Chapter 4

Plotting graphs

Contents

Introduction

The HP 49G enables you to plot functions and statistical data, and to analyze the mathematical characteristics of plotted functions. Sixteen plot types are available. These are:

- function plots
- parametric plots
- polar plots
- conic plots
- differential equations
- truth plots
- slopefield plots
- wireframe plots
- pseudo-contour plots
- Y-slice plots
- gridmap plots
- parametric surface plots
- fast 3-D plots
- scatter plots
- bar graphs
- histograms

Basic plotting

The HP 49G's plotting application enables you to graph functions. You can create the functions before opening the application, or create a function once the plotting application is open.

You can also plot statistical data. Statistical data needs to be placed in a matrix before it can be plotted. You can create the matrix before opening the plotting application, or create it once the application is open.

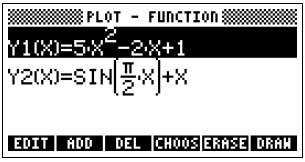
You can plot any number of functions at one time; however, you can only draw one statistical plot at a time. You can, however, superimpose a new statistical plot over a previously drawn statistical plot.

To draw a non-statistical plot

1. Press ↰ (2D/3D) to display the Plot Setup screen.
2. If the type of plot you want to draw is not the one shown in the Type field, press CHOOS and select a new plot type.

   You can also select a plot type by pressing (ALPHA) and the first letter of the name of the plot type. For example, to select gridmap, press (ALPHA) G. The value in the Type field changes to the plot type you selected.
3. Change whatever plotting parameters need changing.

   The parameters on the Plot Setup screen vary according to the type of plot you are drawing. They are discussed later. (See "Plot types" on page 4-6.).



4. Press ↰ (Y=).

   The Plot – Function screen is displayed. This screen lists the functions you last plotted.
5. To delete all the functions listed, press (NXT) CLEAR.
6. To delete a particular function but keep others, use the arrow keys to highlight the function and press DEL.

   If you find you have deleted a function by accident, press (CANCEL) ↰ (Y=).

7. To change a function:
   a. Use the arrow keys to highlight the function.
   b. Press EDIT.

      The function is displayed in Equation Writer.
   c. Edit the function.
   d. Press ENTER.

      Equation Writer closes and your edited function overwrites the function you chose to modify.

      To cancel your edit, press CANCEL ↰ Y=.
8. To choose a user-defined function:
   a. Highlight the function below which you want the new function to be placed.
   b. Press CHOOS.

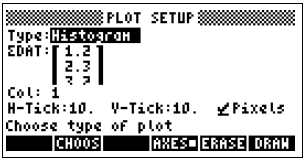
      A list of user-defined functions is displayed.
   c. Highlight the function you want to plot.
   d. Press OK.

   See "User-defined functions" on page 7-4 for instructions on how to create user-defined functions.
9. To create a new function to be plotted:
   a. Press ADD to open Equation Writer.
   b. Create the function.
   c. Press ENTER.

      Equation Writer closes and your new function is added to the list of functions to be plotted.
10. Press ↰ WIN to display the Plot Window screen.
11. If necessary, change the plot window parameters.

    The parameters on the Plot Window screen vary according to the type of plot you are drawing. They are discussed later. (See "Plot types" on page 4-6.)
12. The HP 49G keeps a record of your last plot. This enables you to draw a new function (or set of functions), or data matrix, over the top of an earlier function, set of functions, or data matrix. If you do not want to include the earlier plot, press ERASE.
13. To plot the function(s), press DRAW.

To draw a statistical plot



1. Press ↰ 2D/3D to display the Plot Setup screen.
2. Press CHOOS and select the type of statistical plot you want to draw: bar, histogram, or scatter.
3. Press ▼ to move to the ΣDAT field.
4. Press ↰ MTRW to open Matrix Writer.
5. Create a matrix to represent the statistical data you want to plot.
6. Press ENTER.
7. The matrix you entered appears on screen within square brackets. Press OK to continue (or modify the matrix if necessary before pressing OK).
8. The HP 49G has a number of settings that determine features such as the part of the graph to be displayed, the scale of the graph, and so on. These settings are listed on the:
   - Plot Setup screen and
   - Plot Window screen (by pressing ↰ WIN).

   The settings listed on these two screens vary according to the type of graph you are plotting. They are discussed later. (See "Statistical plots" on page 4-28.) If necessary, change the default or current values of these settings before plotting your data matrix.
9. The HP 49G keeps a record of your last plot. This enables you to draw a new statistical plot over the top of an earlier plot. If you do not want to include the earlier plot, press ERASE.
10. To plot the data matrix, press DRAW.

You can plot the equations listed on the Plot – Function screen, or the data saved in the ΣDAT variable, without first displaying any of the three plotting parameters screens. Just press ↰ GRAPH to select the Graph command. Your equation(s) or data matrix are plotted. The parameters currently set on the Plot Window and Plot Setup input forms are used to determine the appearance of the plot.

Plot types

This section describes the 16 plot types that the HP 49G can draw. The procedure for plotting each type is set out in the previous section ("Basic plotting").

The plot window and plot setup parameters for each plot type are provided. The input forms for setting these parameters are displayed by pressing ↰ (WIN) and ↰ (2D/3D) respectively.

Function plots

The calculator's default plot type is the function plot. A function plot plots equations that return a unique $f(x)$ for each value of x. An example is $y = x^3 + 2x^2 - x$.

When entering a function to be plotted, make sure that it is in the form $y = f(x)$. For example, an equation in the form $9x + y - 7 = 0$ should be entered as $-9x + 7$.

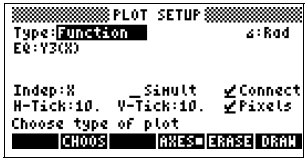


Figure 4-3: Default plot window and plot setup parameters for function plots

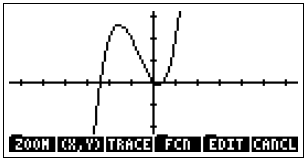


Figure 4-4: Sample function plot

Plot window parameters

H-View	The horizontal display range, with the minimum horizontal value in the first field and maximum horizontal value in the second field.
V-View	The vertical display range, with the minimum vertical value in the first field and maximum vertical value in the second field.

Low	The smallest value of the independent variable that you want plotted.
High	The greatest value of the independent variable that you want plotted.
Step	Determines the resolution of the plot. It is the horizontal distance—in units or pixels—between two plotted points. Larger step sizes provide speedier plots, but show less detail. Smaller step sizes provide more detail but take longer to draw. (For functions, the default step size is 0.2 units). See also PIXELS below.
Pixels	When this field is checked, the STEP value is measured in pixels. When unchecked—which is the default setting—the step value is measured in units.
Auto	Resets the vertical display range so that the maxima and minima within the specified horizontal display range are displayed. Choose this option by pressing AUTO. The V-View fields are recalculated.

