



Chapter 12

2D Plots

To visualize a function of one variable, an expression of one variable, paired data, or a vector, you can create an X-Y plot or a polar plot.

The following sections describe the use of these plots:

Overview of 2D plotting

Introduction to creating X-Y and polar plots.

Graphing functions and expressions

Procedures for graphing a function or expression or one function or expression against another. Multiple traces on a single plot.

Graphing vectors and data

Procedures for graphing a single vector or one vector against another.

Formatting a 2D plot

Procedures for modifying and setting the default formats of axes and traces in an X-Y or polar plot. Adding a title, axis labels, and other labels.


Modifying your 2D plot's perspective

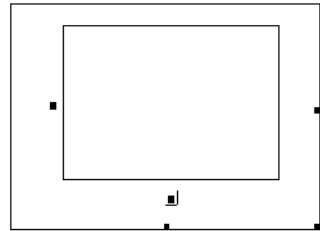
Zooming in on a portion of a plot, and finding coordinates.

Overview of 2D plotting


To visually represent a function or expression of a single variable or X-Y data in Mathcad, you can create an X-Y plot. Or, to plot functions, expressions, or data that don't lend themselves well to Cartesian (X-Y) coordinates, you can create a polar plot. While a typical X-Y plot shows a horizontal value x versus a vertical value y , a typical polar plot shows the value of a radial expression r versus an angular expression θ . See Figure 12-1 for examples.

For example, to create an X-Y plot:

- Click in your worksheet wherever you want the graph to appear.
- Choose **Graph**⇒**X-Y Plot** from the **Insert** menu
or click  on the Graph toolbar. Alternatively, type @. Mathcad inserts a blank X-Y plot.
- Fill in the placeholders on the bottom (x -axis) and on the left (y -axis) with a function, expression, or variable.
- Enter the axis limits if you want to specify them in the placeholders that appear on the axes. Or leave these placeholders empty, and Mathcad automatically chooses limits.
- Click outside the plot or press [**Enter**].



Mathcad creates the plot over a default range using default format settings. See “Formatting a 2D plot” on page 245 for information on specifying a range. See “Formatting a 2D plot” on page 245 to change the format of a plot.

Tip To create an X-Y *QuickPlot* of an expression, enter an expression of one variable and then click  on the Graph toolbar. Mathcad automatically creates an X-Y plot of that expression over a default range of values of the variable on the x -axis. See page 238.

To resize a plot, click in the plot to select it. Then move the cursor to a handle along the edge of the plot until the cursor changes to a double-headed arrow. Hold the mouse button down and drag the mouse in the direction that you want the plot's dimension to change.

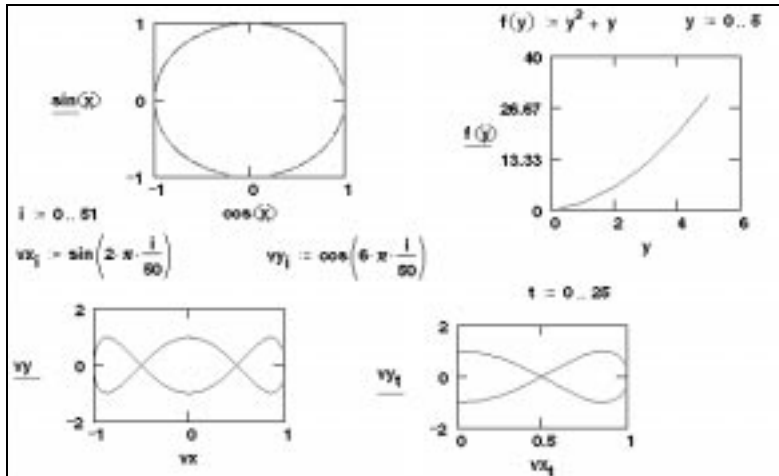



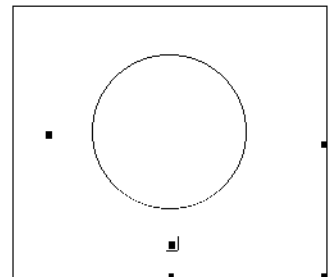
Figure 12-1: Examples of 2D plots.

