Chapter 25
3D Scatter Plots

When using other types of 3D plots, you need to make a matrix in which rows and columns correspond to *x* and *y* values and the value of the matrix element is the *z* value. Scatter plots, on the other hand, let you specify *x*, *y*, and *z* coordinates directly. This makes them useful for drawing parametric curves or for observing clusters of data in a 3D space. This chapter shows how three vectors can be used to build a scatter plot.

This chapter contains the following sections:

Creating a 3D scatter plot

Basic steps in creating a scatter plot.

Resizing scatter plots

Procedures for changing the size of scatter plots.

Formatting scatter plots

Procedures for changing scatter plots: setting the viewpoint and the presentation; adding labels; and formatting markers, lines, and axes.

Creating a 3D scatter plot

Scatter plots allow you to plot an arbitrary collection of points in a three-dimensional space. This is particularly useful for such tasks as identifying data clusters or tracing a trajectory of a point. Scatter plots differ from all other 3D plots as follows:

■ In all other 3D plots, you create a matrix in which the rows and columns correspond to x and y coordinates and the value of the matrix element is the corresponding z coordinate.

■ In scatter plots, you create three vectors with as many elements as there are points to plot. The x, y, and z coordinates of a point go into the three elements of the corresponding vectors.

Unlike other 3D plots, you can easily have several z values corresponding to the same x and y value. This is often necessary in statistical applications in which you take the same measurement more than once. You can also easily create parametric curves through a three-dimensional space since the indices of the vectors are themselves natural parameters to use.

To create a 3D scatter plot:

■ Define three vectors, each having as many elements as you have points to plot. Each vector contains either the x, y, or z coordinates of all the points.

■ Choose **Graph**⇒**3D Scatter Plot** from the **Insert** menu. Mathcad shows a box with a single placeholder as shown below:
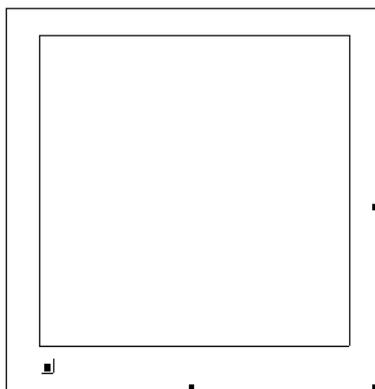
■ Type the names of the vectors, separated by commas, in the placeholder.

Just as with an equation, Mathcad will not process the scatter plot until you click outside the region.

If you have a matrix of rows and columns corresponding to the x and y coordinates that you want to show as a set of points, create a *surface plot*, double-click on it to bring up

the 3D Plot Format dialog box, and select Data Points in the Display As group on the View page. See "Changing your view of the surface plot" on page 524.

Resizing scatter plots

To change the size of a scatter plot, follow these steps:

■ Click in the scatter plot to select it.

■ Move the mouse pointer to one of the three handles along the edge of the scatter plot. The pointer will change to a double-headed arrow.
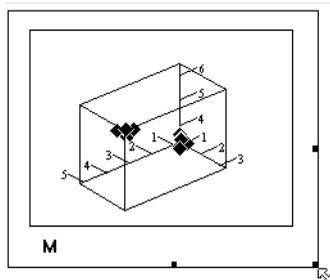
■ Press and hold down the mouse button. While holding down the button, move the mouse. The scatter plot will stretch in the direction of motion.

■ Once the scatter plot is the right size, let go of the mouse button.

■ Click outside the scatter plot to deselect it.

Formatting scatter plots

Mathcad gives you control over many of the visual characteristics of scatter plots. These can be categorized in four groups:

■ Viewing characteristics: the type of plot being displayed, the perspective or point of view from which you see the plot, and the presence or absence of borders, enclosing boxes, axes, and back planes.

■ Color and line formatting: how the plot will mark points; how markers will be connected; and the format of any lines connecting markers.

■ Axis formatting: whether to show tick marks or grid lines on each axis.

■ Title characteristics: how the plot will display titles.

