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**Volume 14
August 2009**

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HP Announces Calculator Software for PCs, iPhone and iPod Touch

What better way to compliment your calculator than a software version for your PC or phone? HP has released some of its most popular calculators as software.

HP 12c and 12c Platinum software are exact replicas of the original calculators that millions of business professionals and students use. The software is built with the same algorithms and calculation sequences and has the identical layout and functions as the originals. The Platinum version of the industry-standard HP12c adds the choice of time-saving Reverse Polish notation or traditional algebraic data entry as well as convenient editing features such as "backspace" and "undo" keys.
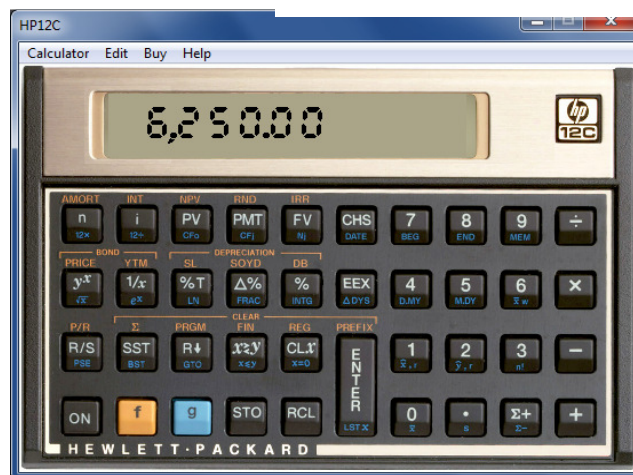
Ideal for engineering professionals, teachers and science students and professionals who already use the HP 35s Scientific Calculator, the software version offers quick, accurate answers from the PC. The software offers the identical HP 35s calculator layout and functionality and provides quick results to scientific and engineering calculations. The software was developed by HP, recipient of the IEEE Milestone in Engineering for the original HP-35. The HP 35s software also offers more than one hundred built-in functions, HP Solve where the user can store an equation, then use it to solve for any variable and the ability to copy and paste calculations directly into financial documents.

Designed for business professionals and students, the software version of the HP 20b Business Consultant is identical to the calculator. It is designed to be a convenient tool for finance, business, and real estate functions. The large two-line display enables the user to view up to 12 digits and scroll through variables, detailed real-text labels, menus and worksheets, and prompts as well as copy and paste answers into other documents.

The HP 15C application, designed for the iPhone and iPod Touch, replicates the original calculator's layout, functions, algorithms and calculation sequences. Used by college students and career people alike, the programmable HP 15C was revolutionary when it was introduced in the 1980s. Like the hardware version, the software application provides an array of matrix calculations plus complex functions and a Solve key that finds the root of an equation.

The "RPN" Stack - Future & Past (Part 2)

In the last issue of *HP Solve* the RPN stack was described and a resource was referenced that provided all possible reorganizations of the four stack registers. The article finished with the following paragraph.

"Why is the HP RPN stack four high? Why did HP use RPN? What was the basis for the first HP RPN pocket calculator? These and other RPN related questions will be discussed in our next issue."

On May 14, 2009, there was a special event at HP Labs when an IEEE (Institute of Electrical and Electronics Engineers) milestone in electrical engineering and computing presented a plaque honoring HP for its work on the first pocket scientific RPN calculator, the HP-35A. HP invited all members of the HP-35A design team to attend the award ceremony, and it was a great opportunity for *HP Solve* to talk to Tom Osborne, the engineer responsible for bringing RPN to HP in the mid 60's.

Tom designed and built the prototype machine that formed the basis for the HP9100. This famous machine is called the Green Machine because of the Cadillac Green Metallic paint he used on its balsa wood case. When the HP 9100 was finished Bill Hewlett asked if the same capability could be put into a shirt pocket and the HP-35A evolved. See figure 1. One of the unique features of the HP 9100 was that it included transcend-dental functions.

Fig. 1 – The green machine, basis for HP-35A, now resides in the Smithsonian Museum.

According to Tom the HP-35A stack was only four registers high because that is all that the memory budget would allow. Memory technology was in its infancy and still very expensive. The HP 9100 stack was only three registers high. Tom wanted to make the stack as high as possible. Tom Osborne had spent time at SCM working on an electronic calculator and he had been exposed to RPN. RPN is a natural way to implement arithmetic in electronic circuits. Here is how Tom Osborne explains it.