Plot setup parameters

Type	The type of plot (in this case, *function).*
∡	The angle units field indicates the units in which angular arguments are to be interpreted: degrees, radians, or gradians.
EQ	The equation or list of equations you want to plot. It defaults to the equation(s) listed on the Plot Functions screen, but it can be changed on the Plot Setup input form.
Indep	The name of the independent variable.
Connect	When checked—which is the default setting—the plotted points are connected to form a line or curve; when unchecked, only the plotted points are displayed.
Simult	When checked, each equation listed on the Plot Functions input form is plotted simultaneously; when unchecked—which is the default setting—one equation is plotted fully before the next equation is plotted.

H-Tick — The number of units (or pixels) between tick marks on the horizontal axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below). This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.

V-Tick — The number of pixels or units between tick marks on the vertical axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below).

This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.

Pixels — When checked—which is the default—the values in the H-Tick and V-Tick fields are interpreted as pixels. When unchecked, these values are interpreted as units.

This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.

Parametric plots

A parametric plot is a compound of two equations, with the dependent variable in each being a function of the same independent variable. An example is $x(t) = 3\sin(3t)$ and $y(t) = 2\sin(4t)$. You need to combine both equations into the form $a + bi$ where a is the first equation and b is the second equation. To continue the example, you would need to specify, as the equation to plot, $3\sin(3t) + 2\sin(4t)i$.

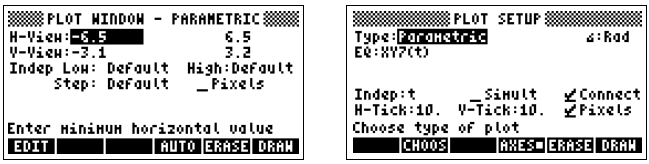


Figure 4-5: Default plot window and plot setup parameters for parametric plots

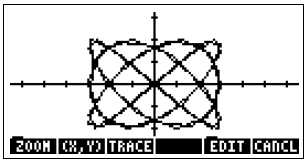


Figure 4-6: Sample parametric plot

Plot window parameters

H-View	The horizontal display range, with the minimum horizontal value in the first field and maximum horizontal value in the second field.
V-View	The vertical display range, with the minimum vertical value in the first field and maximum vertical value in the second field.
Low	The smallest value of the independent variable that you want plotted.
High	The greatest value of the independent variable that you want plotted.
Step	Determines the resolution of the plot. It is the horizontal distance—in units or pixels—between two plotted points. Larger step sizes provide speedier plots, but show less detail. Smaller step sizes provide more detail but take longer to draw. See also PIXELS below.
Pixels	When this field is checked, the STEP value is measured in pixels. When unchecked—which is the default setting—the step value is measured in units.
Auto	Resets the horizontal display range and the vertical display range so that the plot fills the screen. Choose this option by pressing AUTO. The H-View and V-View fields are recalculated.

Plot setup parameters

Type	The type of plot (in this case, *parametric*).
∡	The angle units field indicates the units in which angular arguments are to be interpreted: degrees, radians, or gradians.
EQ	The equations you want to plot. It defaults to the equations listed on the Plot – Parametric screen but it can be changed on the Plot Setup input form.
Indep	The name of the independent variable (usually t for parametric plots).

Connect	When checked—which is the default setting—the plotted points are connected to form a line or curve; when unchecked, only the plotted points are displayed.
Simult	When checked, each equation listed on the Plot – Parametric input form is plotted simultaneously; when unchecked—which is the default setting—one equation is plotted fully before the next equation is plotted.
H-Tick	The number of units (or pixels) between tick marks on the horizontal axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below). This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.
V-Tick	The number of pixels or units between tick marks on the vertical axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below). This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.
Pixels	When checked—which is the default—the values in the H-Tick and V-Tick fields are interpreted as pixels. When unchecked, these values are interpreted as units. This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.

Polar plots

A polar plot is a graph of a function described according to the polar coordinate system *f(θ)*. The independent variable is the polar angle, θ. An example is $r = 5\sin(\theta) + \sin(5\theta)$.

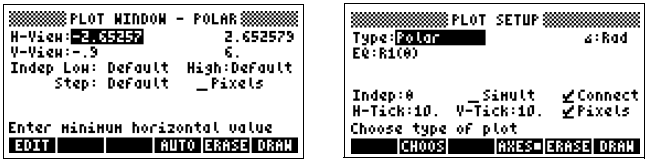


Figure 4-7: Default plot window and plot setup parameters for polar plots

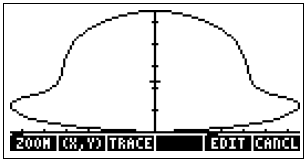


Figure 4-8: Sample polar plot

Plot window parameters

H-View	The horizontal display range, with the minimum horizontal value in the first field and maximum horizontal value in the second field.
V-View	The vertical display range, with the minimum vertical value in the first field and maximum vertical value in the second field.
Low	The smallest value of the independent variable that you want plotted.
High	The greatest value of the independent variable that you want plotted.
Step	Determines the resolution of the plot. It is the horizontal distance—in units or pixels—between two plotted points. Larger step sizes provide speedier plots, but show less detail. Smaller step sizes provide more detail but take longer to draw. See also PIXELS below.
Pixels	When this field is checked, the STEP value is measured in pixels. When unchecked—which is the default setting—the step value is measured in units.
Auto	Resets the horizontal display range and the vertical display range so that the plot fills the screen. Choose this option by pressing AUTO. The H-View and V-View fields are recalculated.

Plot setup parameters

Type	The type of plot (in this case, *polar*).
∡	The angle units field indicates the units in which angular arguments are interpreted: degrees, radians, or gradians.
EQ	The equation(s) you want to plot. It defaults to the equations listed on the Plot – Polar screen but it can be changed on the Plot Setup input form.
Indep	The name of the independent variable (usually θ for polar plots).
Connect	When checked—which is the default setting—the plotted points are connected to form a line or curve; when unchecked, only the plotted points are displayed.
Simult	When checked, each equation listed on the Plot – Polar input form is plotted simultaneously; when unchecked—which is the default setting—one equation is plotted fully before the next equation is plotted.
H-Tick	The number of units (or pixels) between tick marks on the horizontal axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below). This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.
V-Tick	The number of pixels or units between tick marks on the vertical axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below). This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.
Pixels	When checked—which is the default—the values in the H-Tick and V-Tick fields are interpreted as pixels. When unchecked, these values are interpreted as units. This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.

