Using the EL-9650/9900

Contents

ADFA **CMA**

1 Introduction

Mathematics is a visual subject, and graphics calculators can provide the picture in a number of important areas of mathematics. They are also useful in allowing students to explore mathematics numerically and graphically. Graphics calculators are portable, powerful and, for what they do, relatively cheap.

What the EL-9650 can do

- all the features of a scientific calculator plus matrices and complex numbers
- multi-line screen, which displays input and output of calculations simultaneously
- recall and editing of previous entries and answers
- ability to graph Cartesian, parametric, polar and sequence graphs
- statistical functions for organising, analysing and displaying data
- programmable, with a large number of programs available for downloading
- can be linked to other calculators, computers and printers for electronic transfer of programs, data, etc and downloading programs from a computer or the web
- can be used in conjunction with calculator-based data logger: this enables easy collection of real data, which can be organised, displayed and analysed
- an overhead-projector view screen is available.

Implication for teaching and learning

- a need to think about classroom dynamics
- improved student motivation
- enhanced modelling and exploration opportunities
- the potential for using an 'animated' whiteboard[1] with the overhead-projector view screen

The graphics calculator is a tool that can assist teachers, but there is a need to think about its use in the classroom. We need to take care that we don't hand over all of our teaching to the technology. The technology needs to be used to enhance students' understanding, not replace it. It provides a valuable tool for drawing links between various content strands and to complement traditional tools such as pencil and paper.

It is important that teachers remain in control of the learning environment, but the classroom dynamics change — there is more exploration and a problem-solving approach to learning can

[1]Projection of the calculator screen onto a whiteboard provides an 'animated' whiteboard, on which graphs can be annotated, etc using a whiteboard marker.

be encouraged. This may require a change in teaching methodology, the teacher becoming a facilitator of student learning by the use of a wider variety of teaching strategies. The whole process needs to be approached with careful thought, as well as a detemination to persevere if early problems arise.

The use of graphics calculators certainly motivates students. It provides them with different ways of looking at mathematics, it is less tedious for a number of necessary tasks, promotes student investigation by allowing them to explore concepts independently and enhances modelling opportunities.

Graphics calculators are also fun. Kids pick up the operations very quickly (much faster than teachers), and if you can't get your students to use a graphics calculator, there are heaps of games to tempt them.

In the beginning

Getting started is always the hardest, especially when you have to learn the new technology and then modify or write new courses. However, this can be an evolutionary process, not an abrupt change. For students, time needs to be spent on 'button-press' activities or by allowing the students to 'play' with the calculator to see what happens. The use of simple numerical investigations can provide a starting point for the development of understanding of the operation of the calculator. Alternatively, the students can be encouraged to use the calculator in conjunction with investigative activities which highlight the various capabilities of the calculator, particularly in areas that are required in the classroom. The students themselves very quickly become valuable resources for using the calculator.

The experience at ADFA and most other schools and universities at which graphics calculators have been used for a while, is that graphics calculators should not just be an add-on to a course, but should eventually be integrated fully, including their use in tests and exams. This raises many issues, most of which are resolvable. You might like to read for example *Graphics calculators in upper secondary courses* by Barry Kissane and *Graphics calculators in the mathematics curriculum: Integration or differentiation?* by Jen Bradley, Barry Kissane and Marian Kemp about their experiences in WA.[2]

[2]Both papers are available at *wwwstaff.murdoch.edu.au/∼kissane* under Publications. There are a number of other interesting papers here too.

2 Using the Calculator

2.1 Resetting the calculator

The following notes assume that all the default options are set. If the calculator has been used by someone else, it is a good idea to reset the calculator before proceeding.

Press the pointer/pen provide into the hole marked RESET on the back of the calculator. Press [CL] to reset the calculator.

Look at the default options set by RESET by pressing [SET UP] ([2ndF] [BS]). Scroll down and look at the options for each item in the menu. For the time being, change the EDITOR option to *One line* by pressing [2]. When you are more familiar with the calculator, you can experiment with the *Equation* editor.

2.2 Getting started

When you turn on your calculator on, an underline cursor should appear in the upper left corner of the display screen. This screen is where you type in calculations and commands. You can return here anytime by pressing the key below [Y=], the one with [+], [−], [×] and [÷] on it — let's call it the *calculation-screen key*. Other screens are the graphics screen, the table screen, the function-entry screen and the program-editing screen.