"No one that I knew at HP Labs was familiar with RPN when I designed the 9100A. The green machine I took to HP was an interesting combination of infix for multiply and divide but post fix for add and subtract. The 9100A stack was high enough to solve most of the normal computations we encountered. With a bit of mental parsing on the input a 2 deep stack can solve any two operand problem, so we were more than covered. A really deep stack is required if one goes formal and leaves all of the operands in their original order and then relocates the postfix operators (as a full blown parser does)."

"The 9100A stack left the results of a computation in the next to the bottom of the stack (the Y register) - a normal RPN machine would drop the result of a calculation into the bottom of the stack - as I recall, that is what Friden did, and I wanted to avoid any patents they may have had."

"I also inverted the stack's direction from what was done in computers. That way the dividend and divisor were properly located with the divisor below the dividend. Bob Barton went the other way because he visualized the stack as a stack of dishes at the front end of a cafeteria line where one takes the dish at the top of the stack rather than the one at the bottom of the stack."

"I probably would have used postfix on store if we had more than 10 storage cells (0-9), but "STO N"

seemed much more easily understood than "N STO". However with more than 10 numeric memory cells then RPN would have won because it saves a keystroke. "STO 11" would have to be "STO 11 Enter" vs. "11 STO"."

"By the way, I don't remember how PFN (for Parenthesis Free Notation) first came up. It may have been a customer recommendation. I wish I had thought of it at the beginning - but it's never too late to make things right ... right?"

You may read more about the development of the HP9100 by Tom Osborne at:

http://www.hp9825.com/html/osborne_s_story.html

HP 48 One Minute Marvel

One minute marvels are short, efficient, unusual, and fun HP 48 programs that may be entered into your machine in a minute or less.

Delta Percent

Calculating percent is difficult for most people. It is not difficult because of the math; it is difficult because of people. Just look at the percent function on a dozen calculators of various manufacturers and you will see this. Consider a pie that cost $4 last year and costs $5 this year. What is the percent change? (delta percent?)

Percent problems of this type always have two answers. This either confuses people or inspires them to use it to their own advantage. A sales commission may be 15%. Is that 15% of the sale or 15% of the cost of the product sold? The sales person wants the sale price as the reference; the employer wants the cost as the reference. The pie is 25% more expensive this year. The pie was also 20% less expensive last year. These are the same numbers, but using a different reference.

This program solves this "problem". **'D%'** accepts two positive numbers in either order and returns *both* percentage answers. The reduction is negative and *always* on level two. Once you start using this seven command marvel you won't leave home without it in your HP48.

'D%' << %CH LASTARG SWAP %CH MAX LASTARG MIN >>

HP 40gs CAS Calculator: Worth Looking Into

There was a recent article in the *Technology Tips* section of the *Mathematics Teacher* journal from the National Council of Teachers of Mathematics (Volume 102, Number 6, February 2009) titled *TI-Nspire Calculators: Better but Still Not Perfect* that discussed the state of the art of CAS calculators. Specifically, the article addressed two functional areas: 1) Graphing and 2) Automatically Rewriting Expressions. Since the article only addressed the Texas Instruments CAS machines, the TI-89 and TI-Nspire CAS, the audience may have been left with the impression that these are the best machines available with respect to the two above-mentioned functional areas. In this document, the author sets out the capabilities of the HP 40gs CAS calculator, based on the criteria in the article.

Graphing
The graphing section of the article contains a total of 7 examples, numbered (1) through (7), which the authors explain are incorrectly graphed by the TI-89. Of these 7, 5 are now correctly graphed by TI-Nspire CAS. Let us examine the graphs produced by the HP 40gs.

The first example is

(1) $y1 = \left(\sqrt{x}\right)^2 \neq y2 = x$

The desired graphing behavior is to respect the different domains and restrict *y1* to non-negative real numbers. The function *y2* has no such restriction. Figure 1 shows *y1* entered as *f1(x)* on the HP 40gs, while Figure 2 shows the correct graph.