Note If a point is complex or invalid, Mathcad does not graph it. To graph the real or imaginary part of a point or expression, use the *Re* and *Im* functions to extract the real and imaginary parts, respectively.

When you create a polar plot by choosing **Graph⇒Polar Plot** from the **Insert** menu or

clicking  on the Graph toolbar, Mathcad inserts a blank polar plot.

You fill in the placeholders on the bottom (angular axis) and on the left (radial axis) with a function, expression, or variable. Click outside the plot or press **[Enter]** to see the plot.



Note If some points in a function or expression are valid and others are not, Mathcad plots only the valid ones. If the points are not contiguous, Mathcad does not connect them with a line. You may therefore see a blank plot if none of the points are contiguous. To see the points, format the trace to have symbols. See “Formatting a 2D plot” on page 245 for information on formatting traces.

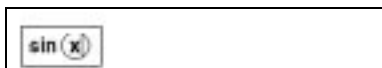
The remaining sections in this chapter focus on plotting functions, expressions, and data. Although the pictures associated with the instructions typically show X-Y plots, the instructions apply to polar plots as well.


Graphing functions and expressions

When plotting a single Mathcad expression or function, you can create either an X-Y plot or a polar plot. For example, to create an X-Y plot of a single expression or function:

- Click in your worksheet wherever you want the graph to appear.

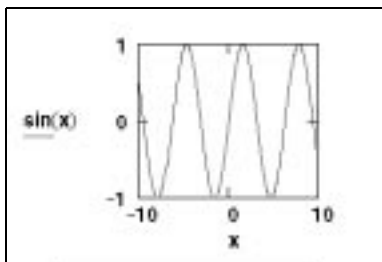
- Enter the expression or function of a single variable you want to plot. Make sure the editing lines remain in the expression.



- Choose **Graph**⇒**X-Y Plot** from the **Insert** menu or click  on the Graph toolbar.

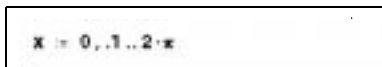
- Press [**Enter**] or click outside the graph.

Mathcad automatically produces a plot over a default range of the independent variable: -10 to 10. A plot such as this, where Mathcad automatically chooses the range for the independent variable, is called a *QuickPlot*.

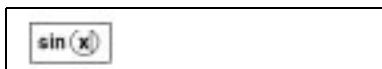



If you don't want Mathcad to use a default range for the plot, you can define the independent variable as a range variable before creating the plot. For example:

- Define a range variable, such as x , that takes on the values you want to graph. (The range variable need not be called x ; you can use any valid name.) See "Range variables" on page 125.



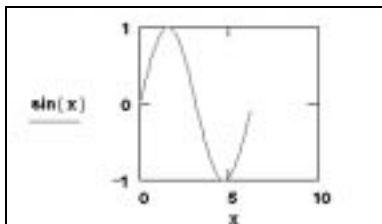
- Enter the expression or function of a single variable you want to plot. Make sure the editing lines remain in the expression.



- Choose **Graph**⇒**X-Y Plot** from the **Insert** menu or click  on the Graph toolbar.

- Press [**Enter**] or click outside the graph.

Mathcad graphs one point for every value of the range variable, and, unless you specify otherwise, connects each pair of points with a straight line.



Tip To override Mathcad's choices for the axis limits on a plot, click on the limits in the plot and edit the placeholders. See "Setting axis limits" on page 245 for more information.


Multiple traces

You can graph several traces on the same X-Y or polar plot. A graph can show several y-axis (or radial) expressions against the same x-axis (or angular) expression. Or it can match up several y-axis (or radial) expressions with a single corresponding x-axis (or angular) expression.

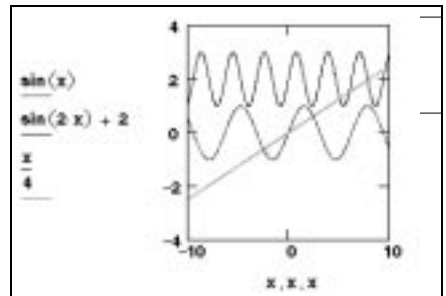
To graph more than one function or expression on an X-Y plot, for example:

- Enter the expressions or functions of a single variable you want to plot, separated by commas. Make sure the editing lines remain in the expression.

