

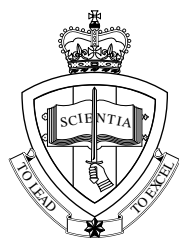
Coordinate Geometry on a CFX-9850GB

Peter McIntyre

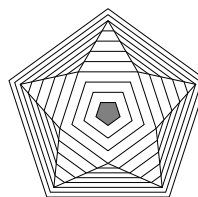
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At www.unsw.adfa.edu.au/pems/news/high_school/hsc_activities.html

- A variety of graphics-calculator activities for Years 9 and 10 — written as part of the CQTP Program for Sharp, Casio and TI calculators.
- *Using the CFX-9850GB* — an introduction to the basic operations, suitable for Years 8–12.
- *The Graphics Screen and Accuracy* — information to help you understand the graphical and numerical limitations of a graphics calculator.
- *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 CFX-9850GB* — basic commands and a variety of problems, suitable for Years 10–12.
- *Matrices on an CFX-9850GB* — suitable for Years 11 and 12.
- *Calculus on an CFX-9850GB* — suitable for Years 11 and 12.
- *Complex Numbers on a CFX-9850* — suitable for Year 12.
- *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.

The programs used in these notes can be found at the above web site. You will need a PC-Link Kit FA-123 to copy the program from your computer to your calculator.

1 Basic Operations

Before starting, press **MENU** **1** to go to the RUN screen, then **SET UP** (**SHIFT** **MENU**). Set your calculator as shown and press **EXIT**.

```

Mode          :Comp
Func Type    :Y=
Draw Type    :Connect
Derivative   :Off
Angle        :Rad
Coord        :On
Grid         :Off
[Comp] [Dec] [Hex] [Bin] [Oct]
  
```

```

Angle        :Rad
Coord        :On
Grid         :Off
Axes         :On
Label        :Off
Display      :Norm2
[Integration] :Gauss
[Gaus] [Simf]
  
```

1.1 Graph $f(x) = x^2 + x - 2$ for $-3 < x < 3$

Press **MENU** **5**: set $Y1 = X^2 + X - 2$.

The key **X, θ ,T** gives X.

Note the highlighted = sign — this function will be plotted when you press **GRAPH**.

Use **F1** (SEL) to toggle the function off/on.

```

Graph Func   :Y=
Y1[X^2+X-2]
Y2:
Y3:
Y4:
Y5:
Y6:
[SEL] [DEL] [TYPE] [COLR] [MEM] [DRAW]
  
```

Press **SHIFT** **F3** (WINDOW): set the viewing window as shown in the figure.

Press **EXE** after each value, *including the last*.

Note the difference between the **-** key (*subtract*) and the **(-)** key (*change sign*).

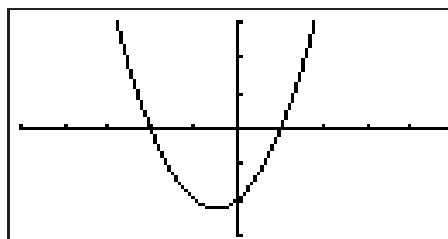
$Xscale$, $Yscale$ are the distances between tick marks on the axes (0 gives no tick marks).

Press **EXIT** to return to the Graph Func screen.

```

View Window
Xmin  :-5
max   :5
scale:1
Ymin  :-3
max   :3
scale:1
[INIT] [TRIG] [STD] [STD] [RCL]
  
```

Press **F6** (DRAW) to graph the function.



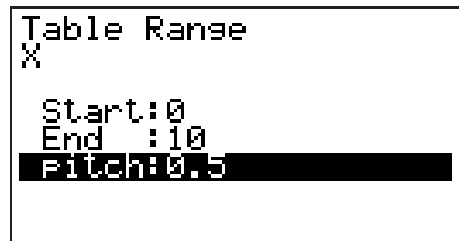
1.2 Generating a table of function values

- Press **MENU** **7**. Make sure the = signs of the functions you want are highlighted.

- Set the table range using **F5** (RANG):
Start = 0 End = 10 Pitch = 0.5.

This generates values automatically, starting at $X = 0$, incrementing in steps of 0.5, up to $X = 10$.

- Press **EXIT** and then **F6** (TABL). The highlighted number is also displayed at the bottom of the screen. Use the arrows to move around the table.