We prefer the more exact notation of *f1(x)* to the somewhat ambiguous *y1*. The article did not delve into the complexities of notation and input, but it is a very real advantage of the HP 40gs. Any command can be typed in, letter by letter, from the keyboard. For example, typing S, I, N, (, 3, 0,), and then pressing the Enter key gives the same result as using the SIN key. This is shown in Figure 3. The top expression was entered character by character while the lower one was entered using the SIN key. The inputs and outputs are identical, regardless of mode of entry.
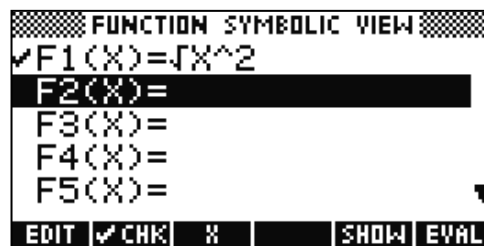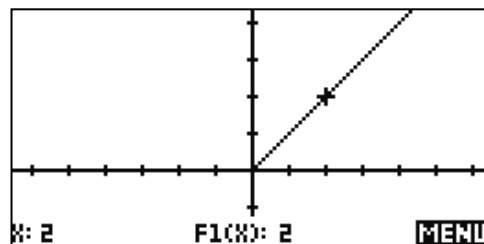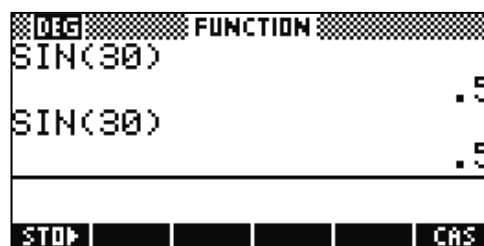

Figure 1

Figure 2

Figure 3

The second example is

$$(2) \quad y1 = \frac{\sqrt{x-1}}{\sqrt{x-3}} \neq y2 = \sqrt{\frac{x-1}{x-3}}$$

In this example, the domain of *y1* is restricted to real numbers greater than 3, while *y2* is not defined for x where $1 \leq x < 3$.

Figure 4 and Figure 5 show the input and correct graphing behavior for *y1*.

Although it is not clear from Figure 5, if one traces to x-values of 3 or less, the tracer readout shows that *f1(x)* is undefined for these values, as required.

Figure 6 and Figure 7 show the input and correct graphing behavior (respectively) for *y2* as well.

The third example is

$$(3) \quad y1 = \sqrt{x-3}\sqrt{1-x} \neq y2 = \sqrt{(x-3)(1-x)}$$

The use of *y1* and *y2* are continued in this example for consistency and clarity, although omitted by the authors.

In this example, *y1* is not defined for any real numbers and thus no graph should be produced. The correct graphing behavior in this case is exhibited by the HP 40gs, though the non-graph is not shown here.

The domain of *y2* is limited to x such that $1 \leq x \leq 3$. Figure 8 shows *y2* entered into the HP 40gs as *f1(x)*.
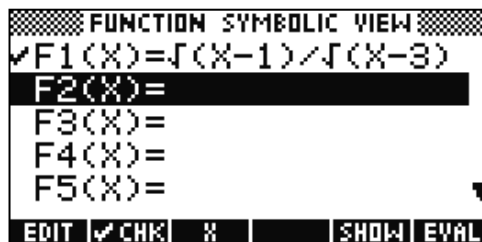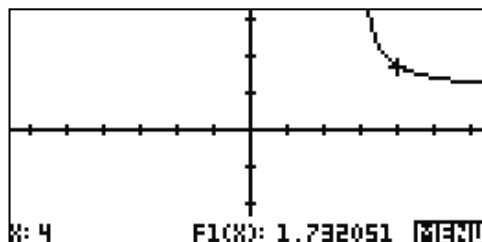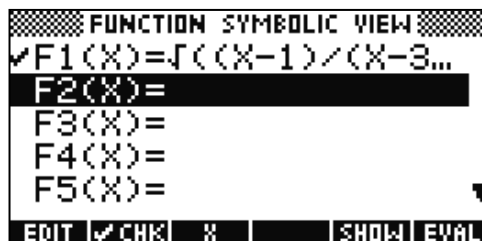