Conic plots

Conic plots are plots of conic sections. The equation for a conic section is a polynomial of second degree or less for both x and y. An example is $5x^2 + 3y^2 - 18 = 0$.

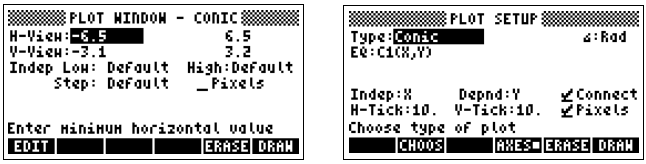


Figure 4-9: Default plot window and plot setup parameters for conic plots

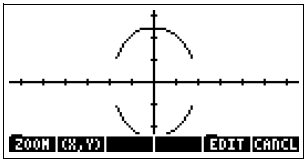


Figure 4-10: Sample conic plot

Plot window parameters

H-View	The horizontal display range, with the minimum horizontal value in the first field and maximum horizontal value in the second field.
V-View	The vertical display range, with the minimum vertical value in the first field and maximum vertical value in the second field.
Low	The smallest value of the independent variable that you want plotted.
High	The greatest value of the independent variable that you want plotted.
Step	Determines the resolution of the plot. It is the horizontal distance—in units or pixels—between two plotted points. Larger step sizes provide speedier plots, but show less detail. Smaller step sizes provide more detail but take longer to draw. See also PIXELS below.
Pixels	When this field is checked, the STEP value is measured in pixels. When unchecked—which is the default setting—the step value is measured in units.

Plot setup parameters

Type	The type of plot (in this case, *conic*).
∡	The angle units field indicates the units in which angular arguments are to be interpreted: degrees, radians, or gradians.
EQ	The equation(s) you want to plot. It defaults to the equations listed on the Plot – Conic screen but it can be changed on the Plot Setup input form.
Indep	The name of the independent variable.
Depnd	The name of the dependent variable.
Connect	When checked—which is the default setting—the plotted points are connected to form a line or curve; when unchecked, only the plotted points are displayed.
H-Tick	The number of units (or pixels) between tick marks on the horizontal axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below). This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.
V-Tick	The number of pixels or units between tick marks on the vertical axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below). This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.
Pixels	When checked—which is the default—the values in the H-Tick and V-Tick fields are interpreted as pixels. When unchecked, these values are interpreted as units. This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.

Differential equation plots

A differential equation is an equation that involves one or more derivatives. An example is $dy/dt = t + y$.

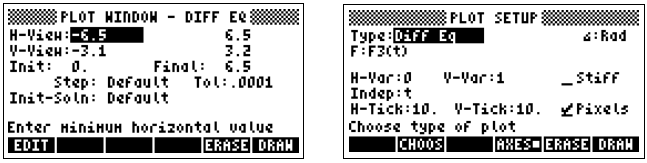


Figure 4-11: Default plot window and plot setup parameters for plotting differential equations

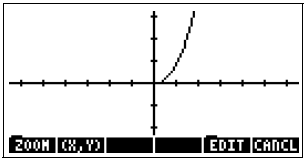


Figure 4-12: Sample differential equation plot

Plot window parameters

H-View	The horizontal display range, with the minimum horizontal value in the first field and maximum horizontal value in the second field.
V-View	The vertical display range, with the minimum vertical value in the first field and maximum vertical value in the second field.
Init	The independent variable's initial value. (This must correspond to the initial value of the solution variable.)
Final	The independent variable's final value.
Init-Soln	The solution variable's initial value.
Tol	An indication of acceptable tolerance, that is, the acceptable level of absolute error. (The default value is 0.0001.)
Step	The initial step size used to compute the solution.

Plot setup parameters

Type	The type of plot.
∡	The angle units field indicates the units in which angular arguments are to be interpreted: degrees, radians, or gradians.
F	The equation(s) you want to plot. It defaults to the equations listed on the Plot – Diffeq screen but it can be changed on the Plot Setup input form.
Indep	The name of the independent variable.
Soln	The solution variable.
H-Var	The variable plotted on the horizontal axis.
V-Var	The variable plotted on the vertical axis.
Stiff	Check this field to select the stiff solver.
∂F∂y	The partial derivative with respect to y of the expression in F.
∂F∂t	The partial derivative with respect to t of the expression in F.
H-Tick	The number of units (or pixels) between tick marks on the horizontal axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below). This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.
V-Tick	The number of pixels or units between tick marks on the vertical axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below). This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.
Pixels	When checked—which is the default—the values in the H-Tick and V-Tick fields are interpreted as pixels. When unchecked, these values are interpreted as units. This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.

Truth plots

Truth plots evaluate expressions that return a true result (that is, any non-zero real number) or a false result (that is, 0). At the coordinates of each pixel, the pixel is turned *on* if the expression is true or is left *unchanged* if the expression is false.

The following example is a plot of $x^2 + y^3 \bmod 2 < 4$.

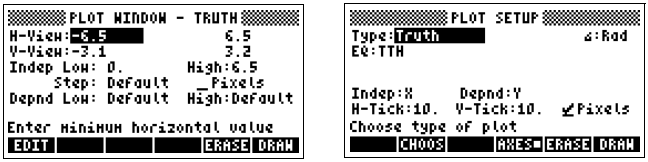


Figure 4-13: Default plot window and plot setup parameters for truth plots

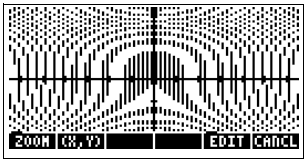


Figure 4-14: Sample truth plot

Plot window parameters

H-View	The horizontal display range, with the minimum horizontal value in the first field and maximum horizontal value in the second field.
V-View	The vertical display range, with the minimum vertical value in the first field and maximum vertical value in the second field.
Indep Low	The smallest value of the independent variable that you want plotted.
Indep High	The greatest value of the independent variable that you want plotted.
Step	Determines the resolution of the plot. It is the horizontal distance—in units or pixels—between two plotted points. Larger step sizes provide speedier plots, but show less detail. Smaller step sizes provide more detail but take longer to draw. (For truth plots, the default step size is 1 pixel). See also PIXELS below.

Pixels	When this field is checked, the STEP value is measured in pixels. When unchecked—which is the default setting—the STEP value is measured in units.
Depnd Low	The smallest value of the dependent variable that you want plotted.
Depnd High	The largest value of the dependent variable that you want plotted.