X	Y1
0	-2
0.5	-1.25
1	0
1.5	1.75

FORM DEL ROW F-COM G-PLT

1.3 Find (estimate) $f(0.5)$

- **From a table** — see above.
- **On the graph**
 - Press **F5** (G-Solv) **F6** **F1** (Y-CAL).
 - Type in the X value, **0** **.** **5** **EXE**, to move to the desired point on the graph. Note the coordinates at the bottom of the screen.
 - Alternatively, press **F1** (Trace) and use the left and right arrows to move the cursor along the curve (but note the problem that arises when trying to reach $X = 0.5$). The up and down arrows move between functions if there is more than one graphed.
- **On the RUN screen**
 - Press **MENU** **1** to go to the RUN screen.
 - The calculator knows f by the name Y1. We need to evaluate Y1 at $X = 0.5$.
First store the value in X: $0.5 \rightarrow X$.
Y is **VAR** **F4** **F1**. You can't just type **Y**. Then press **1** **EXE** to evaluate Y1.
- *Answer:* $f(0.5) = -1.25$.

1.4 Find the zeros of $f(x) = x^2 + x - 2$

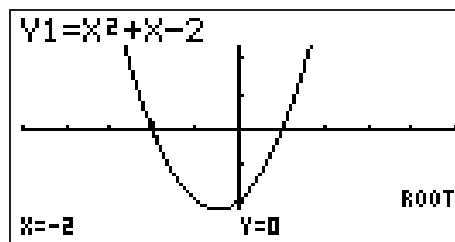
The graphical method in this and all the following operations is usually more meaningful than the corresponding non-graphical numerical operation, which is really just a 'black box'. Numerical operations are in the Appendix.

- Graph the function with **MENU** **5** **F6**.
- For a rough estimate, press **F1** (Trace) and move the cursor as close as possible to the zero. Watch the Y coordinate at the bottom of the screen to see when it changes sign.

Zooming in on the zero — move the cursor to near the zero and press **F2** (ZOOM) **F3** (IN) — will produce greater accuracy with this method.

- For a more accurate estimate, use **F1** (ROOT) in the **G-Solv** menu (**F5**). Press the right arrow to find further zeroes (it works left to right).

If you have more than one curve plotted, the calculator will ask you to select the one you want with the up/down arrows.



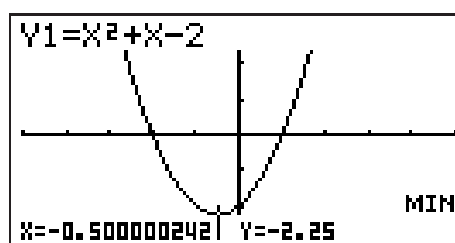
- Answer: $f(x) = 0$ when $x = -2, 1$.

1.5 Find the minimum of $f(x) = x^2 + x - 2$

- For a rough estimate, press **F1** (Trace) and move the cursor as close as possible to the minimum. Watch the Y coordinate at the bottom of the screen.

Zooming in on the minimum — move the cursor to near the minimum and press **F2** (ZOOM) **F3** (IN) — will produce greater accuracy with this method.

- For a more accurate estimate, use **F3** (MIN) in the **G-Solv** menu. *MIN* works the same way as *ROOT* above.
- Finding maxima using the *MAX* command works in exactly the same way.



- *Answer:* the minimum value of $y = -2.25$ occurs at $x = -0.50000$, rounded to 5 decimal places.

1.6 Solve $x^2 + x - 2 = \sqrt{x}$

The solution to the equation is the intersection point of the two curves.

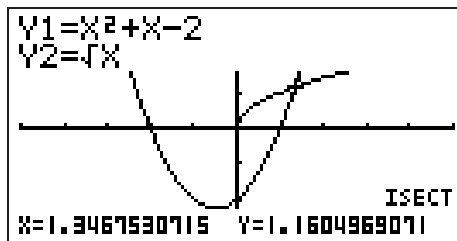
- Graph $Y1 = X^2 + X - 2$ and $Y2 = \sqrt{X}$ using a WINDOW such that the point of intersection of the two curves lies on the screen.
- For a rough estimate of the point of intersection, press **F1** (Trace) and move the cursor as close as possible to the intersection. Read the cursor coordinates at the bottom of the screen.

Zooming in on the intersection — move the cursor to near the intersection and press **F2** (ZOOM) **F3** (IN) — will produce greater accuracy with this method.

- For a more accurate estimate, use **F5** (ISCT) in the **G-Solv** menu.

If there is more than one point of intersection of the two graphs, press the right arrow to find the next one.

If there are more than two graphs plotted, the calculator will ask you to select which two you want to find the intersection of.



- *Answer:* $x^2 + x - 2 = \sqrt{x}$ when $x \approx 1.347$, $y \approx 1.160$. Answers rounded to 3 decimal places.

1.7 Graphing data points and points joined by lines

There are three possible ways to do this.

Series of points

First you need to put the x values of the points in one list, the y values in another. The standard lists on the CFX-9850 are List1 – List6, accessed through the STAT or LIST options in the main menu.

The easiest way to enter the data is to press **MENU** **2** (STAT).

