Introducing the new Casio *fx*-9860G AU

by Peter Karamoshos and Alastair Lupton.

Introduction

For students, teachers and schools who currently use the CFX-9850 GB PLUS, these new machines are very exciting. We have been using these new calculators for the last six months and are very impressed with the new features.

The main advantages we see are:
- the massive increase in processing speed
- mathematical notation available on the screen
- larger, clearer screen
- double the operating memory of the 9850 plus a large backup memory (64K RAM/800K flash memory)
- numerous refinements and improvements to mathematical operations
- two new functions; spreadsheet and e-activity.

We demonstrate here how the 9860 performs the same functions as the 9850 but better, while also introducing the new features of spreadsheet and e-activity.

Looking at RUN mode

The major difference between the RUN mode of the 9850 and 9860 is the ability to be more mathematical in the representation. You are also able to access almost all other modes while in RUN mode.

Math mode

Enter the SET UP by pressing   SHIFT   MENU

The options at the bottom of the screen, allow you to change from Linear mode to Math mode. Linear mode acts in the way as the 9850 while Math mode only exists in the new machine.

Set your machine to Linear mode.

The Fraction Key

1. Evaluate the following on your calculator.

(a) $\dfrac{2}{3}+\dfrac{1}{5}=$ (b) $\dfrac{3}{5}\times\dfrac{1}{4}=$ (c) $2\dfrac{4}{5}-1\dfrac{1}{3}=$

(note – a mixed number is produced by pressing SHIFT then the fraction key)
(Change your answer to (c) from a mixed number to an improper fraction to a decimal.)

2. Enter   SETUP   to set your calculator to   **MATH**   mode

3. Repeat the calculations from above.
(9860 - you must press the fraction button before entering the fraction)

This simple but improved representation of the fraction on the screen will be of benefit to students who will now see fractions in a familiar form.

Logarithms

The 9850 is capable of performing calculations with only logarithms of base 10 or *e*. The 9860 can deal with logarithms of any base.

1   To access the logarithm function, press the MATH button at the bottom of the screen while in RUN mode.

You should see these mathematical options at the bottom of the screen.

2   Press the $\log_a b$ button

Find answers to the following

(a) $\log_2 8$

(b) $\log_3 81$

(c) $\log_2 \dfrac{1}{64}$

Apart from the obvious advantage for students when dealing with logarithms of varying bases, the representation on the screen reinforces the correct notation.

Investigating other features in RUN Mode.

Use the other options at the bottom of the MATH screen to answer the following questions.

1      $\left|-5\right|$

2      $-3\times\left|-2+1\right|$

3      $\dfrac{\left|-8+2\right|}{3}$

4   Find the slope of the tangent to the curve $y=2x^3+3x-4$ when $x=2$

       (note - the polynomial is represented in the correct format on the screen)

5   Determine $\left|\displaystyle\int_{0}^{2}(4x^3-3x^2+x-9)\,dx\right|$

6   Evaluate $\displaystyle\sum_{1}^{4}\dfrac{1}{2^n}$

7      $2\dfrac{2}{5}+\dfrac{1}{5-3\dfrac{3}{4}}$

Matrices

You will notice on the MAIN MENU screen that the Matrices mode no longer exists. Sensibly, it is easily accessed from within the Run mode.

Given $A=\begin{bmatrix} 4 & 2 \\ -1 & -2 \end{bmatrix}$ and $B=\begin{bmatrix} 3 & 1 & 0 \\ 2 & 1 & 3 \end{bmatrix}$
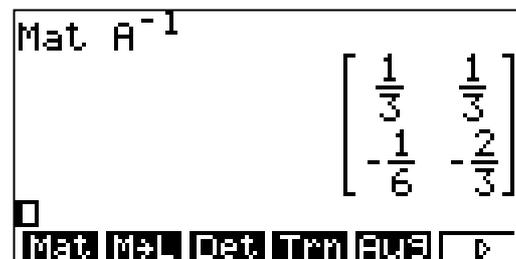
To enter new matrices, press the MAT button at the bottom of the RUN mode screen.
Exit to return to the RUN screen.
You can either access the stored matrices in the traditional way by pressing   OPTN   or press   SHIFT 2

Use your calculator to find   (a)   A × B   (b)   A^{-1}

The elements of the matrix are obviously given as fractions which is of benefit to the students.