$\sin(x), \sin(2x) + 2, \frac{x}{4}$

- Choose **Graph**⇒**X-Y Plot** from the **Insert** menu or click  on the Graph toolbar.

- Press [**Enter**] or click outside the graph.



Mathcad produces a QuickPlot of all the expressions or functions, over a range of -10 to 10 for the variable on the x -axis. You can change the axis range by editing the upper and lower limits on the x -axis as described in "Setting axis limits" on page 245.

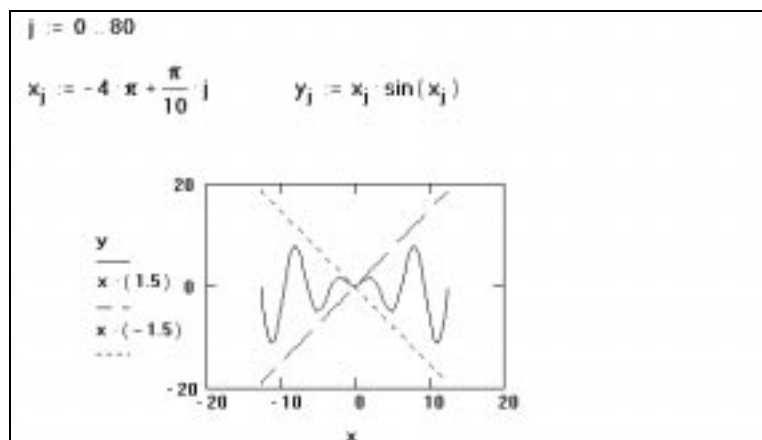



Figure 12-2: Graph with multiple y-axis expressions.

To graph several independent curves on the same set of axes:

- Choose **Graph**⇒**X-Y Plot** from the **Insert** menu or click  on the Graph toolbar.
- Enter two or more expressions separated by commas on the y-axis.
- Enter the same number of expressions separated by commas on the x-axis.

Mathcad matches up the expressions in pairs—the first x -axis expression with first y -axis expression, the second with the second, and so on. It then draws a trace for each pair. Each matching pair of expressions should use the same range variable. However, the range variable for one pair need not match the range variables for the other pairs. Figure 12-3 shows an example.

Note All traces on a graph share the same axis limits. For each axis, all expressions and limits on that axis must have compatible units.

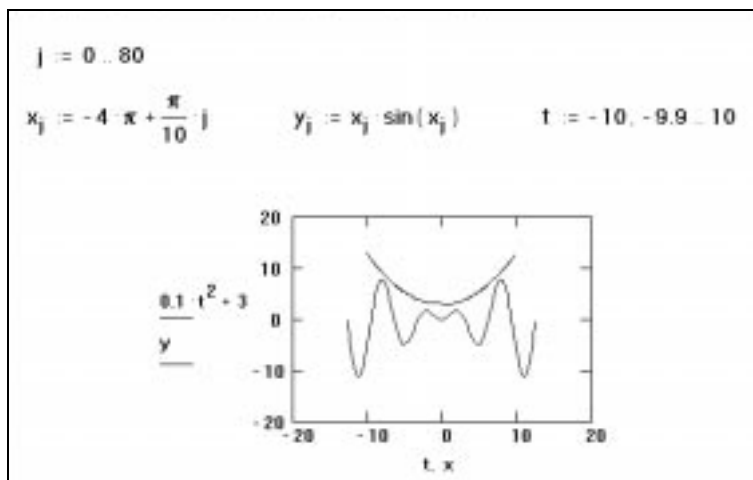



Figure 12-3: Graph with multiple expressions on both axes.

Graphing one function or expression against another

You can graph one function or expression against another in either an X-Y plot or a polar plot. The expressions must refer to the same independent variable. For example:

- Click in your worksheet wherever you want the graph to appear.
- Choose **Graph**⇒**X-Y Plot** from the **Insert** menu or click  on the Graph toolbar. Mathcad inserts a blank X-Y plot with empty placeholders.
- In the placeholder on the bottom, enter the function or expression to plot against.
- In the placeholder on the left, enter the function or expression to plot.

- Enter the axis limits in the remaining placeholders, if you want to specify them. If you do not specify the limits, Mathcad automatically chooses limits for you.
- Click away from the plot or press **[Enter]**.

