## Parametric equations: Graphs and gradients



This resource sheet is designed for use with the Casio fx-CG20. However it can be used with the Casio fx-9860GII or the Casio fx-9750GII although there may be some differences in the key sequences needed and in the screen displays.	
Aim This activity will show you how to graph parametric equations on the calculator. It will also explore how you can display coordinates and derivatives at any point on a graph. There are also some activities for students to explore how these functions can be used to investigate some of the properties of trigonometric functions.	
Set your calculator to GRAPH mode. Press MENU 5	MAIN MENU MIN-Matrix Statistics eActivity Spreadsheet Graph Dyna Graph Table Recursion Statistics B Constraints
Set the calculator to input/output to 'Math' and 'Angle' to Radians by going to SET UP SHIFT WENU. Highlight 'input/output and press F1 to select 'Math. You will need to scroll down to 'Angle' and press F2 to select Radians. Press EXIT to get back to the function table screen	ConicGraphs       Equation       Program       Filtencial         Input/Output:Math         Draw       Type       : Connect         Ineq       Type       : Union         Graph       Func       : On         Dual       Screen       : Off         Derivative       : On       .         Math       Line         Imath       : Off         Derivative       : Off         Background       : None         Plot/LineCol:       : Green         Sketch       Line         Angle       : Rad         Complex       Mode:Real         Imath       Imath
Delete any existing functions using <b>F2</b> and following the on- screen instructions Select TYPE <b>F3</b> and select the parametric option, Param <b>F3</b> Enter the function $Xt1 = 2T - 4$ $Yt1 = 8 - T^2$ Use the $X,\theta,T$ button to get the variable T. Press <b>EXE</b> to finish.	Real [a+b] [r20         Graph Func       Param         Xt1:       []         Yt1:       [-]         Yt2:       [-]         Yt3:       [-]         SELECT [DELETE] TYPE] TOOL [MODIFY[DRAW]
	Image: Selection of the se

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Set the viewing window to standard SHIFT F3 F3 but then scroll down until you see the T, $\theta$ settings and set them as follows: T $\theta$ min = -3.5 T $\theta$ max = 3.5 pitch = 0.1 press EXE to finish	View Window Ymin :-10 max :10 scale:1 T0min :-3.5 max :3.5 ptch:0.1 INITIAL TRIG STANDED V-MEM SQUARE
Select Draw <b>F6</b> to display the graph	HathRadMern] Real 9 -9 -9 -9 -9 -9
Go to SET UP SHIFT MENU and set DERIVATIVE to 'On'. Get back to original screen by pressing EXIT Go back to the graph screen F6. Go to Trace SHIFT F1	<pre> Input/Output:Math Draw Type :Connect Ineq Type :Union Graph Func :On Dual Screen :Off Simul Graph :Off Derivative :On ↓ Math Line</pre>
You can now see the values of T, dx/dt, dy/dt, and dy/dx.	
As you move the cursor, explore the relationship between dy/dt, dt/dx, and dy/dx. What do you notice?	EXE]:Show coordinates f1=2T-4,8-T2 9 y 
	EXE):Show coordinates f1=2T-4,8-T2 -9 0 4X/dT=2 T=3.5 -9 dY -9 0 -9 0 -9 0 -9 0 -9 0 -9 0 -9 0 -9 0 -9 0 -9 0 -9 0 -9 0 -9 0 -9 0 -9 -9 0 -9 -9 -9 -9 -9 -9 -9 -9 -9 -9

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You should now feel fairly confident graphing parametric equations on the calculator. Here are some investigations that will encourage your students to explore some of the features of parametric functions using the graphics calculator. Some investigations: Investigation 1 Investigate the curve with parametric equations: X = 8cosTY = 5sinTUse the standard viewing window with the following settings changed: Tmin = 0Tmax = 360Pitch = 3.6You will need to scroll down in the viewing window and you might also need to check that the calculator is set to degrees in SET UP (SHIFT) (MENU) Why does the calculator show an error for dy/dx when T = 0 and when T = 180?As you move the cursor around the curve notice what happens to dx/dt, dy/dt, and dy/dx. **Investigation 2** Turn off the derivative function by going to SET UP [SHIFT] [MENU] and set DERIVATIVE to 'Off'. Leaving the equations from Investigation 1 in the calculator, enter the following parametric equations in Xt2 and Yt2 X = 7 cosTY = 7 sinTPlot both graphs on the same screen and using the Trace function, (and the Zoom if needed) find the x and y values for the points where they intersect. What do you notice about the values of T for each curve at the points of intersection?