Notice that most of the keys have yellow words or symbols above them. To access these yellow functions press the yellow [2ndF] key, then press the desired key for your yellow operation. Do not hold the [2ndF] key down; it does not act like a shift key. Once you press [2ndF], the cursor changes to 2. To undo this (e.g. if you change your mind), just press [2ndF] again.

To access the blue letters and characters, you first press the blue [ALPHA] key. Now the cursor switches to A. For caps lock, press [2ndF] [ALPHA].

For example, to type the word MATHS, instead of typing [ALPHA] [M] [ALPHA] [A] [ALPHA] [T] . . . , type in [2ndF] [ALPHA] [M] [A] [T] . . . . Another press of the [ALPHA] key returns the cursor to normal.

To clear your screen, press the [CL] key. [DEL] deletes the character the cursor is on. [BS] (BackSpace) deletes the character to the left of the cursor. [INS] ([2ndF] [DEL]) allows you to insert characters at the cursor. Press [2ndF] [DEL] again to turn it off.

From now on, we will not necessarily mention [2ndF] or [ALPHA]. We will assume that you know to use one of these keys if the key we refer to appears in yellow or blue above some other key.

2.3 Syntax

Calculations are performed by constructing an expression in conventional algebraic syntax (including implied multiplication) and then pressing [ENTER] (which acts as the [=] key). Brackets are used where necessary.

Some examples of acceptable syntax are given below, each of which is different from the equivalent on most scientific calculators (but is similar to the way the expressions are conventionally written). Try each of these on your calculator, observing both the screen display and the final result. It is not necessary to press [CL] before each new calculation. Don't forget the [ENTER]. Final brackets must be entered.

[2] [(] [5] [x^2] [−] [1] [)] [ENTER]	for $2(5^2-1)=48$ note the implied multiplication
[4] [x^{-1}] [ENTER]	for $4^{-1}=.25$ or [4] [a^b] [(−)] [1] — see box below
[5] [SIN] [3] [π] [ENTER]	for $5\sin 3\pi=0$ implied multiplication again
[5] [SIN] [(] [3] [+] [π] [)] [ENTER]	for $5\sin(3+\pi)=-.7056000403$ brackets necessary here and recommended above too
[3] [a^b] [5] [ENTER]	for $3^5=243$
[(−)] [2] [−] [(−)] [3] [ENTER]	for $(-2)-(-3)=1$ note [(−)] and [−] — see below
[$\sqrt{}$] [3] [ENTER]	for $\sqrt{3}=1.732050808$ [$\sqrt{}$] is [2ndF] [a/b]
[e^x] [2] [ENTER]	for $e^2=7.389056099$ [e^x] is [2ndF] [LN]
-1^2 and $(-1)^2$	Which one gives the correct answer? (Manual page 19)

> The EL-9650 makes a distinction between *negative* and *minus*. When you enter 'negative 2', use the negative key [(−)] beside [ENTER], not the minus key [−] above [ENTER].

If you type in something with incorrect syntax, the calculator will probably pick it up when you press [ENTER]. It will then offer you the option of going to the error (press either the left- or right-arrow key) or quitting. The *Go to Error* option is very useful as it shows you exactly where the calculator thinks you made a mistake. Correct the mistake and press [ENTER].

2.4 Successive commands

You can construct lengthy commands on the screen if you want before pressing [ENTER], but you can also do chain calculations. The result of the most recent calculation is stored in *Ans*. This is used in chain calculations, and can be recalled using [2ndF] [ENTER]. As an example, try the following key sequence. Watch where *Ans* is automatically recalled.

[1] [3] [+] [1] [4] [+] [1] [5] [ENTER]

[÷] [7] [ENTER]

[x^2] [ENTER]

[x^{-1}] [ENTER]

[$\sqrt{\ }$] [Ans] [ENTER] you have to key in *Ans* ([2ndF] [ENTER]) here

What is the affect of the following?

[1] [ENTER]

[×] [2] [ENTER] [ENTER] [ENTER] ......

Pressing [ENTER] repeats the previous entry.

2.5 Storing and using numbers in variables (memories)

Memories are named alphabetically, as if variables are being given values. To store a specific value in a variable (or memory), first type the value onto your screen, then press [STO], type a variable name ([ALPHA] followed by a single letter) and press [ENTER]. The value stored in the variable will not change unless you store something else in that variable name.

Let's store 3 in variable/memory P and 4 in variable/memory Q:

[3] [STO] [ALPHA] [P] [ENTER].