To change any of these plot characteristics, start with the 3D Plot Format dialog box:

■ Click on the plot to select it.

■ Choose **Graph**⇒**3D Plot** from the **Format** menu. Alternatively, double-click on the plot itself. Mathcad brings up the 3D Plot Format dialog box. The View Page of this dialog box is shown below. The remaining three tabs take you to three additional pages.

■ If necessary, click the tab for the page you want to work with.

■ Make the appropriate changes in the dialog box.

■ To see the effect of your changes *without* closing the dialog box, click "Apply."

■ When you're finished, close the dialog by clicking "OK."
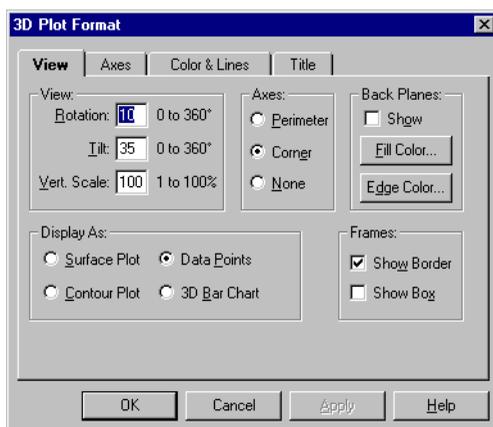
Changing your view of the scatter plot

The View page of the 3D Plot Format dialog box lets you modify the general presentation of your 3D scatter plot.

To change your plot from a scatter plot to another type of 3D plot, click on the appropriate button in the Display As group. You can convert a scatter plot into a Surface Plot, Contour Plot, or a 3D Bar Chart. These plot types are fully discussed in the corresponding chapters in this *User's Guide*.

When you view a scatter plot as a surface or contour plot or a 3D bar chart, Mathcad actually *interpolates* a surface that approximates your scatter data, using a 21 by 21 mesh by default. To change the density of this mesh, click on the Color & Lines tab and edit the number of rows and columns in the Interpolated Mesh group. If your data is not well approximated by a surface, Mathcad may be unable to compile a useful interpolation. If this occurs, Mathcad will signal this fact with a message in the status line.

As you view your scatter plot, you may not be able to perceive any patterns in your data. However, by examining the plot from another perspective, you may be able to isolate clusters of data. To change the perspective, or point of view, from which you

see the scatter plot, change the numbers in the Rotation and Tilt text boxes. Use an integer between 0 to 360 degrees. Figure 25-1 shows the effects of varying the rotation and tilt (as well as the scale) of a scatter plot.

■ Increasing the rotation turns the plot clockwise.

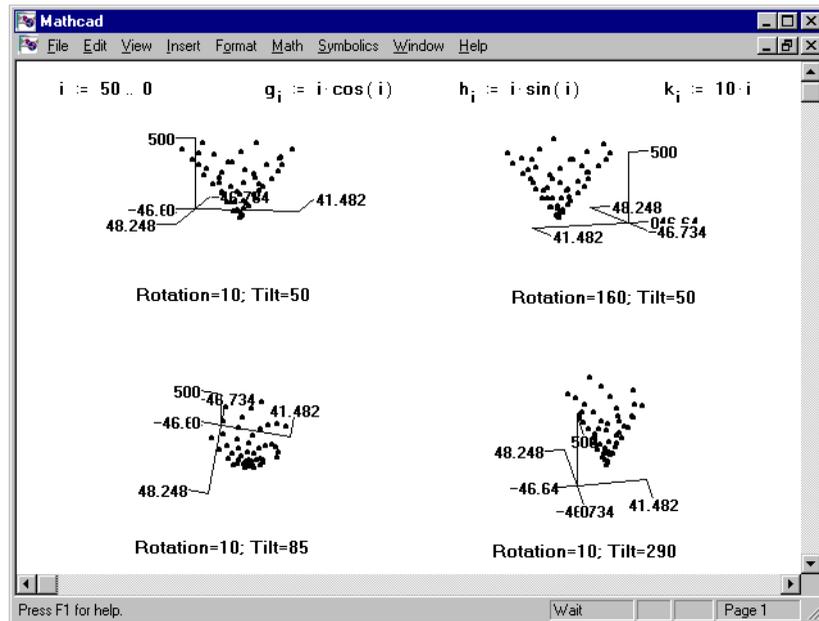■ Tilt controls whether you see the data edge on or whether you look down from directly overhead.

