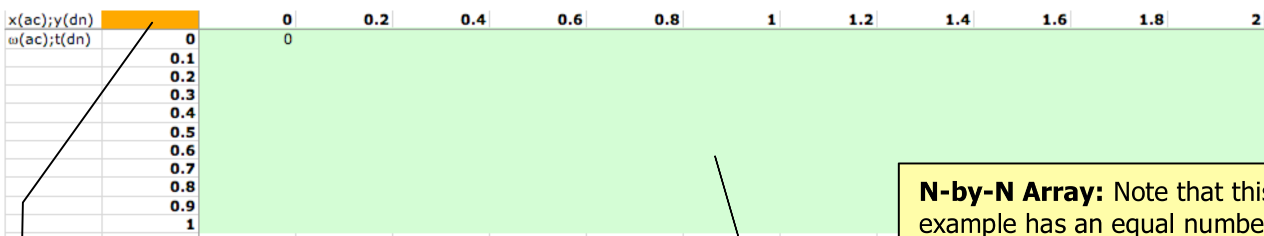
Three-Dimensional (Surface) Plots

Creating a Data Array

3-Dimensional plots (surface plots) are often useful for visualizing the behavior of functions and identifying important mathematical/physical features of these functions. Such plots reveal how a particular unknown quantity will vary as a function of two (or more) known (but variable) quantities. Creating 3-D plots in Excel requires an N-by-N (Row x Column) array of values (much like a multiplication table) with the x-variable in the top row and the y-variable in the left most column of the array. Given that Excel doesn't auto-scale the axes of a 3-D plot, using an N-by-N array (that is to say, an array with an equal number of values for the x- and y-variables), will produce a 3-D plot that is "square." Having more total values in along one axis than another will produce a plot that is more "rectangular" in appearance. A plot that is too narrow may not be as visually interesting or informative.

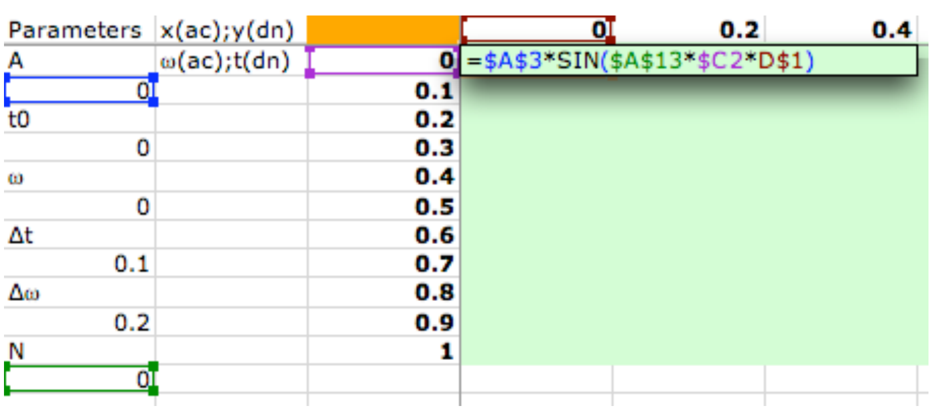


Leave the Upper Lefthand Cell Empty: Keeping this empty will guarantee that the x- and y-axes contain the correct values once the plot is produced.

N-by-N Array: Note that this example has an equal number of rows and columns. This will produce a "square" 3-D plot even though the <u>range</u> of values is not the same.

Writing Functions with Mixed Addressing

The sample plot created here is simply a sine function of the form z = Asin(Nωt), where A and N are constants (for the moment) and ω and t are the x- and y-variables. The x-variable, in this case ω, is located in the horizontal row and the y-variable ("t") is found in the leftmost column. When writing the equation into the N-by-N array, it is necessary to use mixed addressing for each variable (in this example, D$1 for ω and $C2 for t).

