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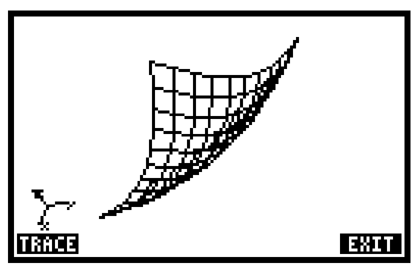
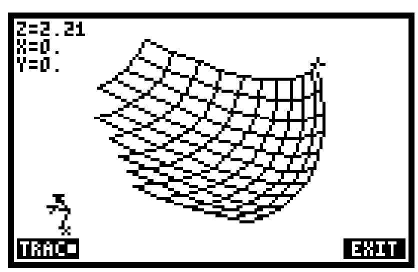
Calculator Lesson 29

3 Dimensional Graphics

In this lesson we will learn how to use some of the tools in the HP 50g for visualizing surfaces given by functions of the form $z = f(x, y)$. There are four such tools, Fast 3D, Wireframe, Pseudo-Contour, and Y-Slice. We will discuss only the first two.

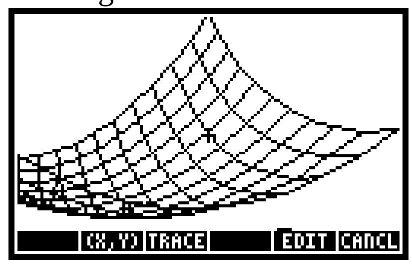
The most commonly used is definitely Fast 3D. It creates a wireframe image of the surface that can then be rotated in space to give a view from any desired angle. To use it press LS(hold) 2D/3D. Press F2-CHOOS and use DA to scroll down to Fast3D, then press F6-OK. In EQ: enter the function. For this example we will use the function $f(x, y) = (x-1)^2 + (x-.3)*(y-.7)+(y-1)^2$. It can be defined as a function (See Lesson 28) and 'F(X, Y)' is entered in EQ:, or the right side can be entered directly as an algebraic expression. If variables other that X and Y have been used, change Indep: and Depnd: to match the variables used. Now press NXT F6-OK LS(hold) WIN. In X-Left: and X-Right: enter the domain of the first variable, and in Y-Near: and Y-Far: enter the domain of the second variable. Finally, in Z-Low: and Z-High enter a reasonable approximation for the range of the output. For this example we will use [0, 3] for both the X and Y domains, and [-1, 7] for the range. The last two entries are for the number of vertical and horizontal grid lines. The default suggested by HP is 10 and 8, but this author has frequently found that it is more useful to us odd numbers for both. We will use 11 for both in this case. The Plot Window should now look like the top figure on the right. Now press F5-Erase F6-DRAW to draw the graph and you will get the middle figure on the right. The coordinate system in the lower left corner shows the orientation of the graph. Pressing RA, LA, UA, or DA will cause the figure to rotate in space, and the coordinate system will also rotate to let you know how the figure is oriented. In the figure below on the right the figure has been turned by pressing LA 8 times and the F1-TRACE key has been pressed. Note that the cursor is now showing in the upper right corner of the graph and the coordinates where it is located show in the upper left corner of the screen. Pressing the arrow keys with TRACE activated as it now is will cause the cursor to move to different mesh points on the graph and the coordinates will change to show the new location. To deactivate the TRACE mode press F1-TRACE again. To return to normal calculator operation press F6-EXIT F6-CANCL NXT F6-OK.



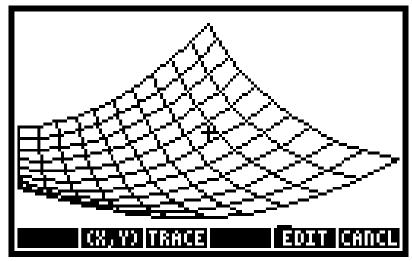


Now suppose we are interested in finding the minimum value of the function given above. In this case it is quite easy to find this analytically (the solution is 13/150 which is .08666…), but let us approximate it graphically. It is possible to do this with the graph we created above, but this author finds it easier to work with the wire frame graphs for this type of problem.

Press LS(hold) 2D/3D to get into the PLOT SETUP dialog box and choose Wireframe for Type:. Assuming everything from the previous example is still in place, press NXT, F6-OK LS(hold) WIN to get back into the PLOT WINDOW and press F5-ERASE F6-DRAW to draw the wire frame graph. You will get the graph shown in the top figure to the right.



Press F6-CANCL to return to the PLOT SETUP screen. Notice that the fourth data line is "XE:0. YE:-3. ZE:0." These are the coordinates of the point from which we are viewing the graph. The Y coordinate must be at least 3 less than the near end of the Y domain, but the other two may be whatever we wish. In this case we would like to look down on the graph from a higher point. Change ZE: to 5 and Z-High: to 10, then redraw the graph. You will get the lower figure shown on the right. Now press F3-TRACE and F2-(X,Y). The cursor will move to the upper left mesh point of the graph and the input coordinates, (0 3) shows at the bottom of the screen. Press the + key and the display at the bottom of the screen shows the output value 4.31. As you repeatedly press the + key the display at the bottom of the screen cycles through the menu, the input, and the output. Set the display to the input and press DA. The cursor moves to the next mesh point on the Y axis and we see the input change to (0 2.7). (Note: This is why your author likes to use 11 for the X and Y step sizes. The distance between consecutive mesh points along a grid line are now 1/10 of the domain in each direction.) Press + to see the output and we see that it has changed to 3.29. As we repeatedly press DA we see the output decreasing to .89, then increase to .95. Press UA to get back to the output of .89. Now press RA and the output continues to decrease to .35. The next press keeps it at .35, but the next moves it up again. Return the cursor to the first point that gave .35 for an output, then try pressing UA and DA again to find a new low point. Now go back to LA and RA seeking a new low point. Continue alternating between changing the X and Y coordinates until you reach a point where changing either coordinate causes the output to increase or stay the same. You will reach a point where the output is .11. Changing the Y coordinate from that point will cause the output to increase, but there are two adjacent points in the X direction with the same output. Place the cursor on the point to the left, then press + twice to view the input, (.9 .6). This suggests the minimum value of the function is between .6 and 1.5 in the X direction and between .3 and .9 in the Y direction, and our approximation for the minimum value is now .11. (Note, we must extend the domain in the X direction an extra grid point because we had the same low output at two points in that direction.) Move the cursor to the four corners of our new domain {(.6 .3), (.6 .9), (1.5 .3) and (1.5 .9)} and observe that the largest output is .53.



Now press CANCEL (the ON button) to get back to the PLOT WINDOW. Set the X domain to .6 and 1.5, the Y domain to .3 and .9, and the Z range to 0 and .6. Redraw the graph and repeat the process from above to find an improved approximation for the minimum. This procedure can be repeated several times to get increasingly better approximations for the minimum value of the function

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