[4] [STO] [ALPHA] [Q] [ENTER].

Now try the following (don't forget the [ALPHA] key before each letter):

[P] [ENTER]

[2] [P] [ENTER]

[P] [Q] [ENTER]

[3] [P] [x^2] [Q] [ENTER]

[$\sqrt{\ }$] [(] [P] [x^2] [+] [Q] [x^2] [)] [ENTER]

2.6 Recycling expressions

Next, let's try evaluating $\sqrt{P^2 + 3Q^2}$. Instead of typing it all over again, press [ENTRY] ([2ndF] [(−)]). $\sqrt{}(P^2 + Q^2)$ should reappear on the screen. Use the arrow keys and the insert key [INS] (on the [DEL] key) to change the expression and press [ENTER]. Thre's no need to move the cursor to the end of the line before pressing [ENTER].

[ENTRY] returns to the screen whatever was entered last; this expression may be edited before re-evaluating it. If you press [ENTRY] again, you will go back to the expression before last, and so on. [ENTRY] is a powerful time-saver, especially for complicated expressions that you want to use again, with or without editing. Furthermore, the calculator keeps only *one* previous answer, but will remember as many previous entries as it can, up to 160 characters.

2.7 Using menus

The EL-9650 is menu-driven, which explains why the keyboard is relatively uncluttered. For example, many functions are located in the MATH menu. To access this, press [MATH] and you will see eight sub-menus displayed.

Select one of these by pressing the appropriate letter key ([ALPHA] not required) or by scrolling down with the cursor. In the examples below, the letter key is given in the key-stroke sequences. The number following the letter selects an item from the menu displayed on the right-hand side of the screen.

To select an item in a sub-menu, press the item number or first press the right-arrow key (or [ENTER]) to move to the item list, then the down-arrow key to highlight the item and [ENTER] to select it. Generally you construct an expression just as you would on paper. To leave a menu without selecting a function, press the calculation-screen key.

Try the following examples.

[MATH] [B] [1] [2] [−] [9] [)] [ENTER]	for $\|2 - 9\| = 7$: absolute-value function
[MATH] [B] [3] [2] [.] [1] [ENTER]	for $[2.1] = 2$, integer-part function
[1] [5] [MATH] [C] [3] [4] [ENTER]	for ${}^{15}C_4 = 1365$
[MATH] [C] [1] [ENTER] [ENTER]	successive random numbers on $(0, 1)$
[1] [2] [MATH] [C] [4] [ENTER]	for $12! = 479001600$

Note that some of the numbers in the above key-stroke sequences select a menu item, while others actually give you the number on the screen.

2.8 Defining and evaluating functions

The top row of keys are for defining and graphing functions, and generating tables of function values.

Defining a function is a simple task. Press [Y=]. This brings up the function-entry screen with eight 'empty functions', Y1 to Y8.[3]

To enter the function $f(x) = x^2$ in Y1, press [X/θ/T/n] [x^2]. The [X/θ/T/n] key provides the appropriate independent variable (X in this case) and the [x^2] key squares whatever precedes it. Note that when you define a function, the equals sign after its name is highlighted. This means the function is 'selected' for tables and for graphing. We will take up graphing soon.

Next enter $g(x) = x^3$ in Y2: in the function-entry screen, press [ENTER] or [▽] to move to the next line. Then press [X/θ/T/n] [a^b] [3]. Press the calculation-screen key.

Now that we have defined some functions, we need to know how to use them. For example, how do we find $g(3)$? g is known to the calculator as Y2, so we have to use that name.

Press [VARS] and press [ENTER]. That brings up a menu of possible function names: press [2] to get Y2 on the calculation screen. (You can't just type [Y] [2].)

To evaluate Y2 (3), just finish the expression with [(] [3] [)] and then [ENTER]. The calculator should display 27.

Now calculate $g(4)$. You can either repeat the steps we just did — or you can think about an easier way to do this (Section 2.6).

2.9 Using a table

A quicker way to find a number of function values is to use the table feature. Press [Y=] to check that you still have both Y1 and Y2 selected.

Then press [TBLSET] (on the [TABLE] key) to get the *Table-setting* screen. Set *TBLStrt* (the starting value of X) to 0 and *TBLStep* (the step size between values of X) to 1. *Auto* should also be selected (use the cursor and [ENTER] if not).

Now press [TABLE] and see what happens.