Plot setup parameters

Type	The type of plot (that is, *truth*).
∡	The angle units field indicates the units in which angular arguments are to be interpreted: degrees, radians, or gradians.
EQ	The equation(s) you want to plot. It defaults to the equations listed on the Plot – Truth screen but it can be changed on the Plot Setup input form.
Indep	The name of the independent variable. It will be plotted on the horizontal axis.
Depnd	The name of the dependent variable (or second independent variable). It will be plotted on the vertical axis.
H-Tick	The number of units (or pixels) between tick marks on the horizontal axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below). This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.
V-Tick	The number of pixels or units between tick marks on the vertical axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below). This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.
Pixels	When checked—which is the default—the values in the H-Tick and V-Tick fields are interpreted as pixels. When unchecked, these values are interpreted as units.

Slopefield plots

A slopefield plot draws a lattice of line segments whose slopes represent the value of the function $f(x,y)$ at their centerpoint. Slopefield plots are particularly useful in understanding antiderivatives and in solving differential equations.

A slopefield plot needs two inputs to generate an output. The HP 49G uses a two-dimensional *sampling grid* of points whose coordinates provide the two inputs required. By default, the sampling grid consists of 80 points: 10 columns by 8 rows.

The following example is a slopefield plot of $\frac{x^3+1}{y^2-1}$.

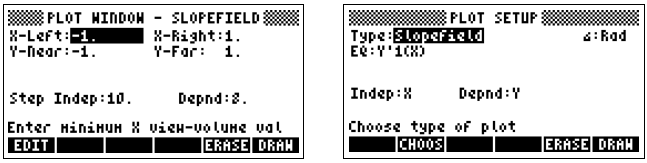


Figure 4-15: Default plot window and plot setup parameters for slopefield plots

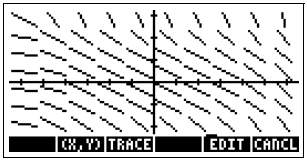


Figure 4-16: Sample slopefield plot

Plot window parameters

X-Left, X-Right	The horizontal display range corresponding to the first independent variable (entered in the Indep field).
Y-Near, Y-Far	The vertical display range corresponding to the second independent variable (entered in the Depnd field).
Step Indep	The number of columns in the sampling grid.
Step Depnd	The number of rows in the sampling grid.

Plot setup parameters

Type	The type of plot (namely, *slopefield*).
∡	The angle units field indicates the units in which angular arguments are to be interpreted: degrees, radians, or gradians.
EQ	The equation or list of equations you want to plot.
Indep	The name of one of the independent variables.
Depnd	The name of the second independent variable.

Wireframe plots

A wireframe plot draws an oblique, 3-D plot of a wireframe model of a surface determined by $Z = F(x, y)$. An example is $z = x^3 - xy^3$.

The plot drawn is the surface of the model as viewed from a specified vantage point. This vantage point is called the *eyepoint*. The surface plotted is that within a region in 3-dimensional space—called the view volume—determined by ranges on each of the three coordinate axes.

A wireframe plot needs two inputs to generate an output. The HP 49G uses a two-dimensional *sampling grid* of points whose coordinates provide the two inputs required. By default, the sampling grid consist of 80 points: 10 columns by 8 rows.

The following example is a wireframe plot of $z = x^3y - xy^3$.

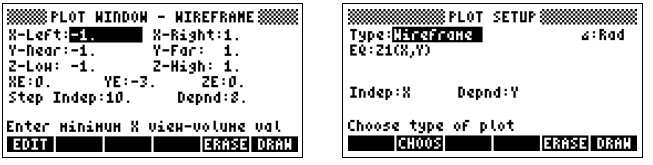


Figure 4-17: Default plot window and plot setup parameters for wireframe plots

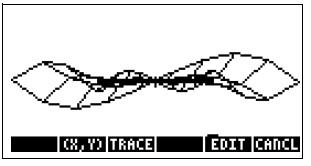


Figure 4-18: Sample wireframe plot

Plot window parameters

X-Left, X-Right	The x-axis range—or width—of the view volume.
Y-Near, Y-Far	The y-axis range—or depth—of the view volume.
Z-Low, Z-High	The z-axis range—or height—of the view volume.
XE	The x coordinate of the eyepoint.
YE	The y coordinate of the eyepoint.
ZE	The z coordinate of the eyepoint.
Step Indep	The number of columns in the sampling grid.
Step Depnd	The number of rows in the sampling grid.

Plot setup parameters

Type	The type of plot (in this case, *wireframe*).
∡	The angle units field indicates the units in which angular arguments are to be interpreted: degrees, radians, or gradians.
EQ	The equation or list of equations you want to plot.
Indep	The name of one of the independent variables.
Depnd	The name of the second independent variable.

Pseudo-Contour plots

A pseudo-contour plot is a lattice of line segments each tangent to a contour of a function (a curve satisfying $F(x,y)$ = constant).

A pseudo-contour plot needs two inputs to generate an output. The HP 49G uses a two-dimensional *sampling grid* of points whose coordinates provide the two inputs required. By default, the sampling grid consist of 80 points: 10 columns by 8 rows. In drawing a pseudo-contour plot, the HP 49G computes a tangent for each point in the sampling grid.

The pseudo-contour plot type produces a fast contour plot, enabling your eye to pick out the integral curves without actually plotting them.

The following example is a pseudo-contour plot of $z = x^3y - xy^3$.

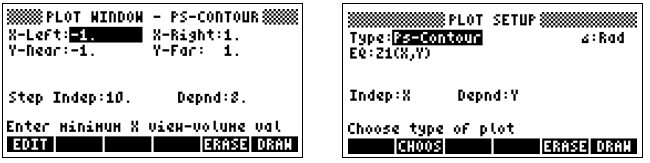


Figure 4-19: Default plot window and plot setup parameters for pseudo-contour plots

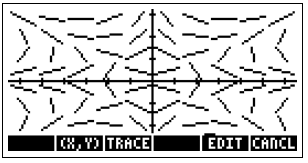


Figure 4-20: Sample pseudo-contour plot

Plot window parameters

X-Left, X-Right	The horizontal display range corresponding to the first independent variable (entered in the Step Indep field).
Y-Near, Y-Far	The vertical display range corresponding to the second independent variable (entered in the Step Depnd field).
Step Indep	The number of columns in the sampling grid.
Step Depnd	The number of rows in the sampling grid.

Plot setup parameters

Type	The type of plot (namely, *ps-contour*).
∡	The angle units field indicates the units in which angular arguments are to be interpreted: degrees, radians, or gradians.
EQ	The equation or list of equations you want to plot.
Indep	The name of one of the independent variables.
Depnd	The name of the second independent variable.