Mathcad automatically produces a QuickPlot over a default range of the independent variable. The first graph in Figure 12-1 shows an example.

If you don't want Mathcad to use a default range for the plot, first define the independent variable as a range variable before creating the plot. Mathcad graphs one point for each value of the independent variable and connects each pair of points with a straight line. Figure 12-4 shows two functions of θ plotted against each other. The range variable θ was previously defined. For information, see "Range variables" on page 125.

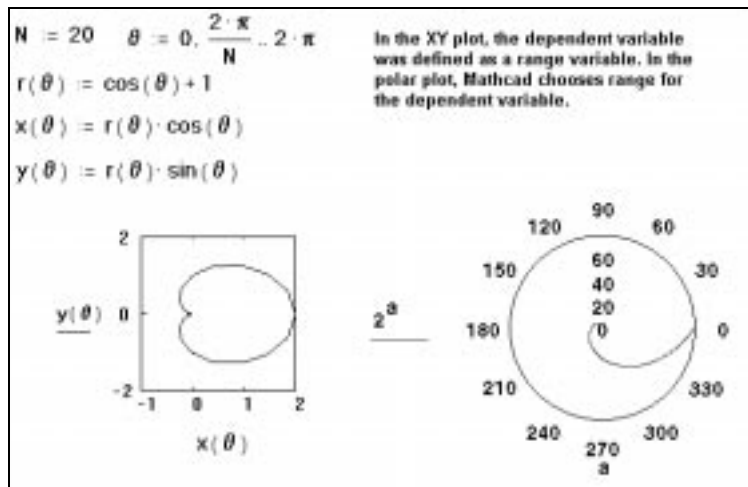



Figure 12-4: Graphing one function against another.

Graphing vectors and data

To graph the elements of a vector, you can create either an X-Y plot or a polar plot. When creating either type, you need to use the vector subscript operator (see "Vector and matrix operators" on page 154) to specify which elements to plot. Some graphs of vectors are shown in Figure 12-5.

To graph a vector on an X-Y plot, for example:

- Define a range variable such as i that references the subscript of each element of the vector you want to plot.
- Click in your worksheet wherever you want the graph to appear.

- Choose **Graph**⇒**X-Y Plot** from the **Insert** menu or click  on the Graph toolbar. Mathcad inserts a blank X-Y plot.
- Place i in the bottom placeholder and place the vector name together with the subscript (y_i for example) in the placeholder on the left. Type `[]` as a shortcut to create the subscript.
- Press **[Enter]** or click outside the graph to see the result.

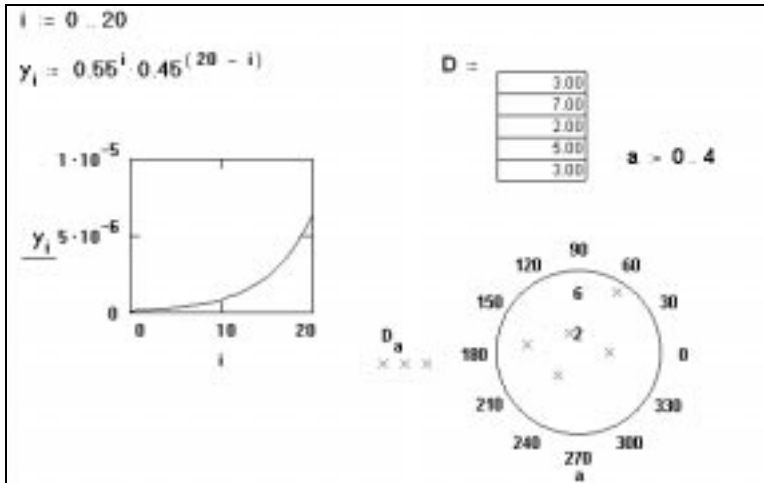


Figure 12-5: Graphing a vector.


Note Subscripts must be non-negative integers (or integers greater than or equal to ORIGIN, if ORIGIN≠0). This means that the x -axis or angular variable used in the graphs in Figure 12-5 can run through whole-number values only. If you want to graph fractional or negative values on the x -axis, graph a function or graph one vector against another, as described in the next section.