Figure 25-1: Changing the rotation and tilt of a scatter plot.

To add or remove a border around the scatter plot region, click on Show Border. The border is a two-dimensional frame around the scatter plot region.

To enclose the plot and the axes within a three-dimensional bounding box, click on Show Box in the Frames group to add a check.

To show the *xy*, *xz*, and *yz* back planes:

■ Click on Show in the Back Planes group.

■ To color the surface of the back planes, click on "Fill Color."

■ To outline the edges of the back planes in a particular color, click on "Edge Color."

Figure 25-2 shows a scatter plot with a border around it and with back planes showing together with the same plot enclosed within a box without showing back planes.
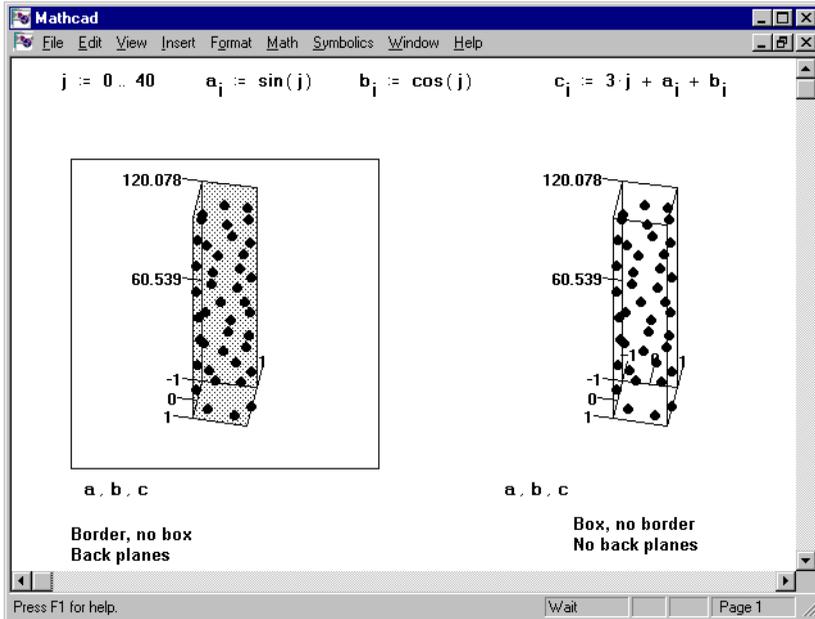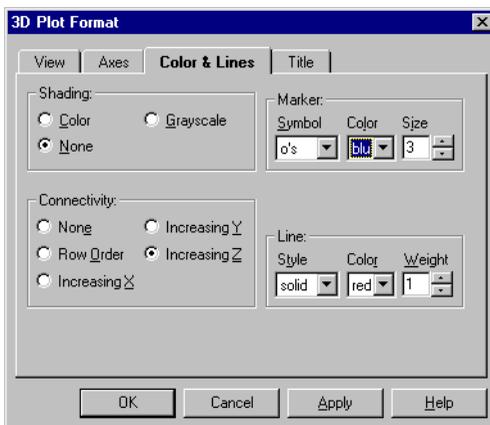
Figure 25-2: Using a border or an enclosing box on a scatter plot.

Changing the format of the markers

You can often make your scatter plot communicate more effectively by changing one of the following:

■ You can mark the points with a symbol.

■ You can connect the points with a line.

To do either of these, use the Color & Lines page of the 3D Plot Format dialog box.

To specify the type of marker your plot will use, select an option from each of the following drop-down lists:

- Symbol: Each point in the scatter plot is marked by a symbol. Select among o's, ×'s, +'s, boxes, and diamonds. You can also select "none"; however, if you do and you aren't using a connecting line, your plot will be blank.