Y-Slice plots

The Y-Slice plot draws a series of cross-sections or slices—each perpendicular to the y-axis—of the surface determined by a specified function.

A Y-Slice plot needs two inputs to generate an output. The HP 49G uses a two-dimensional *sampling grid* of points whose coordinates provide the two inputs required. By default, the sampling grid consist of 80 points: 10 columns by 8 rows. In drawing a Y-Slice plot, the HP 49G draws one slice for each row in the sampling grid.

Once it has completed drawing all the slices, the HP 49G creates and runs an animation, with one slice per frame. This enables you to visualize a moving slice through the surface.

The following example is a Y-Slice plot of $z = x^3y - xy^3$.

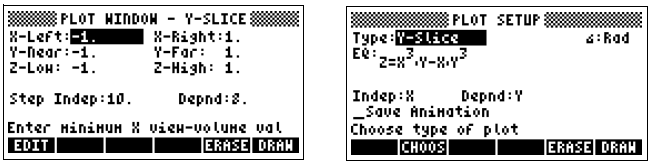


Figure 4-21: Default plot window and plot setup parameters for Y-Slice plots

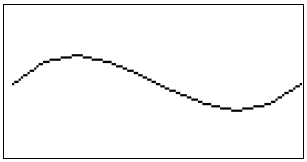


Figure 4-22: Sample slice of a Y-slice plot

Plot window parameters

X-Left, X-Right	The x-axis range—or width—of the view volume.
Y-Near, Y-Far	The y-axis range—or depth—of the view volume.
Z-Low, Z-High	The z-axis range—or height—of the view volume.
Step Indep	The number of columns in the sampling grid.
Step Depnd	The number of rows in the sampling grid.

Plot setup parameters

Type	The type of plot (namely, *Y-Slice*).
∡	The angle units field indicates the units in which angular arguments are interpreted: degrees, radians, or gradians.
EQ	The expression, equation or function you want to plot.
Indep	The name of one of the independent variables.
Depnd	The name of the second independent variable.
Save Animation	When checked, the series of slices used in the animation, and the number of slices, are placed in history. When unchecked, all slices except the current slice are deleted once you leave the plot window.

Gridmap plots

A gridmap plot transforms a specified sampling grid according to a complex-valued function. The coordinates of each point in the sampling grid are the inputs for the function.

The following example is a plot of $\sin((x, y))$.

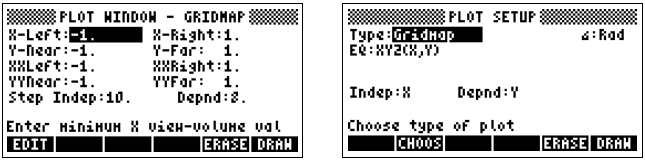


Figure 4-23: Default plot window and plot setup parameters for gridmap plots

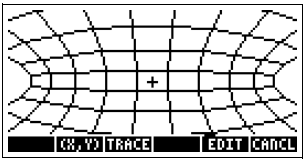


Figure 4-24: Sample gridmap plots

Plot window parameters

X-Left, X-Right	The horizontal display range.
Y-Near, Y-Far	The vertical display range.
XX-Left,	The horizontal range of the input sampling grid,

XX-Right	corresponding to the first independent variable (entered in the Step Indep field).
YY-Near, YY-Far	The vertical range of the input sampling grid, corresponding to the second independent variable (entered in the Step Depnd field).
Step Indep	The number of columns in the sampling grid.
Step Depnd	The number of rows in the sampling grid.

Plot setup parameters

Type	The type of plot (namely, *gridmap).*
∡	The angle units field indicates the units in which angles are to be interpreted: degrees, radians, or gradians.
EQ	The equation or list of equations you want to plot.
Indep	The name of one of the independent variables.
Depnd	The name of the second independent variable.

Parametric surface plots

A parametric surface plot draws an oblique, 3-D plot of a wireframe model of a surface determined by a complex-valued function. This plot type combines the coordinate mapping approach of the gridmap plot (see page 4-22) with the 3-D perspective plotting of wireframe plots (see page 4-20).

The following example is a parametric surface plot of $x\cos(y)\mathbf{i} + x\sin(y)\mathbf{j} + x\mathbf{k}$.

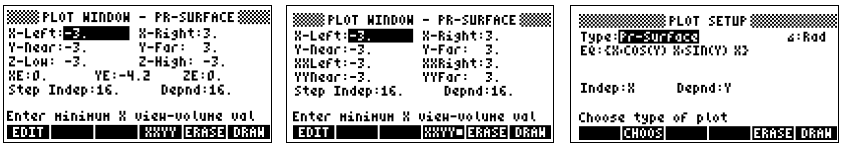


Figure 4-25: Default plot window and plot setup parameters for parametric surface plots

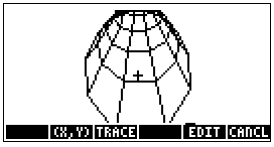


Figure 4-26: Sample parametric surface plot

Plot window (1) parameters

X-Left, X-Right	The x-axis range (that is, width) of the view volume.
Y-Near, Y-Far	The y-axis range (that is, depth) of the view volume.
Z-Low, Z-High	The z-axis range (that is, height) of the view volume.
XE	The x coordinate of the eyepoint.
YE	The y coordinate of the eyepoint.
ZE	The z coordinate of the eyepoint.
Step Indep	The number of columns in the sampling grid.
Step Depnd	The number of rows in the sampling grid.

Plot window (2) parameters

The following parameters can be viewed and set by pressing XXYY. The fields replace the Z-Low, Z-High and eyepoint coordinates fields. Press XXYY again to redisplay the default Plot Window screen.

XX-Left, XX-Right	The horizontal range of the input sampling grid, corresponding to the first independent variable (entered in the Indep field).
YY-Near, YY-Far	The vertical range of the input sampling grid, corresponding to the second independent variable (entered in the Depnd field).

Plot setup parameters

Type	The type of plot (namely, *parametric surface)*.
∠	The angle units field indicates the units in which angular arguments are to be interpreted: degrees, radians, or gradians.
EQ	The equation or list of equations you want to plot.
Indep	The name of one of the independent variable.
Depnd	The name of the second independent variable.

Fast 3-D plots

Standard 3-D functions can be plotted using the Fast 3-D plot type.

A Fast 3-D plot needs two inputs to generate an output. The HP 49G uses a two-dimensional *sampling grid* of points whose coordinates provide the two inputs required. By default, the sampling grid consist of 80 points: 10 columns by 8 rows.