Try scrolling the cursor up and down and watch the changes in the Y1 and Y2 columns. In particular, go beyond X = 6 in the downward direction and beyond X = 0 in the upward direction. Move the cursor into the Y columns, and watch what happens at the bottom of the screen. Only three Y columns fit on the screen at once, but if we had more functions defined and selected, they would all get tabulated, and we could find their values by scrolling to the right.

Finally, we can change the spacing of X values in the tables by changing *TBLSet* in *Table setting*. Try it! If you want to enter your own X values, select *User* in [TBLSET].

[3]There are actually two more, Y9 and Y0 (scroll down), but only eight fit on the screen.

2.10 Graphing functions

To graph the formula-defined functions that are selected in the Y= screen, just press the GRAPH key. The default window for graphing (selected when we reset the calculator) is from −10 (*Xmin*, *Ymin*) to 10 (*Xmax*, *Ymax*) in both the horizontal and vertical directions. You can change that by pressing the WINDOW key. Make the window go from −4 to 4 in the X direction and from −20 to 20 in the Y direction, pressing ENTER after each entry. Press GRAPH again to see the same functions graphed in the new window.

You may find that your Y axis now looks a little funny. Go back to the WINDOW screen. The entries for Xscl (X scale) and Yscl are the distances between tick marks on the axes. With both set at 1, these marks appear at every integer value in both directions. As the Y range extends 40 units, that's a lot of tick marks. Change Yscl to 5, press ENTER and graph again. Better?

Move the cursor around the screen with the arrow keys. The cursor coordinates are shown at the bottom of the screen.

> You can have as many as 10 functions defined at one time, but you may not want to graph them all at once. Turn off ('deselect') any or all of them in the Y= screen by moving the cursor over the = sign and pressing ENTER. Turn them back on the same way.

2.11 Tracing and zooming

Let's try some other keys. First press FORMAT (2ndF ZOOM), select EXPRES and press 1 to turn the expression on. Press GRAPH to return to the graph.

Press TRACE. A (small) flashing cursor should appear on the first graph half way between the left side and the right side of the screen (it happens that this point is on both graphs in this case) and the coordinates of this point should appear at the bottom of the screen. Use the right and left arrows to move along the graph of Y1. Notice the formula for Y1 in the upper left corner (the 'expression' we turned on above). Press the up and down arrows.

Now try ZOOM 5 for *Default*. This is an easy way to recover the standard window with Xmin = −10, Xmax = 10, Ymin = −10, and Ymax = 10. Since we started in the standard window in Section 2.10, the graphs are redrawn as we first saw them.

Next try ZOOM 3 to *Zoom In*. The EL-9650 now zooms in (magnifies), centred on the spot where you left the cursor. Press WINDOW to see the effect of *Zoom In*.

Press ZOOM to go back to the Zoom menu. Try *Box*; again a small cursor appears on your screen. Move it a bit up and a bit left and press ENTER. Move the cursor down and to the right; the screen displays an outlined box with a fixed mark at one corner and the cursor at the opposite corner. Move the cursor to enclose some interesting part of the graphs, and press ENTER again. The graphs are redrawn with your box taking up the whole screen.

There are several more types of zooms in the ZOOM sub-menu; read the manual to see what these do.

2.12 Finishing up

If you don't press any keys for a few minutes, the calculator turns itself off. However, you can also turn it off with (surprise!) [2ndF] [ON]. All settings, function definitions, variable values, etc are remembered when the calculator is off. If you turned it off yourself, the next time you turn it on, you will see the calculation screen. If it turns itself off, the next time you turn it on, you will see the screen you were on when it turned off.

3 The SET UP and FORMAT menus

SET UP

Press [SET UP]. Your screen fills six different menus, each with sub-menus. With the cursor at the top (position A), you can see which option has been set from each menu.

B: DRG

In this menu, you can choose between **Radian**, **Degree** and **Grad** angle measurement. Be careful! *The wrong setting here is the most common cause of error in graphing and analysing trig functions.*

C: FSE

This determines how the calculator displays numbers. **FloatPt** means no fixed number (the calculator chooses appropriately). **Fix** means a fixed number of decimal places set in the next menu TAB. **Sci** displays numbers with an exponent, for example 1230 in normal notation is 1.23×10^3 in scientific notation, and is displayed as 1.23E3 on the calculator (assuming 2 decimal places are set), E standing for exponent. **Eng**, engineering notation, is scientific notation in which the exponent is a multiple of 3.

D: TAB

This menu sets the number of decimal places displayed.

