

Graph 3D Manual

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1 Introduction

Graph3D is an app created for the HP Prime graphing calculator. The app is programmed in the HP Prime Programming Language (HPPPL) and is based on the built-in Advanced Graphing app.

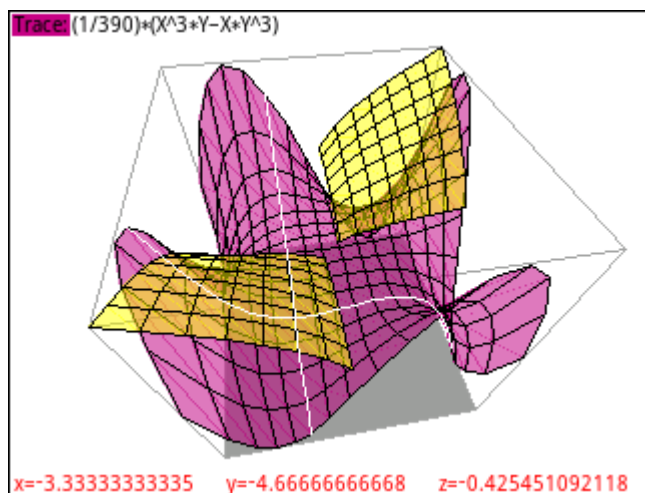









Figure 1: Tracing one of two surfaces in Graph3D

Graph3D is capable of creating surface plots of functions of the form $f(X, Y)$. Its feature set includes

- Rendering surfaces defined by $f(X, Y)$.
- Plots multiple surfaces simultaneously.
- Surfaces may be rendered with translucency (by default) or hidden-surface removal.
- Surfaces may be rendered with or without their wireframe mesh.
- Contour plots in 3D and 2D.
- Tracing of surfaces.
- Multiple color schemes.


2 Installation on HP Prime virtual calculator

Each HP Prime comes with a CD that includes both a simulator and connectivity software. We will assume that both software packages have already been installed and are in working order. To install Graph3D on the simulator:


1. Run the simulator program.
2. Press the  key and highlight the Advanced Graphing app.
3. Click on the Save menu option. When prompted for a new app name, click the Edit menu option and replace the Advanced Graphing text with Graph3D. Press  twice and the newly created copy of the Advanced Graphing app should appear in the apps menu with the name Graph3D.
4. Select the Graph3D app by clicking on the Graph3D icon in the apps menu.
5. Press   to open the Program Editor and highlight the entry listed as Graph3D (App). Click the Edit menu option to open the program listing.
6. Clear the existing program listing using  .
7. Using a word editor such as *Wordpad*, open the source code file for the Graph3D app and copy the entire source listing.
8. On the simulator, (with the Program Editor still opened), paste the source listing by clicking on *Edit* and then *Paste* found in the menu at the top of the simulator window. (If the simulator title bar does not appear, right-click on the simulator window and select *Calculator* and then *Show Titlebar*.)
9. Press  to exit the Program Editor.
10. To ensure that the simulator saves its memory state, close the simulator and rerun it.

3 Installation on the HP Prime calculator

The easiest method is to first install Graph3D on the simulator. Once the app is installed on the simulator, follow these steps:

1. Ensure that the app is installed on the simulator, and press the  key on the simulator to display the apps menu. Highlight the Graph3D app.
2. Connect the calculator to the computer running the simulator using the USB cable provided with the calculator.
3. In the simulator window, select (from the menu at the top of the window): *Calculator*, *Connect To*, *<name of calculator>*. If the calculator has not been named, then its serial number will appear instead.
4. In the simulator (with the apps menu open and Graph3D highlighted), click on the Send menu option at the bottom of the screen.
5. After the app has been sent to the calculator, disconnect the simulator by selecting: *Calculator*, *Connect To*, *None* from the menu at the top of the simulator window.
6. Turn off the calculator to ensure that the app is saved to permanent storage.

4 Graphing $f(x, y)$

To create a surface plot of a function, press the  key and enter in the formula for the function. Make sure that the variables are X and Y (note the capitalization). For example, if we wish to plot

$$f(x, y) = \frac{1}{390} (x^3 \cdot y - x \cdot y^3)$$

then we would enter the formula as shown below. After entering the formula press the  key to view the surface and press  to exit the plot view.