Figure 4
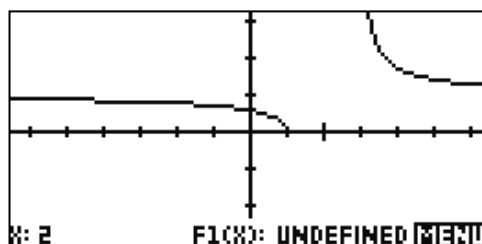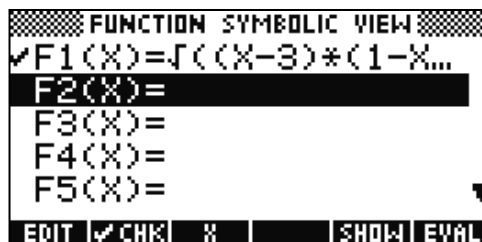

Figure 5

Figure 6

Figure 7

Figure 8

Figure 9 show the required graphing behavior. As with the previous examples, tracing to x-values outside of the domain clearly indicate that *f1(x)* is undefined for those values.
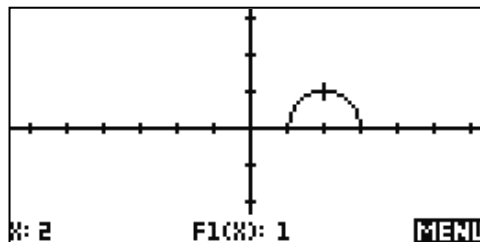

Figure 9

Examples (1) through (3) are followed by a discussion of the expression

$$\frac{\sqrt{4x}}{\sqrt{x}} .$$

Although not treated as a graphing example, the authors explain that evaluation of the expression at x=-1 often produces a result of 2 on most CAS products.
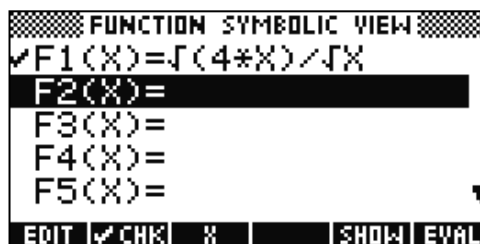

Figure 10

The authors presumably want the domain to be restricted to positive real numbers. It was not clear from the discussion if this was a problem with graphing behavior or not. Figure 10 shows the input and Figure 11 the correct graphing behavior for the expression above.
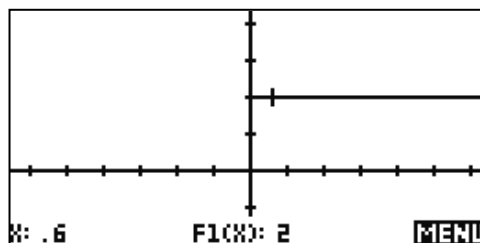

Figure 11

With the default CAS settings, entering the expression shown in Figure 12 and pressing the Enter key gives the result shown in Figure 13.
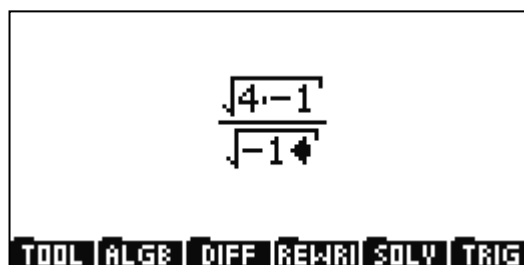
By default, the HP 40gs CAS operates in real versus complex mode. If an operation is requested that requires the CAS to switch to complex mode to complete, then the user will be asked if the CAS may switch to complex mode. If the user declines to switch modes, a simplification error will be displayed and the previous result retained.

Figure 12

Figure 13

In Figure 14, the user has declined to enter complex mode by pressing the NO key in Figure 13, resulting in the error message shown. Pressing OK at this point returns the user to Figure 12. If the user selects YES in Figure 13, then the complex results are accepted and simplified to 2. In the case of an expression with multiple operations, the user may be asked to switch modes multiple times.
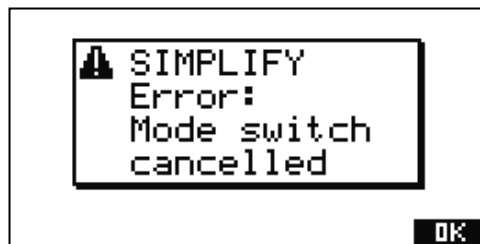