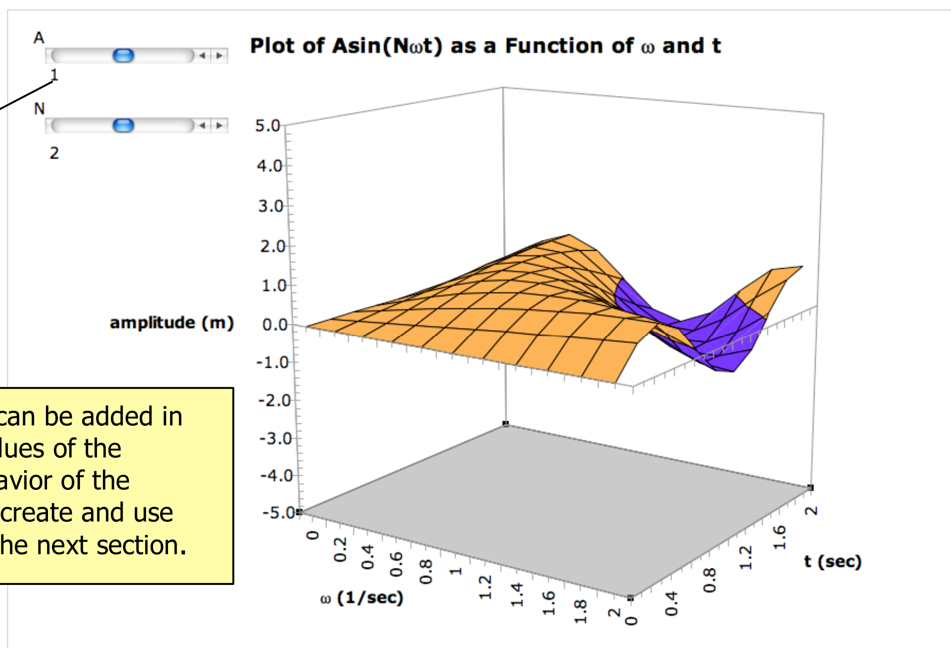


	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Parameters	x(ac);y(dn)		**0**	**0.2**	**0.4**	**0.6**	**0.8**	**1**	**1.2**	**1.4**	**1.6**	**1.8**	**2**
2	A	ω(ac);t(dn)	**0**	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	1		**0.2**	0.0000	0.0799	0.1593	0.2377	0.3146	0.3894	0.4618	0.5312	0.5972	0.6594	0.7174
4	to		**0.4**	0.0000	0.1593	0.3146	0.4618	0.5972	0.7174	0.8192	0.9001	0.9580	0.9915	0.9996
5	0		**0.6**	0.0000	0.2377	0.4618	0.6594	0.8192	0.9320	0.9915	0.9940	0.9396	0.8314	0.6755
6	ω		**0.8**	0.0000	0.3146	0.5972	0.8192	0.9580	0.9996	0.9396	0.7843	0.5494	0.2586	-0.0584
7	0		**1**	0.0000	0.3894	0.7174	0.9320	0.9996	0.9093	0.6755	0.3350	-0.0584	-0.4425	-0.7568
8	Δt		**1.2**	0.0000	0.4618	0.8192	0.9915	0.9396	0.6755	0.2586	-0.2167	-0.6430	-0.9240	-0.9962
9	0.2		**1.4**	0.0000	0.5312	0.9001	0.9940	0.7843	=A3*SIN(A13*$C9*I$1)			-0.9731	-0.9468	-0.6313
10	Δω		**1.6**	0.0000	0.5972	0.9580	0.9396	0.5494	-0.0584	-0.6430	-0.9731	-0.9181	-0.4996	0.1165
11	0.2		**1.8**	0.0000	0.6594	0.9915	0.8314	0.2586	-0.4425	-0.9240	-0.9468	-0.4996	0.1955	0.7937
12	N		**2**	0.0000	0.7174	0.9996	0.6755	-0.0584	-0.7568	-0.9962	-0.6313	0.1165	0.7937	0.9894
13	2													

Mixing Addressing of x- and y-variables:
Once the equation is entered into the first cell and subsequently "copy-dragged" into the rest of the array, the x-variable in the function will always be selected from Row 1 and the y-variable from Column C. The column and row references for the x- and y-variables will vary according to the column and row location of a particular calculation.

Creating a 3-Dimensional Plot

Once the data array is produced, the 3-D plot is created by selecting the entire array (including the row and column for the x- and y-variables, respectively) and choosing the Surface plot option in the Chart Wizard dialog box. The plot should be formatted in the manner outlined in the ***Plotting Data Using Chart Wizard*** section of this Guide.