Given $C=\begin{bmatrix} \dfrac{1}{3} & \dfrac{2}{5} \\ 5 & -\dfrac{3}{4} \end{bmatrix}$ determine $5\times C$.

You will notice that fractions must be entered into the matrix in the Linear Mode method. The resultant matrix does have the newer fraction output. These fractions can be converted from mixed numbers to improper fractions and to decimals.

You can access numbers from the list mode by pressing SHIFT 1.
Would you use this feature?

Investigating Statistics Mode

STATistics - CALCulations

Looking at the MAINMENU screen, you will see that the LIST mode from the 9850 is missing. Its single useful function, the changing of List Files, is now part the SET UP in STATistics mode.

Entering the STATatistics mode you will notice that there is an extra row at the top of the lists entitled SUB. This allows you to name your lists. Just place your cursor there and type in a name using the ALPHA keys.

This is useful for remembering what it is that you have stored in your calculator. If you scroll across, you will see that each List File in the 9860 contains 26 lists rather than 6, and there are still 6 List Files to fill!

To first look at the CALCulation command, enter the numbers {1,2,3,4,5,6,7,8} into List 1.
As the SETup for CALC is the same as the 9850 – with its default as List 1 – you should be able to do a 1 VARiable CALCulation of List 1 without needing to change anything. [Check the SETup then press **F2** then **F1**].

There are two changes here. The $\bar{x} - x\sigma_n$ and $\bar{x} + x\sigma_n$ have gone (not overly useful outputs), and the treatment of Mode has been improved.

At the bottom of the output there are the mode outputs **Mod =…**
and as in this case there are several modes, *all* are provided. Further down, **Mod:n=…** tells you the number of modes and **Mod:F=…** tells you the frequency of these modes.

```
1-Variable
Mod   =5            †
Mod   =6
Mod   =7
Mod   =8
Mod:n=8
Mod:F=1
```

In the 9850, if you entered a data set with multiple modes the mode given was the largest mode. This meant that a data set where each score occurred once, the mode was given as the largest value, far from useful if you were studying measures of central tendency.

EXIT and change your data set to {1,2,3,4,4,5,6,7} and do the 1VARiable CALCulation once more. Have a look at the Mode output now.

Also note that the other measures of central tendency are also integer (they are all 4, whereas mean and median were 4.5 previously).

This is the easiest way to find the middle out of 8 rankings, a question causing some difficulty for a number of people at present.

STATistics – GRAPH

Enter the following data into List 1 and List 2. You might even want to try naming these lists.

Planet	Average distance (d) from the sun (in millions of km)	Period of revolution around the sun (t) (in days)
Mercury	57.9	88
Venus	108.2	225
Earth	149.6	365.25
Mars	227.9	687
Jupiter	778.3	4329
Saturn	1427.0	10753
Uranus	2870.0	30660
Neptune	4497.0	60150
Pluto	5907.0	90670

The GRAPH set up is the same as the 9850 (with the omission of the mean box plot).

Your default GraPH1 should give you a Scatter Plot of List 2 against List 1 [Press **F1** then **F1**]

You will notice that options presented at the bottom of the screen have changed. The CALC button [**F1**] brings up the usual choices for model fitting by the CALCulator. The DefG – Define Graph – button [**F2**] brings up GRAPH mode, where you can select or enter your choice of model, which will be drawn on your Scatter Plot.
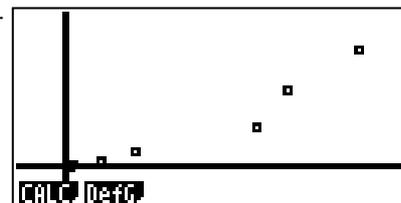
If you press the DefG button [**F2**] and enter the model $y = \frac{1}{5} x^{3/2}$, the one my friend the Physics teacher tells me is

theoretically correct, you can see it drawn on your Scatter Plot.
You can then press CALC, find the calculator's power model
[**F1** for CALC then **F6** and **F4**], which you can then draw to see
 how good the theory is.