Figure 14

This approach allows the user to distinguish between contexts in which only real-number calculations are appropriate and those in which the larger realm of complex operations can be invoked.
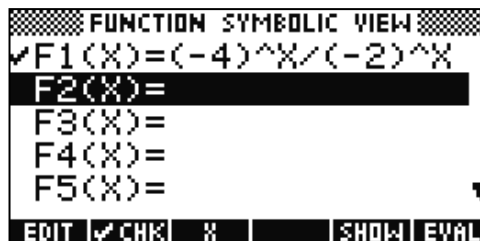

Figure 15

To return to our graphing examples, Example 4 is

$$(4) \quad y1 = \ln(1-x) - \ln(x-2) \neq y2 = \ln\left(\frac{1-x}{x-2}\right)$$

Figure 16

Again, this author uses *y1* and *y2* for consistency here, although the article omits them in this example. Since *y1* is not defined over any of the real numbers, no graph should be displayed. For *y2*, the domain is restricted to x such that 1<x<2. The HP 40gs exhibits the required behaviors in both cases (not shown).
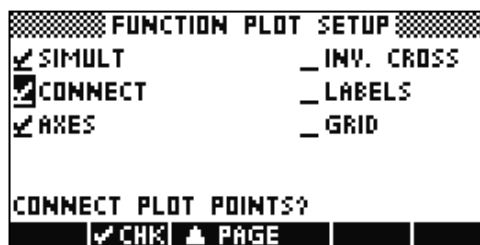

Figure 17

Example 5 is

$$(5) \quad y1 = \frac{(-4)^x}{(-2)^x} \neq y2 = \left(\frac{-4}{-2}\right)^x = 2^x$$

The authors note that y1 may graph incorrectly if the plot style is chosen to be continuous. Figure 15 shows y1 entered as f1(x) with the Connected option on (Figure 16). Note that the HP 40gs considers f1(x) to be defined for all integer values of x (Figure 17) and undefined for all other real numbers (Figure 18).
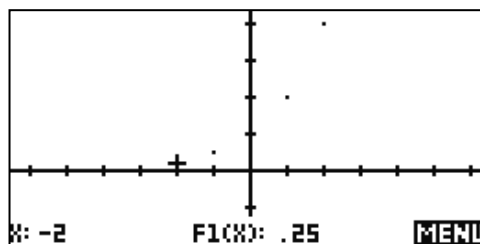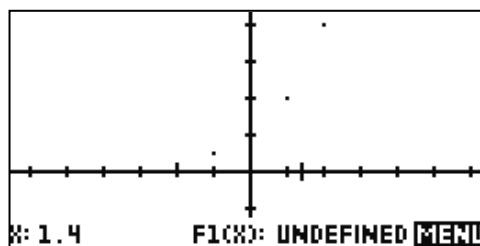

Figure 18

Example 6 is

(6) $y = \dfrac{2\sin^{-1} x + \pi}{\sqrt{x-2}}$

For this example, the expression is not
defined for any real number, so no graph
should be produced. The HP 40gs exhibits
the required behavior, showing the
expression as undefined for all real
numbers.

The last graphing example is

(7) $y = i^{\sqrt{x}}$

Clearly, the expression is not defined for
negative real numbers, and the HP 40gs
indicates as much. It is not clear from the
article what exactly the authors expect for
non-negative real numbers. If only real
number operations are to be allowed, then
this expression is not defined for any real
number and absolutely no graph should be
displayed for any real number. This is
precisely the behavior of the HP 40gs, as
shown in Figure 19 and Figure 20.

Automatically Rewriting Expressions
In this section, the authors provide another two sets of examples. The first, Examples (8)
through (10), consist of purely numerical expressions which are rewritten in various
equivalent forms. For these examples, the HP40gs behaves much like the products under
review in the article.

The second set, Examples (11) through (15), consist of expressions containing variables
which are also rewritten in various ways. The resulting forms would be equivalent
except for the fact that the domains are different for the input and output expressions.
Thus, they cannot be viewed as equivalent. Again, for all but one of these examples, the
HP 40gs behaves in much the same way as its counterparts.