The following is a Fast 3-D plot of $z = x^2y - xy^3$.

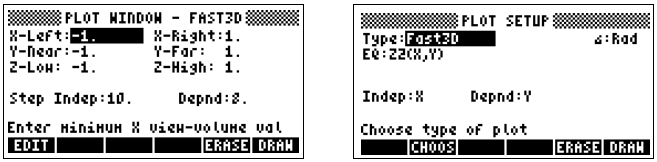


Figure 4-27: Default plot window and plot setup parameters for Fast 3-D plots

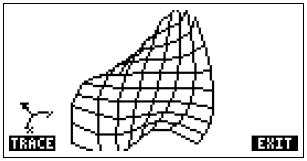


Figure 4-28: Sample Fast 3-D plot

You can rotate a Fast 3-D plot by pressing the arrow keys, or the TOOL and NXT keys.

Plot window parameters

X-Left, X-Right	The horizontal display range corresponding to the first independent variable (entered in the Indep field).
Y-Near, Y-Far	The vertical display range corresponding to the second independent variable (entered in the Depnd field).
Z-Low, Z-High	The *z*-axis range—or height—of the view volume.
Step Indep	The number of columns in the sampling grid.
Step Depnd	The number of rows in the sampling grid.

Plot setup parameters

Type	The type of plot (namely, *fast 3-D*).
∡	The angle units field indicates the units in which angular arguments are to be interpreted: degrees, radians, or gradians.
EQ	The equation or list of equations you want to plot.
Indep	The name of one of the independent variables.
Depnd	The name of the second independent variable.

Statistical plots

You can create three types of statistical plot:

- scatter plot
- bar chart
- histogram.

Statistical plots are drawn from data you have stored in a real matrix. A quick way to enter a matrix is to use Matrix Writer. (Matrix Writer is described in chapter 8, "Vectors, lists, arrays, and matrices"). You then store the matrix in a variable and refer to that variable when plotting the data.

Only one data matrix can be plotted at one time (although you can consecutively plot different data matrices to superimpose one statistical plot over another).

The last data matrix used to draw a statistical plot is stored in a special system variable called *sigma data* (labelled ∑DAT on the screen).

Scatter plots

A scatter plot shows the relationship between two variables by plotting an x–y coordinate point for each item in a sample. For variables that are statistically correlated, the points should cluster along some curve.

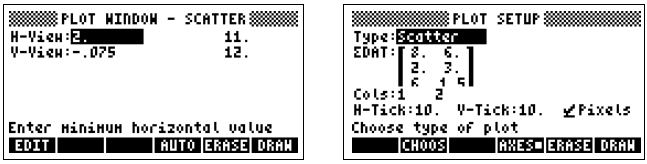


Figure 4-29: Default plot window and plot setup parameters for scatter plots

Figure 4-30: Sample scatter plot

Plot window parameters

H-View	The horizontal display range, with the minimum horizontal value in the first field and maximum horizontal value in the second field.
V-View	The vertical display range, with the minimum vertical value in the first field and maximum vertical value in the second field.
Auto	Resets the horizontal display range to span the minimum value and the maximum value of the variable in the first Cols field, and resets the vertical display range to span the minimum value and maximum value of the variable in the second Cols field. (The Cols field is explained in the next section.)

Plot setup parameters

Type	The type of plot (namely, *scatter*).
∑DAT	The data matrix, or name of the data matrix, containing the data to be plotted. The name of a matrix is the name you gave it when you stored it as a variable. (See chapter 7, "Storing objects", for information on storing objects in variables.) The name must be entered in single quotes. If you are entering the data matrix directly, the entire matrix, and each row of the matrix, must be enclosed in square brackets. (See chapter 8, "Vectors, lists, arrays, and matrices" for information on creating matrices.)
Cols	The columns of the data matrix that you want to plot. The first field indicates the column to be plotted along the horizontal axis and the second field indicates the column to be plotted along the vertical axis.
H-Tick	The number of units (or pixels) between tick marks on the horizontal axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below). This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.
V-Tick	The number of pixels or units between tick marks on the vertical axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below). This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.
Pixels	When checked—which is the default—the values in the H-Tick and V-Tick fields are interpreted as pixels. When unchecked, these values are interpreted as units. This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.

Bar charts

A bar chart provides a visual representation of the relative magnitudes of the values in a specified column of a data matrix.

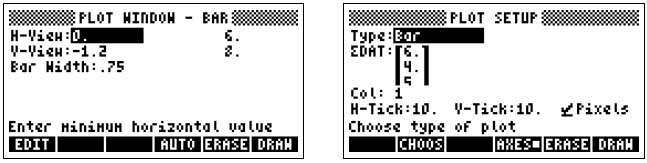


Figure 4-31: Default plot window and plot setup parameters for bar charts

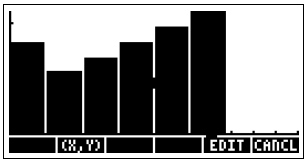


Figure 4-32: Sample bar chart

Plot window parameters

H-View	The horizontal display range, with the minimum horizontal value in the first field and maximum horizontal value in the second field.
V-View	The vertical display range, with the minimum vertical value in the first field and maximum vertical value in the second field.
Bar Width	The width of each bar. The default setting is one unit.
Auto	Resets the horizontal display range to fit the total number of elements in the Col field, and resets the vertical display range to span from the minimum value to the maximum value of the elements in the Col field.

Plot setup parameters

Type	The type of plot (that is, *bar chart*).
∑DAT	The data matrix, or name of the data matrix, containing the data to be plotted. The name of a matrix is the name you gave it when you stored it as a variable. (See chapter 7, "Storing objects", for information on storing objects in variables.) If you are entering the data matrix directly, the entire matrix, and each row of the matrix, must be enclosed in square brackets. (See chapter 8, "Vectors, lists, arrays, and matrices" for information on creating matrices.)
Col	The column of the data matrix that you want to plot.
H-Tick	The number of units (or pixels) between tick marks on the horizontal axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below). This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.
V-Tick	The number of pixels or units between tick marks on the vertical axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below). This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.
Pixels	When checked—which is the default—the values in the H-Tick and V-Tick fields are interpreted as pixels. When unchecked, these values are interpreted as units. This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.

Histograms

A histogram is a representation of a frequency distribution. The length of each bar in a histogram indicates how many items fall within its range.