One way to investigate the fit of a model is to compare model values with the available data. The 9860 does this with a new feature. With the model drawn we can Trace [SHIFT **F1**] through the function *or* the data. Go up or down with the Arrow keys to go from StatGraph1 to Y1, then left or right to go through data set or model.

Use the Trace function to find the difference between the length of the Uranus year, according to the theoretical model compared to the data given.

One other change in the model fitting department is the calculation of an 'r^2' value for Cubic and Quartic model. This brings the Casio in line with other brands of Graphics Calculator.

Some other new features:

Inverse Normal Calculations

Performing inverse normal calculations is slightly different on the 9860 as you will soon see.
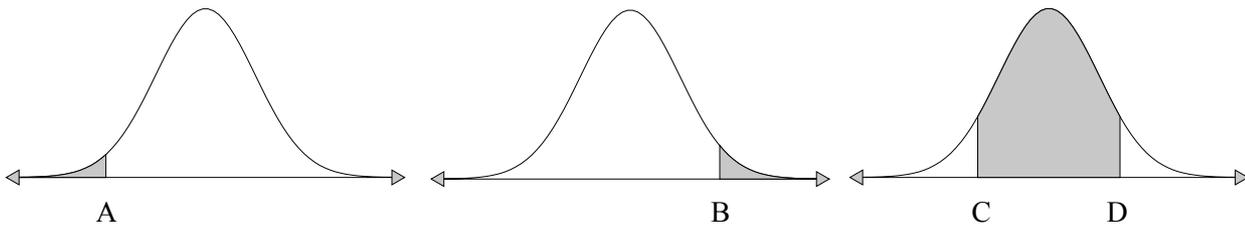

Challenge
"Eastern Star" are manufacturers of margarine whose containers are labelled as having 275 grams. The weight of margarine in the containers is normally distributed with $\mu = 279$ grams and $\sigma = 3$ grams. One container is selected at random.

---

1 P(weight < A) = 0.1
   Find A.

2 P(weight > B) = 0.13
   Find B.

3 P(C < weight < D) = 0.75
   Find C and D

The unknowns should be determined in the following way.

```
Inverse Normal
Tail    :Left
Area    :0.1
σ       :3
μ       :279
Save Res:None
Execute
None LIST
```

```
Inverse Normal
Tail    :Right
Area    :0.13
σ       :3
μ       :279
Save Res:None
Execute
```

```
Inverse Normal
Tail    :Central
Area    :0.75
σ       :3
μ       :279
Save Res:None
Execute
```

Table Mode

Being able to represent an algebraic expression in both table and graphical modes simultaneously in a split screen is a lot quicker than before.

1   Select the TABLE mode from the MAIN MENU

2   Enter Y1 = 2X + 1

3   SET the table range as shown

4   Press SHIFT   MENU to access the SET UP

5   Highlight Dual Screen as shown and select T + G
        (Table and Graph)
6   Set your view window to STD

7   EXIT, then Press TABL

8   You will see the table of values on the right of the screen and a set of axes on the left.

9   Press G-PLT. Your screen should look like this.

10   Press   OPTN GLINK Move the curser down.

```
Table Setting
X
Start:-5
End  :5
Step :1
```

```
Variable    :Range
Graph Func  :On
Dual Screen :Off
Frac Result :d/c
Simul Graph :Off
Derivative  :Off
Background   :None  ↓
T+G Off
```
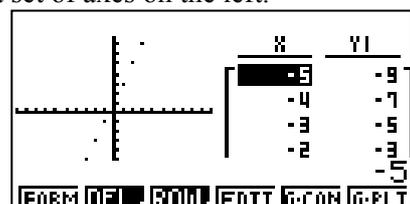

This connects the table of values to a graph. It highlights a specific point on a graph with its corresponding ordered pair.