- Color: The markers can be any of the colors listed on the drop-down list, for example, red, blue, green, magenta, cyan, brown, black, and white.

- Size: Markers can range in size from 1 (thinnest) to 10 (thickest).

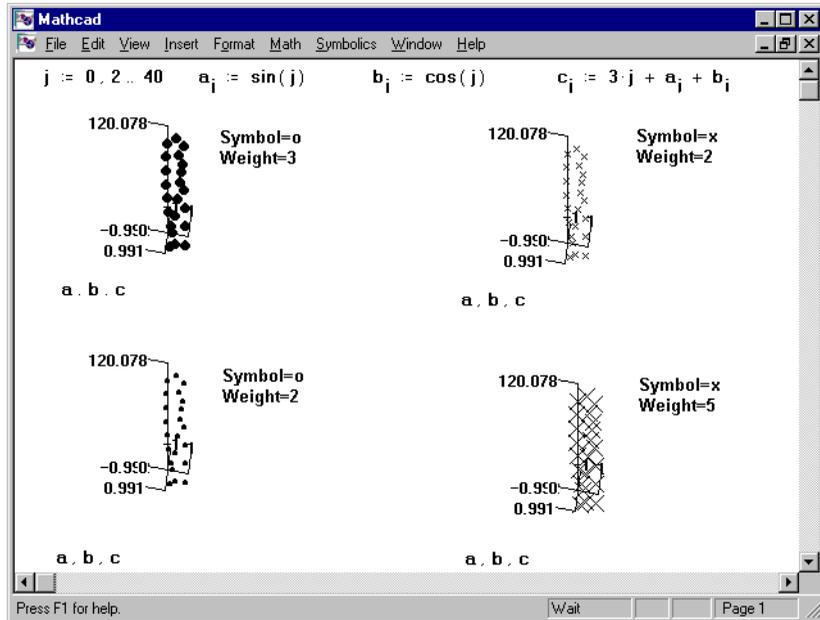Figure 25-3 shows the same plot with markers formatted in several ways.

Figure 25-3: Different formatting options for markers on a scatter plot.

If you are plotting data that shows progressive movement in a direction (for example, points in a trajectory), you may want to connect the data points with a line. Mathcad provides several options for connecting the data points:

- No line

- The order in which the points occur in the matrix (row order)

- Increasing x values

- Increasing y values

- Increasing z values

Use the buttons in the Connectivity group to choose which of these options Mathcad should use to connect the data points.

Once you've decided on the order for connecting the points, you can specify the way the line connecting them will look. Use the buttons in the Line group to choose:

- Style: The connecting line can be solid, dashed, dotted, or alternately dashed and dotted. You can also select "none"; however, if you do so and aren't using markers, your plot will be blank.

- Color: The lines can be any of the colors on the drop-down list.

- Weight: Lines can range in size from 1 (lightest) to 10 (the heaviest).