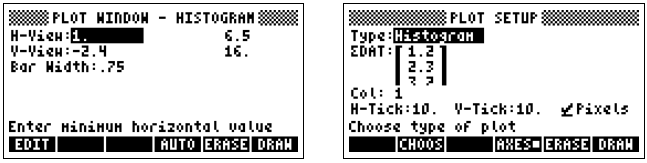


Figure 4-33: Default plot window and plot setup parameters for histograms

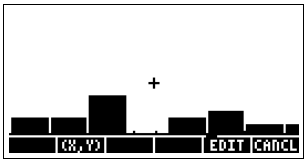


Figure 4-34: Sample histogram

Plot window parameters

H-View	The horizontal display range, with the minimum horizontal value in the first field and maximum horizontal value in the second field.
V-View	The vertical display range, with the minimum vertical value in the first field and maximum vertical value in the second field.
Bar Width	The width of each bar. The default setting is one unit
Auto	Resets the horizontal display range to span from the minimum value to the maximum value of the elements in the Col field, and resets the vertical display range to span from zero to the total number of rows in ∑DAT.

Plot setup parameters

Type	The type of plot.
∑DAT	The data matrix, or name of the data matrix, containing the data to be plotted. The name of a matrix is the name you gave it when you stored it as a variable. (See chapter 7, “Storing objects”, for information on storing objects in variables.) If you are entering the data matrix directly, the entire matrix, and

each row of the matrix, must be enclosed in square brackets. (See chapter 8, “Vectors, lists, arrays, and matrices” for information on creating matrices.)

Col — The column of the data matrix that you want to plot.

H-Tick — The number of units (or pixels) between tick marks on the horizontal axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below).

This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.

V-Tick — The number of pixels or units between tick marks on the vertical axis. The default is one tick every 10 pixels. Whether units or pixels is used depends on the setting in the Pixels field (see below).

This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.

Pixels — When checked—which is the default—the values in the H-Tick and V-Tick fields are interpreted as pixels. When unchecked, these values are interpreted as units.

This field is only available if you have chosen to display axes. Press F4 to include or exclude axes.

Cursor movement

With the plot screen displayed, you can move the cursor in one of two ways:

- standard graphics mode
- trace mode.

Standard cursor movement

In standard graphics mode, the cursor moves independently of the plot. That is, pressing ◀, ▼, ▶, ▲, causes the cursor to move parallel to an axis in the direction indicated by the key.

Tracing a plot

In trace mode, the cursor jumps from plotted point to plotted point along the function when you press the ◀ or ▶ key. (The points that are plotted depend on the step value set on the Plot Window input form.)

Where multiple functions have been plotted, pressing ▼ or ▲ moves the cursor from function to function.

Trace mode is available for function, polar, and parametric plots. To activate trace mode, press TRACE.

You would typically choose trace mode to determine the coordinates of the points plotted (as explained in the next section). You can also display plotted coordinates in tabular form. You do this by pressing ↩ TABLE when the plot is not displayed. See “Tables” on page 4-40 for more information.

Deactivate trace mode by pressing TRACE again. (Trace mode is automatically deactivated if you choose a ZOOM function, or any other function that causes the plot to be redrawn.)

Cursor coordinates

To display the coordinates of the cursor, press F2 to select (X, Y). The menu is replaced by the coordinates of the cursor.

As you move the cursor, the coordinates of the cursor’s current position is displayed. If you had turned on trace mode before pressing F2, the coordinates of consecutive plotted points are displayed as you press the ◀ or ▶ key. (Plotted points are points that correspond to the values of the independent variable as determined by the step value.)

Note that you cannot choose trace mode while you have the cursor coordinates displayed. You must choose trace mode *befor*e you choose to display the cursor's coordinates.

To redisplay the menu—thereby hiding the cursor coordinates—press ⊕. (The ⊕ and ⊖ keys enable you to display and hide the menu respectively. You can also redisplay the menu by pressing a function key.)

Zooming

The **ZOOM** functions enable you to look at a particular region of the plot in more detail (by zooming in) or look at more of the plot than is currently displayed (by zooming out).

To zoom in

1. Press ZOOM. The ZOOM menu is displayed.
2. Press ZIN to select ZOOM IN.

You can also zoom in on a rectangular area of the plot you specify. To specify the area:

1. Press ZOOM. The ZOOM menu is displayed.
2. Use the arrow keys to position the cursor at a corner of the rectangular area that you want to zoom in on.
3. Press BOXZ to select BOX ZOOM.
4. Press the appropriate arrow keys to create a box around the area you want to zoom in on.
5. Press ZOOM. The calculator zooms in on the boxed area.

To zoom out

1. Press ZOOM. The ZOOM menu is displayed.
2. Press ZOUT to select ZOOM OUT.

Zoom options

A number of zoom options are available from the ZOOM menu. You display the ZOOM menu from the plotting screen by pressing ZOOM. The main options are set out below.

Setting the zoom factor

You can set the factor by which you zoom in or zoom out by changing the values on the Zoom Factors input form.

1. Press ZFACT to select ZOOM FACTOR.
2. Change the values in the H-Factor and V-Factor fields.

   Keep the values you enter the same if you want zooming to be horizontally and vertically proportional. (See also "Forcing a proportional zoom" below.)
3. If you want zooming to center around the position of your cursor, check the Recenter at Crosshairs field.
4. Press OK.

Forcing a proportional zoom

Press ZSQR to select ZOOM SQUARE.

The plot is redrawn with the vertical scale the same as the horizontal scale.

Resetting the zoom default

Press ZDFLT to select ZOOM DEFAULT. The plot is redrawn using the default display ranges.

Analyzing functions

The HP 49G provides numerous tools for analyzing the mathematical properties of functions. For example, you can calculate roots, extrema, slopes, areas, and the point of intersection of two graphs.

Where you have plotted more than one function, you may first need to select the function you want to analyze. By default, the first function listed on the Plot Functions screen is the function that is selected.

To select another function for analysis:

1. Press TRACE to turn on trace mode. (See "Tracing a plot" on page 4-35.)
2. Press ▲ or ▼ until the cursor is on the function you want to analyze.

You can also select another function by pressing NXEQ (found on the second page of the FUNCTION menu). In this case, you do not need to be in trace mode.

Function analysis tools list

The tools discussed below are available from the FUNCTIONS sub-menu (labeled FCN on the PICT menu).

1. Press FCN to display the FUNCTIONS menu.
2. Press the function key for the analysis tool you want.

When you choose a function analysis tool, the menu is hidden to make room for the result. You can restore the menu by pressing any one of the function keys: F1 to F6.

Finding roots

A root is a point where a graph meets or crosses the x axis. To find the root closest to the cursor, press ROOT on the FUNCTIONS menu.