Tip If you have a handful of data points, you can use an input table to create a vector as shown in the second graph in Figure 12-5. For more information, see “Entering data into a table” on page 222.

Graphing one vector against another

To graph all the elements of one vector against all the elements in another, enter the names of the vectors in the axis placeholders on the X-Y plot or polar plot operator. For example, to create an X-Y plot of two vectors x and y , do the following:

- Define the vectors x and y .
- Click in your worksheet wherever you want the graph to appear.

- Choose **Graph**⇒**X-Y Plot** from the **Insert** menu, or click  on the Graph toolbar. Mathcad inserts a blank graph with empty placeholders.
- Place y in the placeholder on the y -axis and x in the placeholder of the x -axis.
- Press [**Enter**] or click outside the graph to see the result.

Mathcad plots all the elements in the vector x against the elements in the vector y .

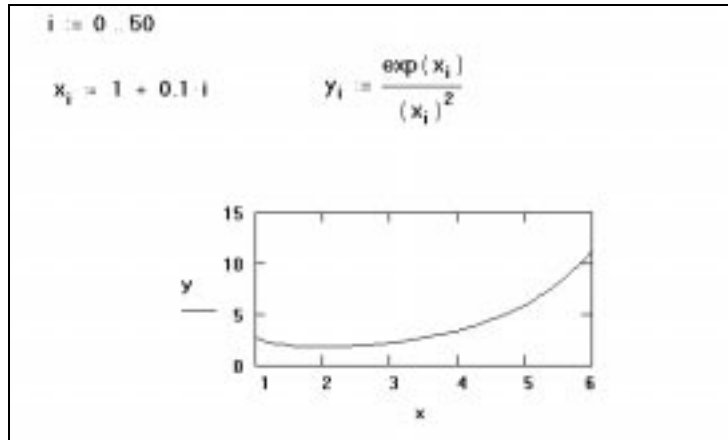


Figure 12-6: Graphing two vectors.

Note If the vectors being plotted are not the same length, Mathcad plots the number of elements in the shorter vector.

If you want to plot only certain vector elements, define a range variable and use it as a subscript on the vector names. For instance, in the example outlined above, you could plot only the fifth through tenth elements of x and y against each other. To do so:

- Define a range variable such as k going from 4 to 9 in increments of 1. (Note that the first elements of the vectors x and y are x_0 and y_0 by default.)
- Enter y_k and x_k in the axis placeholders.

Note The range variable on a vector must have integer values. However, Figure 12-7 shows how you can calculate vectors in terms of other vectors of equally spaced non-integer values.

Formatting a 2D plot

When you create an X-Y plot or a polar plot, Mathcad uses the default settings to format the axes and traces. You can, however, reformat a plot's axes and traces. You can also add titles and labels and control the default plot settings.

To format a 2D plot:

- Double-click the plot. Alternatively, click once on the plot and choose **Graph**⇒**X-Y Plot** or **Graph**⇒**Polar Plot** from the **Format** menu. You'll see the dialog box for formatting a selected plot.
- Click the tab for the page you want to work with. Use the **Axes** tab to determine the appearance of the axes and grid lines. Use the **Traces** tab to set the color, type, and width of the traces. Use the **Labels** tab to insert labels on the axes. Use the **Defaults** tab to specify the default appearance of plots.



- Make the appropriate changes in the dialog box.
- Click “Apply” to see the effect of your changes *without* closing the dialog box.
- Close the dialog by clicking “OK.”

Note In the **Axes** page, make sure you turn options on and off in the appropriate axis column. In the **Traces** page, click on a trace's name in the **Legend Label** column and change characteristics by clicking on the arrow beside each of the drop-down options.

Tip If you double-click an axis on a plot, you'll see a formatting dialog box for that axis alone.

On-line Help Click “Help” in the dialog box for details on particular formatting options.

Setting axis limits

When you create a 2D plot, the **Autoscale** option is turned on. Use the **Axes** page of the plot formatting dialog box to turn **Autoscale** on or off:

- With Autoscale on, Mathcad automatically sets each axis limit to the first major tick mark beyond the end of the data. This is a reasonably round number large enough to display every point being graphed.
- With Autoscale off, Mathcad automatically sets the axis limits exactly at the data limits.