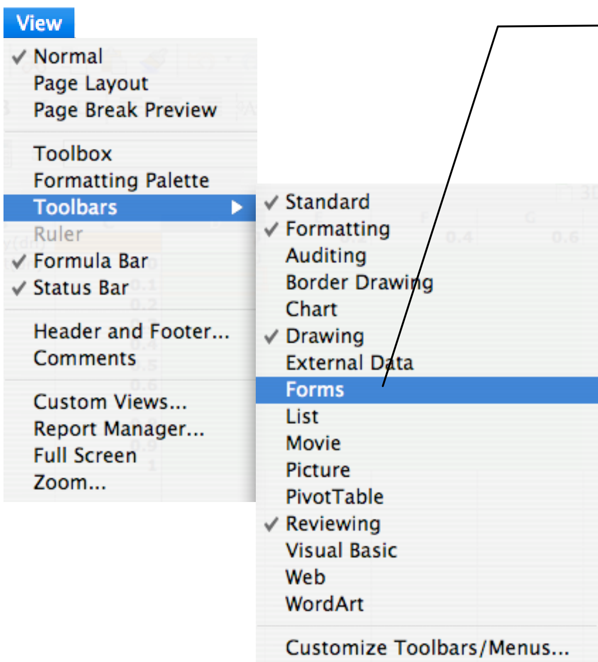


Scrollbars: Scrollbars ('sliders') can be added in order to demonstrate how the values of the constants A and N affect the behavior of the function. A discussion of how to create and use these scrollbars can be found in the next section.

Scrollbars

Scrollbars are extremely useful visualizing how different variables, particularly those not directly plotted, can affect the behavior of a particular function. In the example above, ω and t are the x- and y-variables being plotted but scrollbars are used to reveal how N and A also affect the function.

Creating Scrollbars



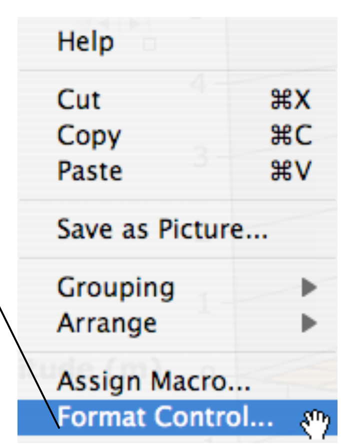
Open the **Forms toolbar** located in the View menu to create scrollbars.

Forms Toolbar: Scrollbar option highlighted.

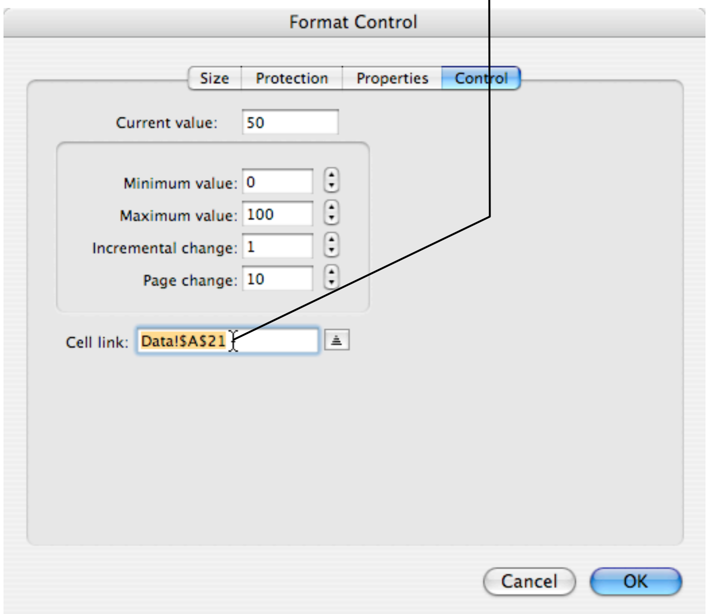
Scrollbars can be placed on either a plot or a worksheet. As with most objects, they can be sized by selecting the scrollbar and then clicking, holding and dragging the bar as desired.