Page 6

GRAPH

Enter into GRAPH mode. You will notice that on the right-hand side there is a line indicating the STYLe of each graph. This can be changed (solid line or various dot styles) using **F4**. This is instead of being able to select the colour of graphs.

Question 1.

| |
|---|
| Find the maximum value and roots of $y = \ln(x^3 + 100) - e^x$ |

(Why not!)

Start with the INITial View-Window and draw the function. Use the Arrow keys to move the view-window up to see the maximum of the graph. You could do this with the 9850 but it was so slow that it was better to alter the view window.

Once you have a good view of the graph use the G-SOLV menu to find the maximum value of the function. This takes under 3 seconds with the 9860. It took 21 seconds for my 9850 to do the same thing.
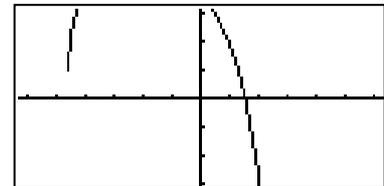
So what is going on with the left hand side of the graph? Go to Trace [**SHIFT F1**] and try to find the limit to the domain for which the function is defined.
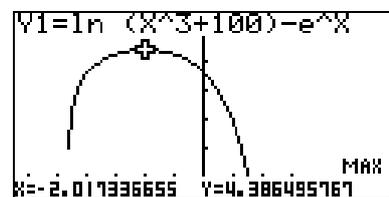
You should get $x \geq -4.6$ or thereabouts at this resolution, but we can look closer.

Use ZOOM BOX [**SHIFT F2 F1** then the arrows keys and the EXE key to set the BOX] to zoom in on the left hand 'end' of the graph. You can quickly see that the function actually has a negative root at around $x = -4.6259$ and keeps going down the closer you look! (asymptote here)
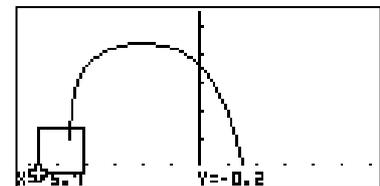
 As for the limit to the domain, the calculator can give you better and better approximations (I got to $x \geq -4.6412$ with a couple of zooms). A more theoretical approach will give the answer $x \geq -4.6416$ correct to 5 significant figures.

None of the commands used above are new to the 9860. However, with a relatively complex function, the lack of processing power (and therefore speed) of the 9850 made this sort of calculation slow and painful (to say the least). With the much faster processor of the 9860 these commands become much more appealing to use as a way of exploring mathematical phenomenon.

Question 2

The number of new cases per day (in 1000's) of a 'flu virus within a given population can be modelled by

$$P = 2t(0.8)^t \text{ with } t \text{ in days}$$

Find the number of new cases
      i.   on day 5
      ii.   on day 9

Lets look at the first 10 days. Set your view-window to $0 \le x \le 10$ and $0 \le y \le 5$ and draw the graph of the function.

Use TRACE to find the function value at day 5 and day 9.

You will have trouble with day 9, as the pixel size does not let you get to exactly $x = 9$.

Go back to your view window and notice the **dot** input. This lets you *choose* the pixel size, and adjusts the x-max accordingly. It is currently showing 0.0793… but this could be changed to 0.1 allowing us to Trace in increments of 0.1. Notice that this changes the x-max to 12.6.

Redraw the graph and try tracing now.