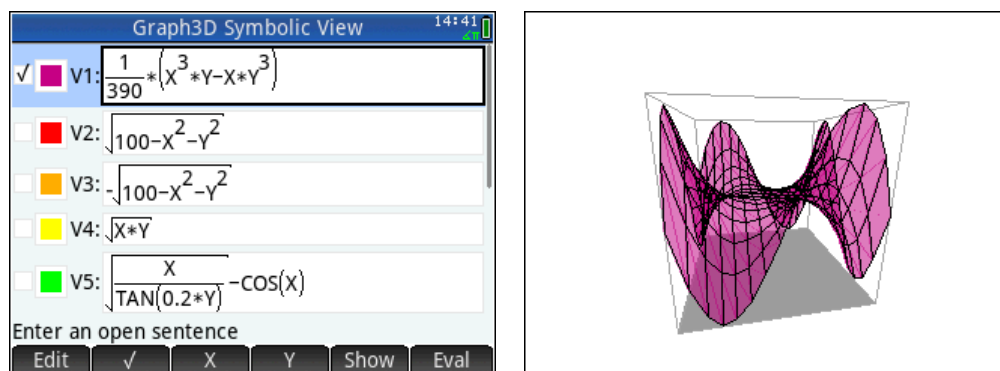



Figure 2: Surface plot of $f(x, y) = \frac{1}{390} (x^3 \cdot y - x \cdot y^3)$

4.1 Creating multiple plots simultaneously

Graph3D is capable of creating multiple surface plots simultaneously. Enter in several formulas and check the box left of the functions to be plotted as shown in Figure 4.1. Then press .

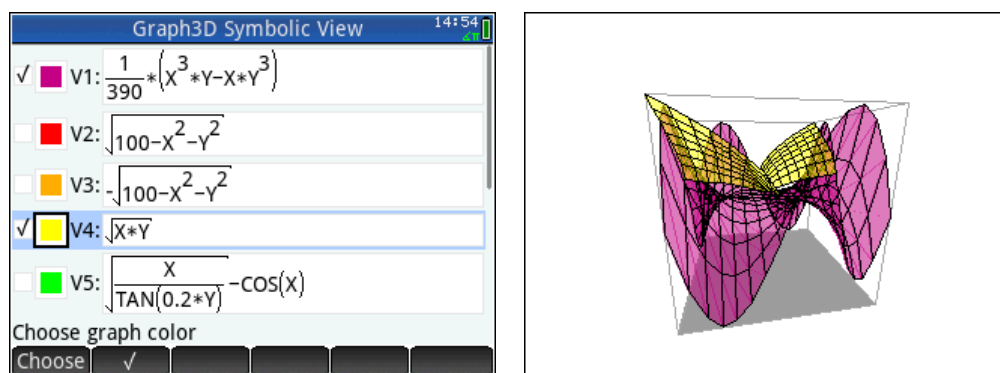
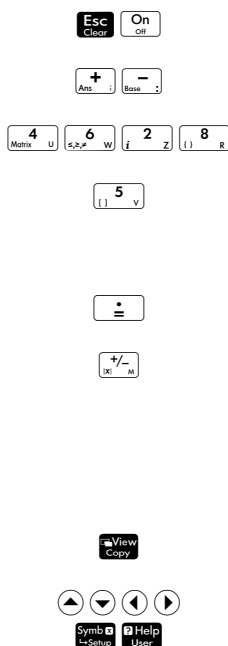


Figure 3: Surface plot of $f(x, y) = \frac{1}{390} (x^3 \cdot y - x \cdot y^3)$ and $g(x, y) = \sqrt{x \cdot y}$

While Graph3D is capable of graphing all ten functions defined in the Symbolic View, graphing multiple functions will result in slower surface rendering. Several other graphing options may additionally impact the rendering performance. See the section on the options for more information.

4.2 The plot view

Upon pressing **Plot** **Setup**, the display will show the Plot View. While this view is active, we may interact with the plot via the following keys:



Either key will exit the plot view.

Zoom in and out of the viewing box, respectively.

Move the viewing box left, right, down, and up, respectively.

Recenter the viewing box. Should the viewing box be accidentally moved off-screen, this key will return the viewing box so that the center of the viewing box is at the center of screen.

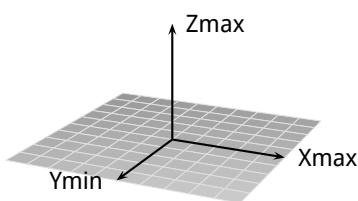
Enter the trace environment.