But the underlying point of these examples is to show that the CAS products
automatically perform these simplifications without explicit direction from the user. The
products under discussion incorporate an input model where any expression is evaluated
and simplified when the Enter key is pressed. In fact, in their recommendations, the
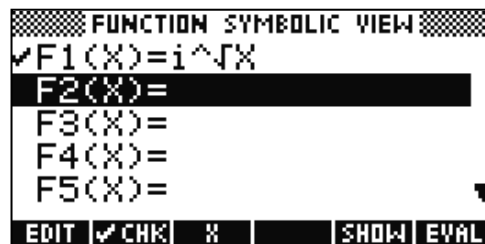authors make the following argument:
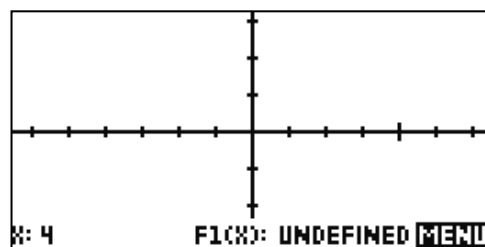

Figure 19

Figure 20

In this discussion, we continue the argument found in Bosse and Nandakumar (2004) that loading any expression into the calculator should be differentiated from performing an operation on an expression. The user should be allowed to enter any expression onto the screen and have nothing occur until the calculator is prompted to perform some operation.

We now proceed to an examination of the HP 40gs CAS editor. In this examination, the audience will see the steps taken by HP to address the authors' concerns.

The HP 40gs CAS editor does not use the same input/output model as its counterparts. Instead, it employs what we call an *Interactive Editor*. The *Interactive Editor* performs two major functions. First, it makes sure that the expression under edit is always valid. Second, it allows the user to operate on the expression or any of its sub-expressions. Let us illustrate these two roles with an example.

We return to the expression mentioned previously:

$$\frac{\sqrt{4 \cdot -1}}{\sqrt{-1}}$$

Figure 21 shows the user entering the numerator. In Figure 22, the user selects the numerator and in Figure 23 invokes the operation of division. If the user presses the Enter key at this point, nothing happens because the expression is not yet valid. In Figure 24, the user has completed the entire expression. Note that the user has not pressed the Enter key and no action is being taken by the HP 40gs. At this point, the user can opt to press the Enter key and the HP 40gs will respond as previously discussed (see Figure 13). But the user can also select the entire expression or any valid sub-expression and invoke a command.
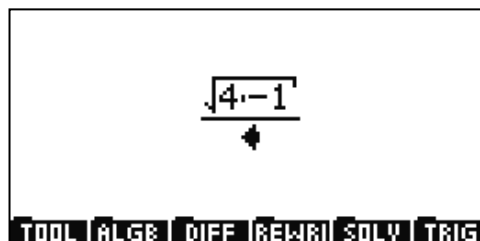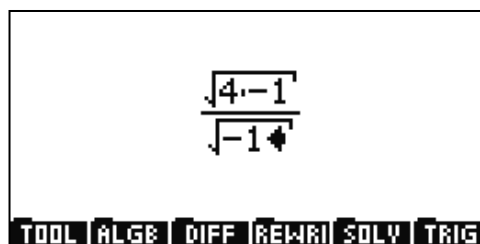

Figure 21

Figure 22

Figure 23

Figure 24

For example, in Figure 25, the user has selected just the radicand in the numerator. The user can press the Enter key or invoke the Simplify command to see the result of -4. In Figure 26, the user opted to invoke the Simplify command; Figure 27 shows the result after the Enter key is pressed.

Pressing the Enter Key at this point will result in the behavior discussed earlier (see Figure 13 and accompanying discussion).

The design of the HP 40gs *Interactive Editor* addresses the authors' recommendation to separate entry of mathematical expressions and operation on mathematical expressions. Further, the *Interactive Editor* allows the user to operate on expressions in place. In fact, the Interactive Editor goes one step further and allows the user to operate on any valid sub-expression as well. Finally, the *Interactive Editor* continually parses expressions in place to ensure that an expression maintains validity.

In summary, the HP 40gs not only compares favorably to the CAS machines reviewed in the article, it also has some strong differentiating advantages, both in graphing and in the entry and simplification of mathematical expressions by the CAS.
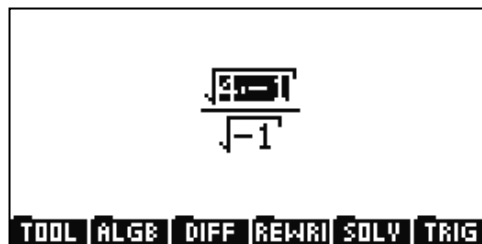

Figure 25

Figure 26

Figure 27