What if I wanted to know about day 30? There are many ways to do this but try this one. While you are tracing,, hold down the across right arrow and wait til you reach $x = 30$. Try doing that on a 9850!
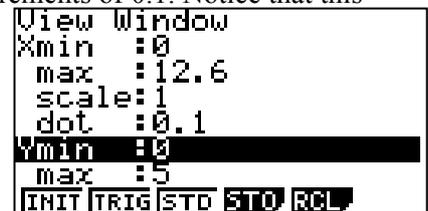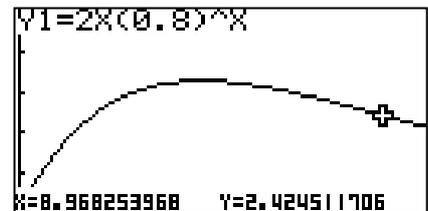
Question 3

Find the equation of the Normal to $y = x^3 - 2x^2$ at its point of inflection.

First draw the function and its derivative on the same screen. using the initial view-window.

Put the function in as Y1 and the in Y2 put $d/dx(Y1, X)$. The key sequence for this is **OPTN F2 F1 VARS F4 F1** [**1**] [**,**] [x, θ, t]. This is the same as the 9850.

Once you have entered that, change the STYLE (F4) to of Y2 to dotted (you choose the type).

These two graphs will take a while to draw, just under 10 seconds. My 9850 took 30 seconds.
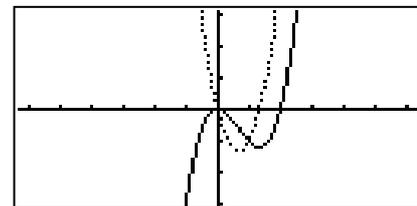
Now we have to find the x-value of the point of inflection. One way is to find the x-coordinate of the minimum of the derivative function.

This takes about 25 seconds on the 9860, from pressing MIN to selecting the second function (use the down Arrow key) and then locating the minimum. This is a full minute quicker than a 9850!

Once I have my x-value ($x = 0.66665$, which looks like two thirds to me!) it is time to redraw the function (deselect Y2 as the derivative
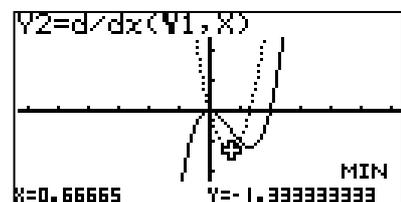
is no longer needed).

To get the Normal go to Sketch [**SHIFT F4**] then Norm. Move the cursor onto 0.7 (as close as you'll get at this view window) and press EXE. You get the Normal drawn, *and its equation*. The 9850 draws the Normal but doesn't give its equation.

This isn't quite what we wanted though as we need the Normal at $x = 0.667$ (two thirds to 3 sig. figures. Press Sketch and Cls to get a clean graph.

Now go to Sketch and Norm, but don't trace to find the point…enter it! Just type 0.667 using the number keys. EXE will locate the point and EXE again will draw the Normal and provide its equation.
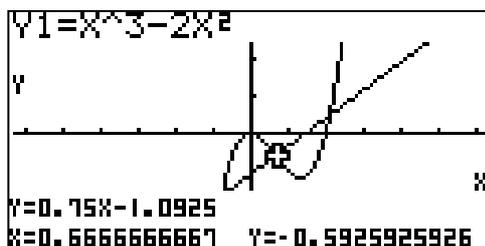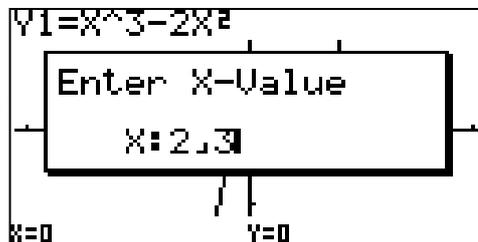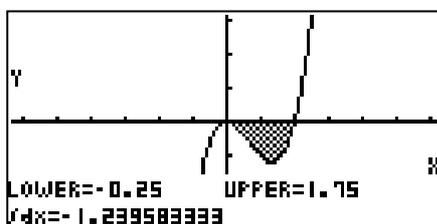
This new functionality, to enter desired *x* values in GRAPH mode works in Trace and also in the definite integral command where it is particularly useful.