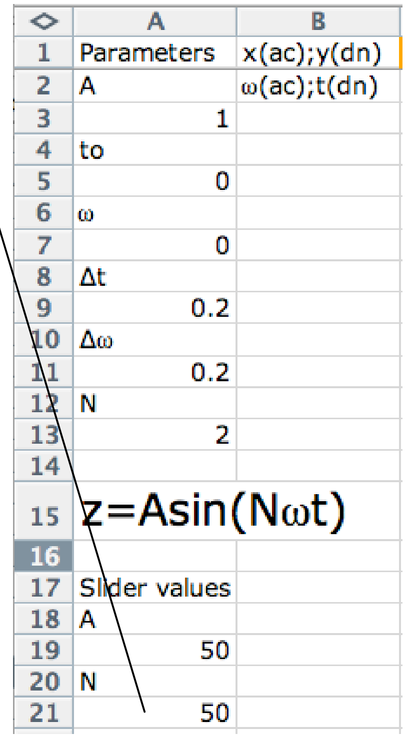
Linking Scrollbars to Spreadsheet Data

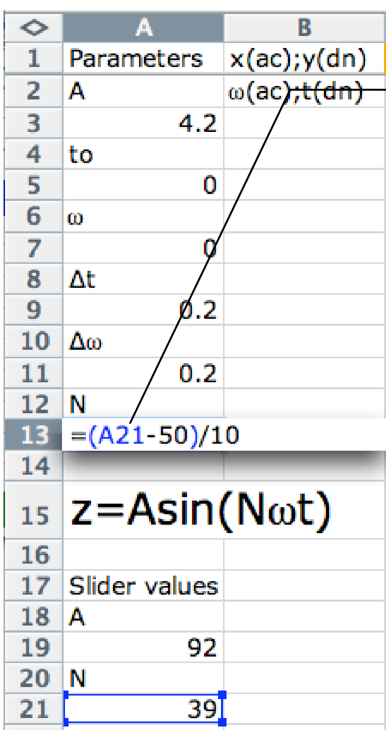
Contextual menu for Scrollbars: The numeric value generated by a scrollbar can be linked to a specific cell on a spreadsheet. This value may be linked to other calculations on the spreadsheet in order to produce and observe (graphically) the effect of this variable on a particular function. Control-click (right-click) on the scrollbar to open this contextual menu and select the **Format Control...** option.



Scrollbar values: Given that scrollbars produce positive integer values (default range: 0 to 100), it is a good idea to link the scrollbar value to a "dummy" cell on the spreadsheet. This cell can then be "re-referenced" to another cell on the sheet in order to produce values in a desired range (including, if desired, both positive and negative values). Here, the scrollbar for the N value is linked to cell A21 on the worksheet named "Data"



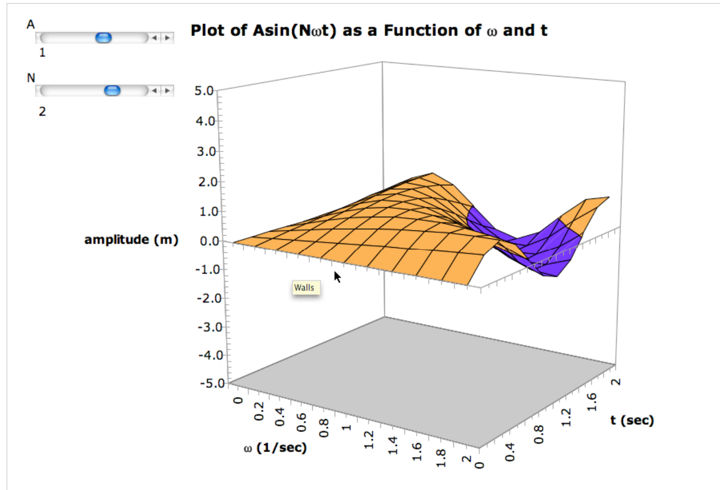




Linking Parameter Value to the Scrollbar "Dummy" Cell: Let's say we want the value for N to be in the range of -5 to +5. To do this, we set the value for N (in cell A13) in the "Parameter section" of the spreadsheet equal to (A21-50)/10. This takes the value in A21 (an integer from 0 to 100), subtracts 50 and divides this difference by 10, thereby producing values for N from -5 to +5 in steps of 0.1

Using Scrollbars to Produce Dynamic Plots

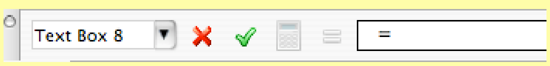
Here are three different views of the same plot, with the values for A and N changed by means of scrollbars. Now it is easy to see how changing the values for A and N affect the shape and appearance of the plot, revealing the role of each of these variables in this function. "A" affects the amplitude of this function while "N" affects the frequency of the oscillation.



Scrollbar values on plot: The actual value for the variable controlled by the scrollbar can added to the plot by means of a text box.

1. Create a text box on the plot.

2. Go to the formula bar and enter and equal sign.



3. Switch to the correct worksheet that has the data used to create the plot.

4. Click on the cell that contains the desired value and hit ENTER.

5. The value now appears in the text box on the plot. The value will change as the scrollbar is moved. The text box can be positioned near the scrollbar and formatted as desired.