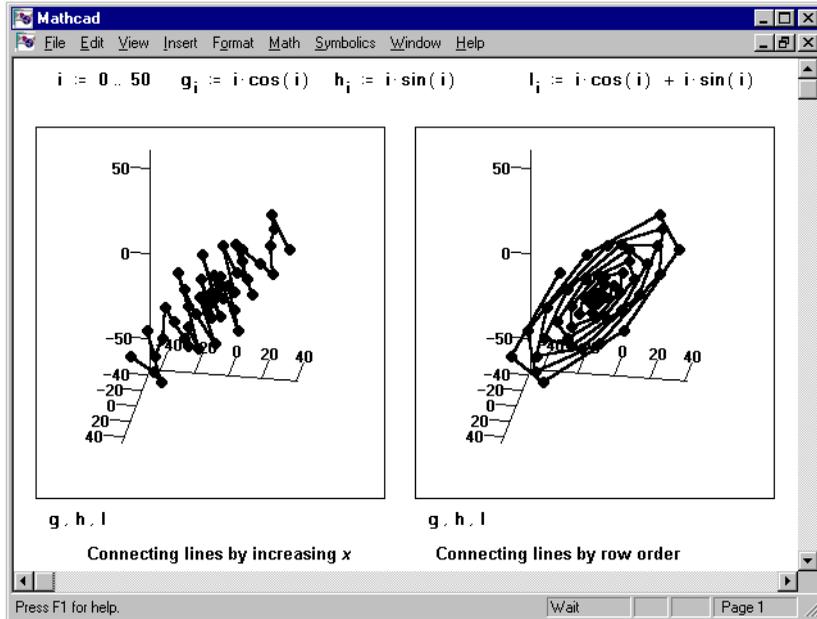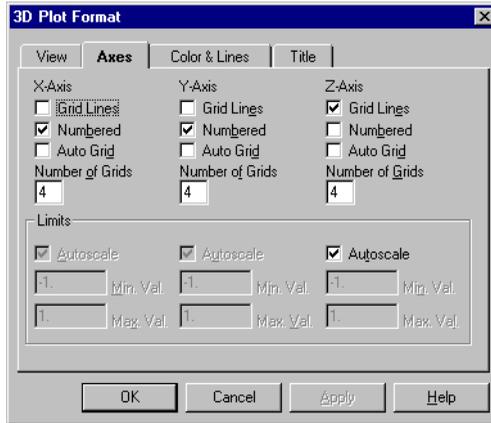Figure 25-4 shows the same plot connected in different orders.

Figure 25-4: Passing a line through points on a scatter plot.

Formatting the axes

The Axes page of the 3D Plot Format dialog box lets you modify the format of the *x, y,* and *z* axes of your plot. Each axis is described by its own set of check boxes and text boxes.

Mathcad generates grid lines on the plot at the same positions as the tick marks. To choose between using tick marks or grid lines on a selected axis, use the Grid Lines check box. When Grid Lines is checked, Mathcad adds grid lines to the plot. Figure 25-5 shows the same scatter plot with and without grid lines.
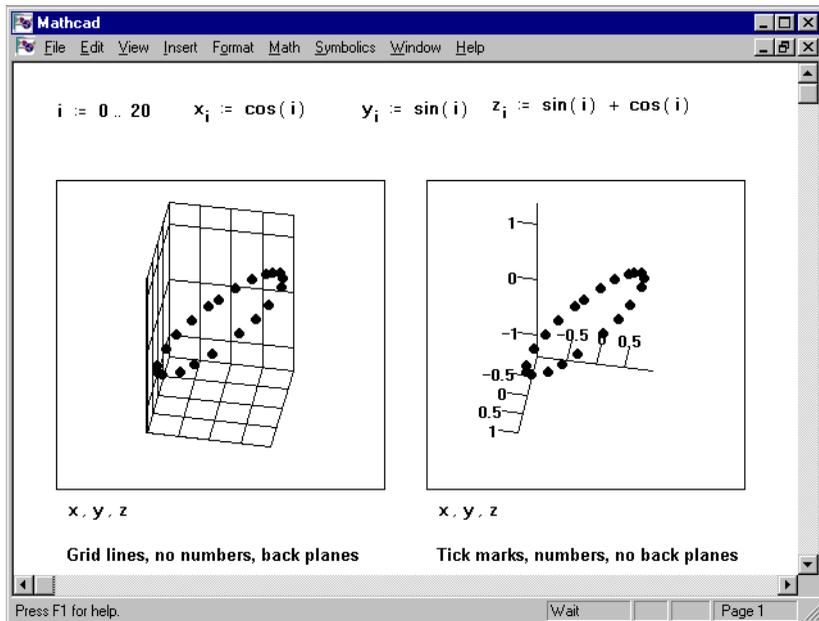

Figure 25-5: Using the different options for axes on a scatter plot.

To add or remove numbers for the tick marks on an axis, use the Numbered check box for that axis. The plot with grid lines in Figure 25-5 doesn't have numbers on the axes while the plot without grid lines does have them.

You can have Mathcad automatically select the number of grid intervals on an axis or you can specify the number yourself. Grid intervals are the spaces between tick marks or grid lines.