E: COORD

This menu sets the types of graph to be plotted. We were using **Rect** for Cartesian graphs, $y = f(x)$, and this is the graph mode we will use most of the time. The other modes are parametric, polar and sequence.

F: ANSWER

This menu determines how numerical answers are displayed. **Decimal** displays all numbers as decimals. **Mixed** displays answers as proper fractions, provided all fractions are input using the fraction key [a/b]. **Improp** is the same, but displays answers as improper fractions.

The last two display complex numbers and enable calculations using complex numbers to be carried out.

G: EDITOR

We've met this previously. **Equation** allows the input and display of mathematical expressions in a form more closely corresponding to the way they are written by hand. This has advantages (looks better) and disadvantages (harder to type in).

FORMAT

Select FORMAT (on the ZOOM key). The Format screen works just like SET UP.

B: CURSOR

In TRACE, the cursor coordinates can be displayed in rectangular or polar coordinates.

C: EXPRESSION

This allows you to turn on/off the equation of the function in the top left corner of the graphics screen when you are in TRACE. This should be ON. Sometimes the expression obscures part of the graph and it is useful to be able to turn it off. After RESET, for some reason it is set to OFF. If you are going to use TRACE, you should turn it back on.

D: Y′

With Y′ ON, the (approximate) value of the derivative at a point on a graph is displayed in TRACE.

E: STYLE1

This controls whether the plotted 'dots' in a graph are connected by lines or not. Change the mode to **Dot** and graph the functions of Section 2.10 using ZOOM Default. Change back to **Connected**, the default.

F: STYLE2

Sequen means that the functions to be graphed are graphed sequentially, whereas **Simul** means they are graphed simultaneously.

4 Further Resources

Contact for more help

We at University College ADFA are happy to help any school (free of charge) with

- backup and assistance in using graphics calculators
- PD sessions at your school on general or specific applications of graphics calculators
- resource materials, programs for any activity and development of materials, in association with teachers.

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At ADFA

At *www.unsw.adfa.edu.au/pems/news/high_school/hsc_activities.html*

- A variety of graphics-calculator activities for Years 9 and 10 — written as part of the CQTP Program for Sharp, Casio and TI calculators.
- *The Graphics Screen and Accuracy* — information to help you understand the graphical and numerical limitations of a graphics calculator.
- *Coordinate Geometry on an EL-9650/9900* — basic commands and a variety of problems, suitable for Years 9 and 10.
- *Population Modelling* — a variety of problems from simple exponential growth to Leslie matrices and difference equations, covering Years 7–12.
- *Sequences and Series on an EL-9650/9900* — basic commands and a variety of problems, suitable for Years 10–12.
- *Matrices on an EL-9650/9900* — suitable for Years 11 and 12.
- *Calculus on an EL-9650/9900* — suitable for Years 11 and 12.
- *Complex Numbers on an EL-9650/9900* — suitable for Years 11 and 12.
- *Programming an EL-9650/9900* — suitable for teachers and keen students.
- *Introduction to Complex Numbers* — complex numbers from the beginning, covering the basic operations, but set in the context of complex numbers as a mathematical structure.

Other useful websites

www.prenhall.com/divisions/esm/app/calculator, a terrific site for finding out how to do specific operations on a graphics calculator (all brands).

sharp-world.com/products/calculator/education/index.html, the Sharp education site. Some useful materials here.

www.aamt.edu.au, the AAMT home page is a good starting point for web links, in particular the links to other Maths sites under *3 Resources / Members' Sites / Mathematical Software and Technology.*

smard.cqu.edu.au — a collection of resources from the QAMT, including some graphics calculator activities.

wwwstaff.murdoch.edu.au/∼kissane, Barry Kissane's home page, is another web site of general interest. This page contains some interesting discussion papers under Publications and lots of other useful stuff, including resources.

Acknowledgements

This material has drawn on a variety of sources: from the Graphing Calculator Lab Manual to accompany *Calculus: Modeling and Application* by Lewis Blake, David Smith Samuel Morris and Lawrence Moore, Heath Publications, 1996; from *Calculating on the TI-82* by Barry Kissane at *wwwstaff.murdoch.edu.au/∼kissane* under Publications; from *Using the TI-83* by M.J. Clark at *www.eddept.wa.edu.au/graphcalc/sup*; and from *Integrating the Graphic Calculator into Year 9 and 10 NSW Mathematics Syllabus*, T^3 Australasia, 1998.

Last revised: 16 November 2005.