For example, to find $\int_{-0.25}^{1.75} x^3 - 2x^2 \, dx$, have the graph of the function drawn as above.
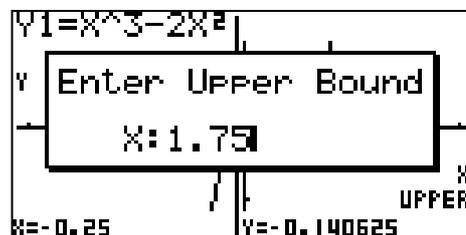
Go to G-SOLV then $\int dx$ [**SHIFT F5 F6 F3**] then type in **–0.25 EXE 1.75 EXE**.

Spreadsheet Mode

One of the impressive new features of the 9860 is the spreadsheet function. This will enable many of the tasks, normally requiring a computer, to be completed in the classroom. The initial challenge will be trying to find the commands that let you complete the simple tasks you know so well from Excel.

Challenge 1

We are going to set up a very simple spreadsheet which determines the total cost of buying 20 loaves of bread and 15 cartons of milk given bread costs $2.40 per loaf and milk costs $2.10 per carton.

---

1   Open up the spreadsheet mode (S-SHT) from your MAIN MENU

2   To name a new sheet and save it, press FILE   NEW

3   Type in the COST as the title. Press EXE. The title should be in the top right corner of the spreadsheet.

COST	A	B	C	D
1		COST	NO	
2	BREAD	2.4	20	
3	MILK	2.1	15	
4				
5			TOTAL	

FILE EDIT DEL INS CLR ▷

4   We wish to prepare a spreadsheet as shown.

To move between the different cells, use your arrows.

To enter text, you must first press ALPHA EXP to display ".
Follow this with the text you wish. (C is produced by pressing ALPHA In). You do not need the quotation mark at the end of the text.

5   We now wish to determine the total cost in cell D5 by using a formula.

To enter a formula, you must start with = as with Excel. (= comes from SHIFT .)
Enter the appropriate formula to determine the total cost of these 35 items.   (Total should be $79.50)

6   Recalculate the cost given the number of loaves of bread has changed to 25 and milk 21.

Hopefully, the formula recalculates the cost.

7   Edit your spreadsheet to find the total cost of 30 loaves of bread, 24 cartons of milk and 15 bars of chocolate which cost $3.15 each.

Challenge 2

We will use the spreadsheet function to determine Pythagorean Triads.

Given that the following triangle is right angled with shorter sides A and B and hypotenuse C, we will try to determine Pythagorean Triads using a systematic approach.
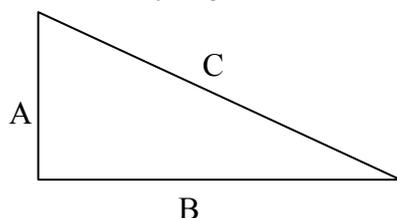
We will set   A = 1, B = 1 and calculate C
                 A = 1, B = 2 and calculate C
                 A = 1, B = 3 and calculate C

                 Continue for B = 100

We will obviously be looking for values of C which are integers, giving us Pythagorean Triads.

We will then do the same test for A = 2, A = 3, etc.