To clear a list, move the cursor to the list and press **F6** **F4**; respond to the prompt with **F1**.

Enter the x values into List1, pressing **EXE** after each value, *including the last*.

Similarly, put the y values into List2.

	List 1	List 2	List 3	List 4
1	1	2		
2	2	5		
3	3	0.5		
4				
5				

1

GRAPH CALC TEST DMTB DOST

Now you need to tell the calculator what type of plot we want, where the data are and the type of marker for each point.

Press **F1** (GRPH). (If you deleted values from a list, you will need to press **F6** to see the GRPH menu.) Up to three plots can be displayed.

Press **F6** to select SET, and select **F1** (GPH1) if necessary.

Select the StatGraph options as shown in the figure.

StatGraph1	
Graph Type	: Scatter
XList	: List1
YList	: List2
Frequency	: 1
Mark Type	: ◻
Graph Color	: Blue
GPH1 GPH2 GPH3	

Press **EXIT** to return to the list editor.

Press **F4** (SEL) and turn on *StatGraph1* by pressing **F1**. Make sure the other two StatGraphs are turned off.

Press **EXIT** to return to the list editor.

StatGraph1	
StatGraph1	: DrawOn
StatGraph2	: DrawOff
StatGraph3	: DrawOff
On Off DRAW	

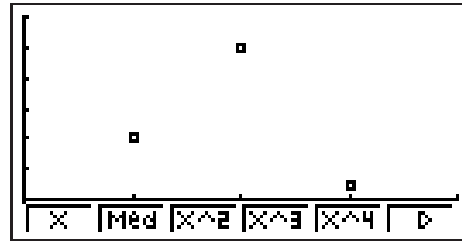
Next the View Window. Press **SHIFT** **F3** (V-Window) and enter the values shown in the figure, pressing **EXE** after each value, including the last.

View Window	
Xmin	: 0
max	: 4
scale	: 1
Ymin	: -1
max	: 6
scale	: 1
INIT TRIG STD STO RCL	

Press **EXIT** to return to the list editor.

Press **F1** (GRPH), then **F1** (GPH1) to graph the data.

Use **Trace** and the arrow keys to move around the plot.



Line segment

Use the *F-Line* command: **Sketch** (**SHIFT** **F5**) **F6** **F2** **F2**.

From the Run screen: F-Line X1, Y1, X2, Y2.

Example: F-Line 3, 4, 5, 2 draws the line (segment) between (3, 4) and (5, 2).

On a graph (**MENU** **5**): select *F-Line*, move the cursor to one end of the line segment you want and press **EXE**. Move the cursor to the other end of the line and press **EXE** again.

Point

Use the *Pl-On* command: **Sketch** (**SHIFT** **F5**) **F6** **F1** **F2**.

From the home screen: Pl-On (X, Y).

Example: Pl-On (3, 4) plots the point (3, 4).

On a graph: select *Pl-On*, move the cursor to the point you want plotted and press **EXE**. Plot as many points as you like this way.

1.8 Shading regions

There are several possible ways of distinguishing between graphs using different colours or shading under/over graphs. These are selected from the GRAPH menu (**MENU** **5**).

- **Colour** (**F4**): red, orange, green.
- **Type** (**F3** **F6**): shaded above (**F1** and **F3**); shaded below (**F2** and **F4**) — select the type before entering the function.

1.9 Appendix: Non-graphical numerical operations

Finding zeros: Use the interactive *Solver*, **F3** in the EQUA menu (**MENU** **A**). See the manual for details.

Finding minima: $FMin(Y1, -3, 3)$: *FMin* is **OPTION** **F4** (CALC) **F6** **F1**. The last two inputs are the bounds.

Y1 can be replaced by a function defined explicitly in terms of X.

Finding maxima using the *FMax* command works in exactly the same way.

Solving equations: Use the interactive *Solver*, **F3** in the EQUA menu (**MENU** **A**). See the manual for details.

2 Activities

2.1 Linear Models

Renting a car

The Rent-a-Wreck Car Rental Company has the cheapest car rentals in town.

You can choose one of two options.

- **Option A** — no flat fee, but a charge of 28c per kilometre.
- **Option B** — a flat rate of \$36 per day, plus 18c per kilometre.

(a) We want to hire a car for one day.

Under Option A, how much will it cost in dollars to drive 1 kilometre? 2 kilometres? 10 kilometres? 100 kilometres? x kilometres?

For Option A, what is the equation for the cost in dollars y in terms of the number of kilometres driven x ? Check your equation with the numbers you calculated above.

Under Option B, how much will it cost in dollars to drive 1 kilometre? 2 kilometres? 10 kilometres? 100 kilometres? x kilometres?