Cycle through the various color modes. The default color mode is to use the color specified in the Symbolic View. The next color mode is based on the x -coordinate and y -coordinate of each point (x, y, z) on the surface of the plotted function(s). The third color mode is to use a color gradient based on the z -coordinate of the plotted function(s).

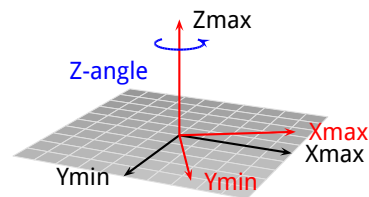
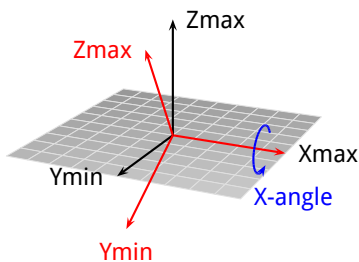
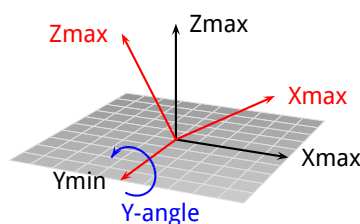
Manually set the rotation angles.

These keys rotate the viewing box relative to an initial fixed set of axes. If all rotation angles are set to 0° then the x -axis lies on the same plane as the screen and runs from left (negative) to right (positive), and the y -axis protrudes out of the screen (negative) and extends behind the screen (positive). The z -axis lies on the same plane as the screen and runs from the bottom of the screen (negative) to the top of the screen (positive).


The rotation angles are X-angle, Y-angle, and Z-angle and refer to rotations in which the respective axis is fixed as shown below. These values may be adjusted by the \uparrow \downarrow , **Symb Setup** **Help User**, and \leftarrow \rightarrow , respectively. The grey plane in the figures below is defined by the equation $z = \frac{1}{2}(Z_{\max} + Z_{\min})$.



Reference Frame



4.3 The trace view

Once in plot view, we can trace a function by either tapping on the screen and then tapping the right-most icon, or by pressing the  key. The trace view the selected surface $f(x, y)$ and the curves associated with the cross-sections of f with the planes $x = h_i$ and $y = k_j$. The values of h_i and k_j are determined as

$$h_i = Xmin + i \cdot \frac{Xmax - Xmin}{grid3D}$$



$$k_j = Ymin + j \cdot \frac{Ymax - Ymin}{grid3D}$$

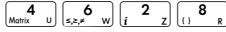
where i and j are integers such that $0 \leq i, j \leq grid3D + 1$ and $grid3D$ is the size of the wireframe grid. The selected function is displayed at the top. The trace point $(h_i, k_j, f(h_i, k_j))$ is displayed at the bottom of the screen in the form $X=h_i, Y=k_j$, and $Z=f(h_i, k_j)$. If f is undefined at $x = h_i$ and $y = k_j$, then no z -value will be displayed. While in trace view, the following keys are active:



Either key will exit the trace view. The  key will additionally exit the plot view as well.



Toggles through the list of functions for tracing. The  key will switch from V_n to V_m , where $m > n$. And the  will switch from V_m to V_n , where again $m > n$ (i.e. the reverse order).



Move the viewing box left, right, down, and up, respectively.



Recenter the viewing box. Should the viewing box be accidentally moved off-screen, this key will return the viewing box so that the center of the viewing box is at the center of screen.



Exit the trace environment.











Cycle through the various color modes. The default color mode is to use the color specified in the Symbolic View. The next color mode is based on the x -coordinate and y -coordinate of each point (x, y, z) on the surface of the plotted function(s). The third color mode is to use a color gradient based on the z -coordinate of the plotted function(s).





Manually set the rotation angles.




