your calculator usage involve more than your profession?**

Mark: It hasn't for some time, but I took up astronomy as a minor hobby recently, so I should find an excuse to dig out the 50g and put it to use for that. Many programs have been written by the worldwide community of HP calculator programmers in this and a wide range of other disciplines.

***HP Solve*: What was the largest problem you have solved with an HP calculator?**

Mark: It might depend on how one defines "largest problem". If you consider calculating if you can afford the payments on a mortgage a large problem, then that would be my answer. However, I think that the most complete "solution" I wrote was back in school when I needed to prepare to calculate and tabulate results during physics lab sessions. The calculations themselves were not complicated, but my

HP-67 saved me a lot of time and allowed me to work more quickly when conducting an experiment - both to derive results and to record data.

***HP Solve*: What are you currently using HP calculators for?**

Mark: Mostly for idle curiosity. I am very pleased with the HP 30b. I like it because it looks good, and is a little bit different from previous models. It combines scientific and financial functions, which is a powerful and useful combination. I am studying some simple (easy) modules in astronomy with the Open University, so I do have a requirement for scientific functions. My trusty 12C does not have these.

***HP Solve*: What appeals to you about HP calculators?**

Mark: Firstly the quality standard that HP calculators defined from the beginning, including the tremendous effort that must have gone into writing the manuals. Then the enthusiasm and skill of the community of dedicated users of HP calculators - HHC grew from this community. The HHC conference is an amazing event where a very diverse group of people gather to share a strong focus in a common interest.

***HP Solve*: Have you had contact with HHC?**

Yes. I find the annual "pilgrimage" to HHC to be an inspirational event. I only wish I had started going in earlier years.

Ed. Note: Mark has participated in HHC activities last year and this year by arranging the special NOAA and NIST tours that 24 lucky attendees made on Monday following the weekend Conference. See the HHC report elsewhere in this issue.

***HP Solve*: How many HHCs have you attended?**

Mark: Four - so each one since 2007, when the conference was kindly hosted by HP in San Diego.

***HP Solve*: What have you gained from the HHCs?**

Mark: A sense of wonder and sometimes awe at the dedication of time and effort that some attendees and organisers put into making the conference what it is. It is often inspirational. I am also really grateful to HP for agreeing to host and participate in the last four conferences and for caring about what could be viewed as a rather fanatical group! HP's generosity, participation and openness make it a really special event.

***HP Solve*: Do you have a calculator collection? How extensive is your collection?**

Mark: I have a lot of HP calculators, but I wouldn't call it a collection. I own more than one of some models, not because they are special or unusual, but because they are useful and if one fails or breaks, I know I have a backup. I think I have about 50 machines in total. Many never get used, unfortunately. A few get used a lot.

***HP Solve*: Do you have any "special" HP calculators?**

Mark: I have one or two early release models.

***HP Solve*: What does your family think of your interest in calculators?**

Mark: They tolerate it. My wife is just happy that I have an interest that doesn't involve alcohol, gambling or women!

***HP Solve*: What kind of HP calculator would you like in the future?**

Mark: As an HP fan, I would probably like any serious calculator that HP produces. But seriously, I would like to see development on portable devices like the iPhone and iPad. I think I would be interested in a machine that has a great user interface and display capability combined with strong number crunching power and extensibility. So, you could have wireless for connectivity or USB for connectivity and for power for example. I think my ideal would be along the lines of a MATLAB like product behind an HP calculator on an iPad, with lots of memory for handling large data sets. I like the list handling capabilities in the 50g, which is powerful in a similar way to MATLAB's ability to handle matrices.

***HP Solve*: Do you have any additional comments that may be of interest to *HP Solve* readers?**

Mark: HP programmable calculators are a great portable numerical laboratory. If you have any interest in programming portable devices for numerical applications, get to an HHC conference if at all possible. See a new part of the U.S. and meet great people - both HHC members and HP themselves.

***HP Solve*: Thank you for spending your time with us.**