1   Create a new spreadsheet by pressing FILE NEW

2   Name this spreadsheet PYTHAG

3   Label cell A1 as A, cell B1 as B and cell C1 as C

4   We now wish to fill column A with the number 1.
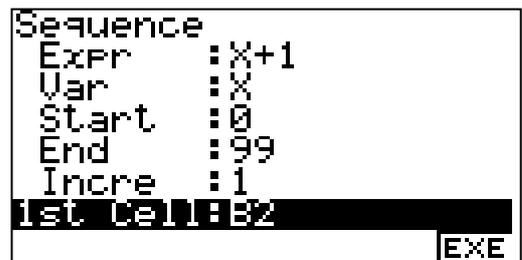
     Press EDIT, F6 to move across to show FILL.
     We will enter the following to fill the
     cells A2:A101 with the number 1.
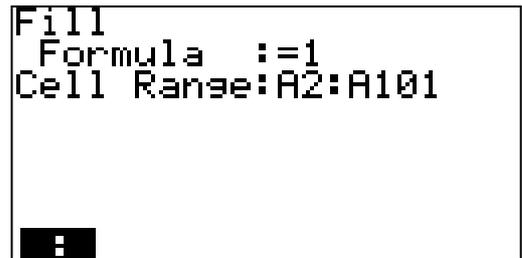
Note, the = sign is still required when entering a formula

You should see the number 1 in the first column.

5   To enter the numbers 1 to 100 in the second
     column, press EDIT, SEQ as we are about to
     enter a sequence. Enter the information as shown
     beside.

     This should enter the numbers 1 to 100 in the
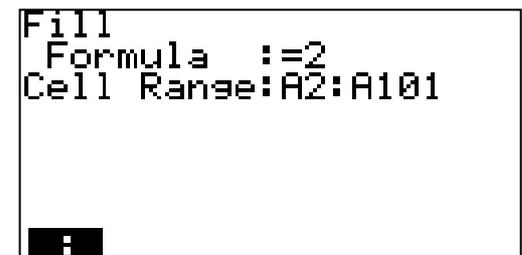   second column. Check.

6   We will use Pythagoras' Theorem in the third
     column to determine the length of side C.

     To do this, press EDIT FILL
     Enter the appropriate formula remembering to
     begin with =
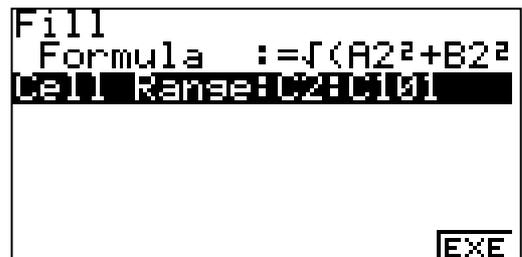
7   Check for Pythagorean Triads.

8   We now need to change the 1 in the first
     column to 2.

     EDIT   FILL
     Enter information as shown.

     Are there any Pythagorean triads using A = 2?

9   Repeat for A = 3.   Any Pythagorean Triads?

10   Repeat for A = 5,   A = 13.   Any Pythagorean triads?

E-ACTivity

The E Activity mode is a new one to this type of calculator. The Casio Classpad 300 features a similar mode of the same name. The author's skills with this mode can be best described as developing, so what follows are only some introductory thoughts.

An E-Activity can be best described as a webpage for graphics calculators. It allows the user to write a document made up of text, calculations and, most importantly, links to other calculator modes.

Enter the E-ACTivity mode and OPEN [**F1**] the E-Activity called QUADPATT.
Scroll down using the Arrow keys. You will see lots of text and links to LIST, STAT Graph, NOTES (more text) and the GRPH Editor. If you EXE on one of these links it will take you to one of these menus where you can do work. If you choose to, this work can be saved as part of the E-Activity.

Once you have finished with this link press [**Shift ARROW** – under the tan key] to return to the E-Activity.

Get back into QUADPATT (or open a NEW E-Activity if you wish) and have a look at some of the functions available to the E-Activity creator/user.

Text can be entered using the ALPHA key [use **SHIFT ALPHA** to use Alpha-lock to enter continuing text].
The STRIP function (**F2**) allows you to create links – known as Strips. As you can see there are Strips that link to pretty much every other part of the 9860. This is the power of the E-Activity.
F3 lets you change your input from text (if **text** is showing) to calculations to be evaluated (if **calc** is showing).
When in **text** mode the CHARacter function [**F4**] allows you to enter a *very* wide range of mathematical symbols in your E-Activity.
When in **calc** mode the MATH function [**F4**] is the same as RUN mode (in MATH input mode).

The remaining commands are fairly self-explanatory … so have a play!