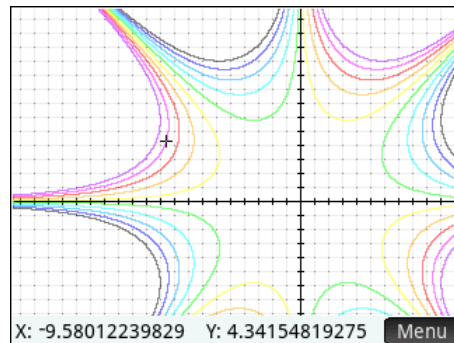
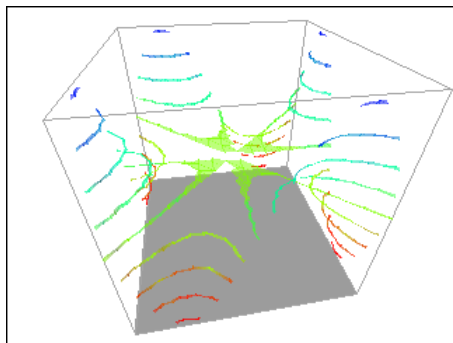
These keys adjust the x - and y -coordinates. The  key changes $x = h_i$ to $x = h_{i-1}$ and wraps around if necessary so that $x = h_1$ changes to $x = h_{grid3D+1}$. The  key adjusts the x -coordinate in the opposite direction, so that $x = h_i$ switches to $x = h_{i+1}$ (wrapping when necessary). The  and  keys adjust the y -coordinate by switching from $y = k_j$ to $y = k_{j+1}$ or $y = k_{j-1}$, respectively.

Note: This convention may seem disorienting when (improperly) assuming that the arrow keys will move the traces lines in the respective direction (relative to the display). However, the scheme above was specifically chosen since seeing how the trace lines move can help determine the orientation of the viewing window. That is, pressing  or  will always move the x -trace toward $Xmin$ or $Xmax$, respectively. Similarly,  and  will move the y -trace toward $Ymax$ and $Ymin$, respectively.

5 Plot settings

The viewing window and various options may be adjusted in the Plot Setup view, accessible via  . The settings are described below.

Xmin, Xmax, Ymin, Ymax, Zmin, Zmax	These values determine the viewing box. The planes $x = \text{Xmin}$ and $x = \text{Xmax}$ correspond to the left and right side of the viewing box when all viewing angles are set to 0° . Similarly, the Ymin, Ymax, Zmin, and Zmax values correspond to the front, back, bottom, and top of the viewing box, respectively.
Zoom	This value determines the initial zoom factor. If $\text{Zoom} > 1$ then the plot will “zoom in” whereas $\text{Zoom} < 1$ corresponds to “zoom out.”
Transparent?, Show grid?, Show box?	These flags determine whether the surface plots will be transparent or opaque (hidden surface removal), whether the surface wireframe should be drawn or not, and whether the viewing box frame should be displayed or hidden.
Type	This selects the plot type. Surface (default) will plot functions as surfaces. The 3D Contour option will create three dimensional contour plot. Only one function may be selected (due to performance reasons). The 2D Contour option creates a two-dimensional contour plot. Again, only one function may be selected. For the latter two types, if multiple functions are checked in the Symbolic View, then pressing  will result in a choose menu from which the user may select the desired function to view. Below are sample contour plots. There is no trace mode available for three dimensional contour plots.






The 3D Contour plot has the same active keys as those for the Surface plot, excluding the trace feature. The 2D Contour plot uses the same interface as the Advanced Graphing app. And the contour levels are computed as cross-sections with the planes

$$z = \text{Zmin} + i \cdot \frac{\text{Zmax} - \text{Zmin}}{9}$$

where $0 \leq i \leq 9$.

6 Numeric view and grid settings

The  key allows users to view the generated table of z -values for each function. Only one function may be viewed at a time. To adjust the size of the table, press   and enter in the size desired. This value is stored in grid3D and also determines the size of the wireframe of each surface. Unfortunately, the Numeric View is quite limited at this point. Firstly, for points not in the domain of the function, the corresponding

z -value is listed as 1E-499 as opposed to simply being blank. Secondly, the columns and rows do not have proper labels. The columns correspond to the $x = h_i$ values (increasing from left to right) and the rows correspond to the $y = k_j$ values (increasing from top to bottom). See also Section 4.3: The trace view.

7 Miscellaneous

- To change the color of a particular function, go to the Symbolic View and tap (twice) on the color box next to the function. Then select the desired color, or tap on the bottom right color palette to select a custom color. Another way to alter the color is to enter: `V1(COLOR):=#FF00CCh` where `#FF00CCh` is the color in RGB format. This **must** be done in the Home view and not the CAS view. Change V1 accordingly.
- If the plot or trace view is left idle for more than one minute, it will auto-exit to allow the calculator to power off.