■ To have Mathcad select the number of grid intervals, use the Auto Grid check box. When Auto Grid is checked, Mathcad will automatically select the number of grid intervals on the specified axis.

■ To specify the number of grid intervals on an axis *yourself*, enter an integer from 1 to 99 in the No. of Grids text box. This text box is only available when Auto Grid is unchecked.

By default, Mathcad sets the axis limits according to the data ranges in the three input vectors. However, you can set these limits by hand as follows:

■ Click on the Autoscale box in the appropriate axis columns of the Axes page to uncheck it.

■ Enter the maximum and minimum values in the Max. Val. and Min. Val. text boxes.

Fixing the axis limits in this way is useful when you are comparing plots of related data sets or setting up an animation sequence.

Labeling the scatter plot

The Title page of the 3D Plot Format dialog box, shown below, lets you add and modify labels on your scatter plot.
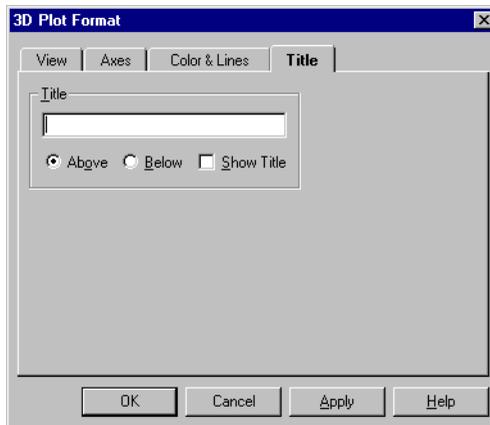
To add or edit a title for your scatter plot:

■ Type the title for your plot into the Title text box.

■ To display the title, click on Show Title to insert a check. To conceal the title without deleting it, click on Show Title to remove the check.

■ To position the title, click on either the Above or Below button. Mathcad places the title either directly above or below your plot.

■ To change the title's text, edit the information in the Title group as appropriate.

- Click "OK" to close the dialog box when you have finished.

- To delete the title, highlight it and press **[Del]**.

If you initiate this process by double-clicking on the title itself, you'll see an equivalent dialog box.
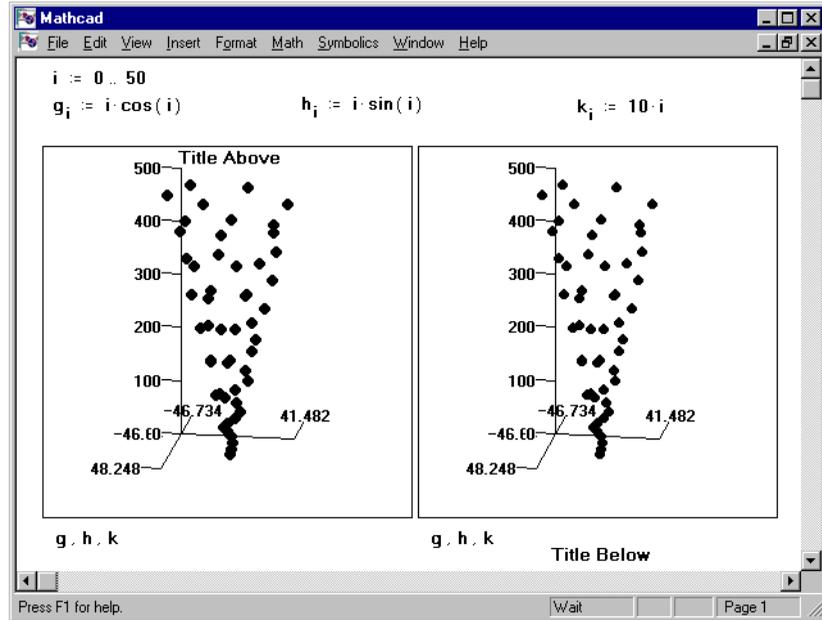
Figure 25-6 shows how Mathcad positions titles on a scatter plot.

Figure 25-6: Titles on a scatter plot.

Chapter 25 3D Scatter Plots