If the root is within the display area, the cursor moves to the root and the value of the root is displayed near the bottom left corner of the screen. If the root is not within the display area, the cursor remains where it is, the message OFF SCREEN is briefly displayed, and the value of the root is displayed near the bottom left corner of the screen.

If you want to find another root, move the cursor so that it is closer to that root than to any other root before selecting ROOT.

The message "Constant?" appears on the screen if the same value was calculated at every sample point.

Finding extrema

An extremum is the maximum or minimum value. To find the extrema closest to the cursor, press EXTR on the FUNCTIONS menu.

If an extremum is within the display area, the cursor moves to the point and the x and y coordinates of the extremum are displayed near the bottom left corner of the screen. If the extremum is not within the display area, the cursor remains where it is, the message OFF SCREEN is briefly displayed, and the x and y coordinates of the extremum are displayed near the bottom left corner of the screen.

If the derivative changes sign at the extremum, the message "Sign Reversal" briefly appears on the screen before the coordinates are displayed.

Finding slopes

The slope tool displays the slope of the function at the x value of the cursor and moves the cursor to the point on the function where the slope was calculated. To find the slope, press SLOPE on the FUNCTIONS menu.

If the point is not within the display area, the cursor remains where it is, the message OFF SCREEN is briefly displayed, and the slope of the point is displayed near the bottom left corner of the screen.

Finding areas

The area tool displays the area between a curve and the x axis between two x values that you select.

1. Move the cursor so that it is over the graph at one end of the area that you want to calculate.
2. Press (X).
3. Move the cursor until it is over the graph at the other end of the area that you want to calculate.
4. Press AREA on the FUNCTIONS menu.

   The area is displayed near the bottom left corner of the screen.

Finding intersections

The intersection tool displays the coordinates of the intersection between two functions, or between a function and the x axis.

The intersection tool determines the intersection of the currently selected function and the function that follows it on the Plot Functions screen. If you have more than two functions plotted, you may need to select another function, or change the order of the functions listed on the Plot Function screen. (You can change the order of the functions listed by pressing MOVE↓ or MOVE↑, on the second page of the function key menu on the Plot Function screen.)

If two functions intersect at more than one point, the result is the coordinates of the intersection closest to the cursor. If only one function is plotted, the result is the coordinates of the intersection of the function and the x-axis.

To find the intersection, press INTER from the FUNCTIONS menu.

If the intersection is within the display area, the cursor moves to the intersection and the coordinates of the intersection are displayed near the bottom left corner of the screen.

If the intersection is not within the display area, the cursor remains where it is, the message OFF SCREEN is briefly displayed, and the coordinates of the intersection are displayed near the bottom left corner of the screen.

Tables

If you have chosen to display the coordinates of the cursor while in trace mode, you can read the coordinates of consecutive plotted points by pressing the ▶ or ◀ key. This is explained in "Cursor movement" on page 4-35.

You can also display the coordinates of plotted points in tabular form. The Tables function—selected by pressing ↰ (TABLE)—shows the value of the dependent variable for each value of the independent variable within the range specified on the Plot Window input form. The values of the independent variable are listed in increments determined by the step value (also specified on the Plot Window input form).

If you have plotted more than one function, the values of the independent variable for each function is given, each in a separate column.

Customizing table values

The default values for the independent variable are taken from the parameters on the Plot Window input form. You can override these defaults by specifying a different starting value and step increment.

To change the default table values:

1. Press ↰ (TBLSET) to select TABLE SETUP.
   The Table Setup input form is displayed.
2. To have the calculator automatically generate the series of values for the independent variable, specify a starting value and step value.
3. If you want to specify values for the independent variable, choose BUILD YOUR OWN rather than AUTOMATIC as the type of table.
4. Press ↰ (TABLE) to select TABLE.
   If you chose an automatic table, the table values are redrawn according to the start and step values you specified.

If you chose to build your own table, the previous values are displayed. Press ↱ CLEAR to clear these values, and then enter values in the independent variable column. As you enter values, corresponding values for the dependent variables are displayed.

Special plotting and table variables

All the information about a plot is automatically stored in a set of reserved variables that you have direct access to. These variables are named *EQ*, *ΣDAT*, *PPAR*, *VPAR*, *ΣPAR*, and *ZPAR*. Similarly, the information regarding tables is automatically stored in *TPAR*.

Although these variables are *reserved*—which means that you should not use them as the name of some object you create—you can have different versions of these variables, providing that each version is in a separate directory.

EQ

EQ contains the current equation or the name of the variable containing the current equation. Specifically, EQ can contain:

- A single algebraic object or the name of a variable containing a single algebraic object.
- A real number—or complex number in the case of a parametric plot—or the name of a variable containing a real or complex number.
- A program that takes no parameters and yields exactly one result, or the name of a variable that contains such a program.
- A list containing any combination of the these possibilities.

∑DAT

ΣDAT contains the current data matrix for statistical plots or the name of the variable that contains the data matrix. It is the equivalent of EQ when you are plotting a scatter plot, bar chart, or histogram.

PPAR

PPAR stores the plot window and plot setup parameters for non-statistical plots. It is displayed as a list. In general, the objects in this list are:

{ (x_{min}, y_{min}), (x_{max}, y_{max}), *independent variable*, *resolution*, (*axes-intersection coordinates*), *plot type*, *dependent variable* }

The values in the list vary according to the type of plot. They are the parameters you find on the Plot Window input form and Plot Setup input form for the particular plot type.

VPAR

VPAR stores the view volume, eyepoint and plotting density parameters for 3-D plots. It is displayed as a list. In general, the objects in this list are:

$$\{ x_{\text{left}}, x_{\text{right}}, y_{\text{near}}, y_{\text{low}}, z_{\text{low}}, z_{\text{high}}, xx_{\text{left}}, xx_{\text{right}}, yy_{\text{left}}, yy_{\text{right}}, x_{\text{eyepoint}}, y_{\text{eyepoint}}, z_{\text{eyepoint}}, \textit{grid columns}, \textit{grid rows} \}$$

∑PAR

∑PAR stores the plot window and plot setup parameters for statistical plots. (See pages page 4-29 to page 4-34 for information about these parameters.)

ZPAR

ZPAR stores zoom information. It is displayed as a list, with the following parameters as elements:

{ *horizontal scale, vertical scale, recenter flag* }

These fields are described in “Setting the zoom factor” on page 4-37. In some instances, the list will include the *PPAR* variable as a final element.

TPAR

TPAR stores the table setup parameters. These are:

{ *starting value, step, table format, zoom factor, font size, filename* }