Specifying other limits

You can override Mathcad's automatic limits by entering limits directly on the graph. To do so:

- Click the graph to select it. Mathcad displays four additional numbers, one by each axis limit. These numbers are enclosed within corner symbols, as illustrated in the selected plot in Figure 12-9.
- Click on one of these numbers and type a number to replace it. Do the same for the other numbers if you want to change more than one limit.
- Click outside the graph. Mathcad redraws it using the new axis limits you specified. The corner symbols below the limits you changed disappear. Figure 12-9 shows the effect of manually setting limits on a graph.

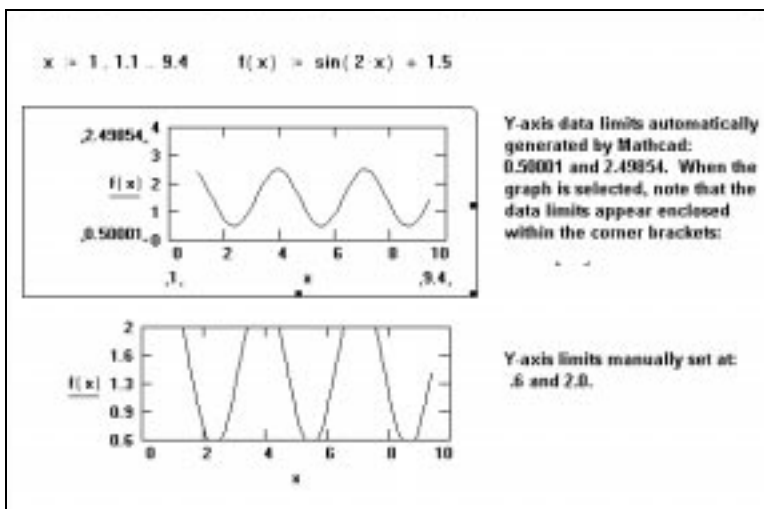


Figure 12-9: Data limits set manually and automatically.

Setting default formats

Mathcad uses default settings to format the axes and traces of new graphs you create.

Copying defaults from an existing graph

One way to create a new set of defaults is to use the format settings of an existing graph. The advantage of this method is that you can actually see how the format settings look as you define them.

To use the format of a particular graph as the default graph format:

- Double-click the graph, or click in the graph and choose **Graph⇒X-Y Plot** (or **Graph⇒Polar Plot**) from the **Format** menu. Mathcad displays the dialog box for formatting a selected graph.
- Click the Defaults tab to see the Defaults page.
- Check Use for Defaults. When you click “OK,” to close the dialog box, Mathcad saves these settings as your default settings.



Setting defaults without using a graph

You can use the Setting Default Formats dialog box to change default plot settings. To set defaults this way:

- Make sure that you don't have any graphs selected.
- Choose **Graph⇒X-Y Plot** (or **Graph⇒Polar Plot**) from the **Format** menu. You'll see the Setting Default Formats dialog box.
- Change the appropriate settings on the Axes and Traces pages.
- Click “OK” to accept your changes and close the dialog box.


Modifying your 2D plot's perspective

Mathcad provides options for manipulating the presentation of your X-Y plot or your polar plot:

- You can zoom in on a portion of the plot.
- You can get the coordinates for any point that was plotted to construct the plot.
- You can get the coordinates for any location within the plot.

Zooming in on a plot

Mathcad allows you to select a region of a plot and magnify it. To zoom in on a portion of a plot, follow these steps:

- Click in the plot and choose **Graph**⇒**Zoom** from the **Format** menu, or click  on the Graph toolbar. The Zoom dialog box appears. The X-Y plot Zoom dialog box is shown to the right.



- If necessary, reposition the Zoom dialog box so that you can see the entire region of the plot you want to zoom.
- Click the mouse at one corner of the region in the plot you want to magnify.
- Press and hold down the mouse button and drag the mouse. A dashed selection outline emerges from the anchor point. The coordinates of the selected region are listed in the Min and Max text boxes (or the Radius text box of the Polar Plot Zoom dialog box).
- When the selection outline just encloses the region you want to magnify, let go of the mouse button. If necessary, click on the selection outline, hold the mouse button down, and move the outline to another part of the graph.
- Click “Zoom” to redraw the plot. The axis limits are temporarily set to the coordinates specified in the Zoom dialog box. To make these axis limits permanent, click “OK.”