For Option B, what is the equation for the cost in dollars y in terms of the number of kilometres driven x ? Check your equation with the numbers you calculated above.

(b) Graph the equations for the two options, assuming we will drive up to 600 kilometres in a day.

(c) Estimate from the graph how far we have to drive before Option B becomes cheaper.

(d) From the graph, what is the slope of the line for Option A?

Hint: Press **Trace** and use the left/right arrows to find two points on the graph; use these work out the slope.

What is the slope of the line for Option B?

What does the slope represent in this problem?

(e) What is the y intercept of the graph of Option A?

Hint: Press **G-Solv** **F4**.

What is the y intercept of the graph of Option B?

What does the y intercept represent in this problem?

(f) Work out *exactly* how far we have to drive before Option B becomes cheaper.

Marketing a computer game

You have just written a cool computer game and your company wants to sell it. *How much should it charge?*

If it puts on a high price, the company won't sell as many games, but it will make more money per game sold. If the game is sold for a low price, the company won't make as much money on each game sold, but it will sell more games.

Clearly, the number sold depends on the price. Economists often assume that the number sold and price form a *linear equation*.

After doing some market research, the company thinks that if it sells the game for \$160 per copy, it will sell about 800 copies. If the price is dropped to \$40 per copy, it should sell about 8000 copies.

- (a) Let's use a graph of number sold versus price to help us in our problem. Price will be on the x axis and number sold on the y axis. What are suitable scales for the two axes?
- (b) What are the two points that we know on the graph of number sold versus price? Use the Line command (Section 1.7) to draw a straight line between these two points. The syntax is (from the home screen) `Line(x_1, y_1, x_2, y_2)`, where (x_1, y_1) and (x_2, y_2) are the two points.
- (c) What is the slope of the line? *Hint:* Use two points on the graph to work out the slope.
- (d) What is the equation of the line? What extra information about the line do we use here? Graph the line and check that the points you know actually lie on the graph of the line.
- (e) Does this graph tell us the answer to the question of what the price should be?
- (f) Revenue means total income. It is the product of price and number sold. Write down the equation for revenue as a function of price x . What kind of function is this?
- (g) Plot the graph of revenue versus price. Estimate the revenue if the price is \$50.
- (h) What is the best price to sell the game at? Why is it best? What is the revenue?
- (i) What is the revenue if the game is sold at a price of \$180? Explain.

Acknowledgement to material from an unknown website.

Linear Models Assignment

Brock has \$_____ in the bank, has no income, but is spending about \$_____ a week on his new girl friend Amber.

His sister Minerva has only \$_____ in the bank, but is spending nothing and saving about \$_____ a week.

- (a) Find the equation of the line that gives how much money each person has in the bank as a function of time in weeks.
- (b) What is the slope of each line?
- (c) What is the physical interpretation of the slope?
- (d) What is the y intercept of each line?
- (e) What is the physical interpretation of the y intercept?
- (f) When will Minerva and Brock have the same amount of money?
- (g) When will Minerva have twice as much money as Brock?

The following Coordinate Geometry activities are available separately at www.ma.adfa.edu.au under *High School and College Activities*. Solutions and teacher's notes are also provided.

2.2 Coordinate Geometry Art

A simple picture consisting of straight-line segments is 'coded' using the coordinates of the points of its vertices. These are used 'transmit' the picture to someone else. A graphics calculator is used to 'decode' and check the 'transmitted' picture.

Year 9, Levels 1 and 2; Algebra; Coordinate Geometry.

2.3 A Classic Problem — The Hare and Tortoise

The graphs of the distances covered versus time in this classic race are used to answer various questions about the race, such as who won and by how much. A fun exercise in putting questions into maths and solving equations graphically.

Year 10, Level 1; Algebra; Sketching Other Graphs, Simultaneous Equations.

2.4 The Best Shape for a Can

Minimising the surface area of a cylinder (can) for a fixed volume. Numerical and graphical techniques, rather than Calculus, are used to find the minimum. Aspects of mathematical modelling are introduced.

Year 10, Level 1; Algebra/Measurement; Sketching Other Graphs/Volume.

2.5 Parabolic Aerobics

The first activity investigates the effect of changing the numbers A, B and C on the graphs of the family of parabolas $Y=A(X-B)^2+C$. In the second activity, you have to guess the numbers A, B and C for the graph of a mystery parabola generated by the PARABOLA program. The calculator checks your answers and keeps score.

Year 9, Levels 1 and 2; Algebra; Coordinate Geometry.

2.6 Alien Attack

Uses one of Newton's equations of motion to explore properties of quadratic equations both numerically and graphically.

Years 9 and 10, Levels 1 and 2; Algebra; Coordinate Geometry.