Tip If you’re working with a plot that has already been zoomed, you can restore the original appearance of the plot. To do so, click “Full View” in the Zoom dialog box.

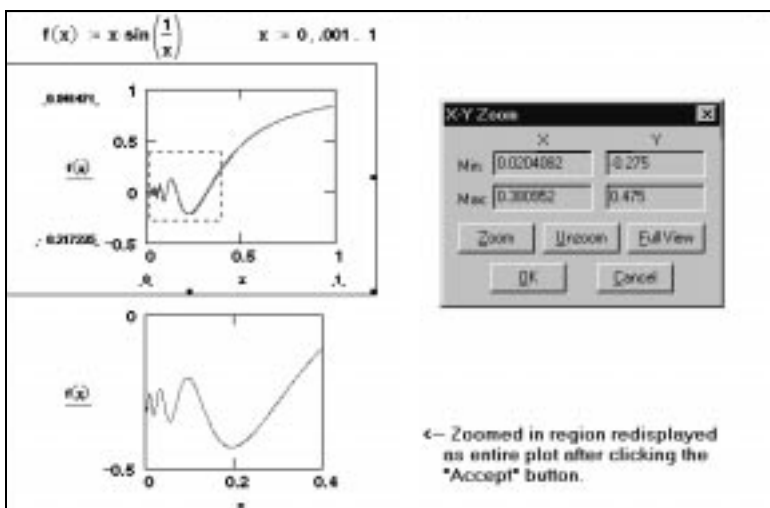



Figure 12-10: A zoomed-in region of an X-Y plot.

Getting a readout of plot coordinates

To see a readout of plot coordinates of the specific points that make up a trace, follow these steps:

- Click in the plot and choose **Graph**⇒**Trace** from

the **Format** menu, or click  on the Graph toolbar. The Trace dialog box appears as in the example at right. Check “Track Data Points” if it isn’t already checked. If necessary, reposition the Trace dialog box so that you can see the entire plot.



- Click and drag the mouse along the trace whose coordinates you want to see. A dotted crosshair jumps from one point to the next as you move the pointer along the trace.
- If you release the mouse button, you can use the left and right arrows to move to the previous and next data points. Use the up and down arrows to select other traces.
- As the pointer reaches each point on the trace, Mathcad displays the values of that point in the X-Value and Y-Value boxes (or the Radius and Angle boxes in the Polar Trace dialog box).
- The values of the last point selected are shown in the boxes. The crosshair remains until you click outside the plot.

Tip When Track Data Points is unchecked in the Trace dialog box, you can see a readout of plot coordinates for any location in a graph, not just the data points that created the graph.

Figure 12-11 shows an example of a graph whose coordinates are being read.

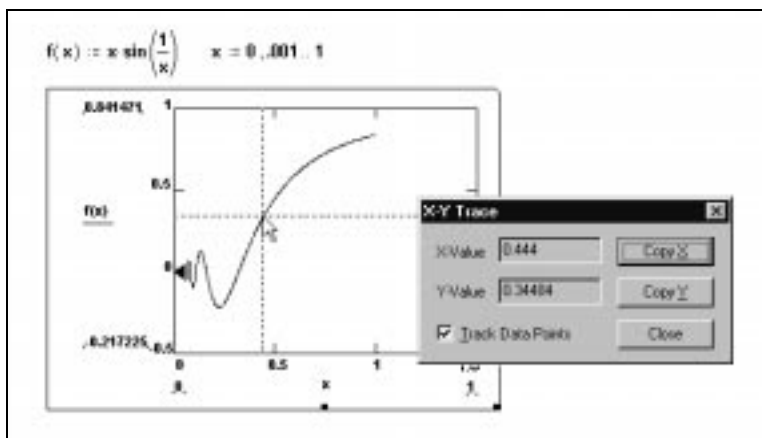


Figure 12-11: Reading coordinates from a graph.

To copy and paste a coordinate using the Clipboard:

- Click “Copy X” or “Copy Y” (or “Copy Radius” or “Copy Angle” in the case of a polar plot).
- You can then paste that value into a math or text region in your Mathcad worksheet, into a spreadsheet, or into any other application that allows pasting from the Clipboard.