

Classroom Tips and Techniques: Context-Menu Plotting

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Introduction

The Context Menu for a Maple mathematical expression in a single variable provides two distinct options for plotting. In this month's article, we examine these options and provide a rationale for guiding the choice between them.

Context-Menu Plotting Options

The Plots option in the Context Menu for an expression such as $\sin(x)$ provides three relevant choices amongst the five shown in Figure 1. These are 2-D Plot, 3-D Plot, and Plot Builder. In a word, the first option invokes the **smartplot** command; the second, the **smartplot3d** command; the third, the **plot** command. The 2-D Plot option and the Plot Builder provide a planar graph of the curve $y=f(x)$. The 3-D Plot option and the Plot Builder provide a graph of the developable cylinder $z=f(x)$ with generator parallel to the y -axis.

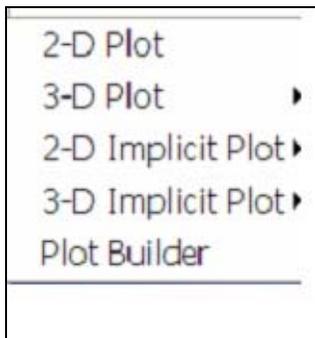
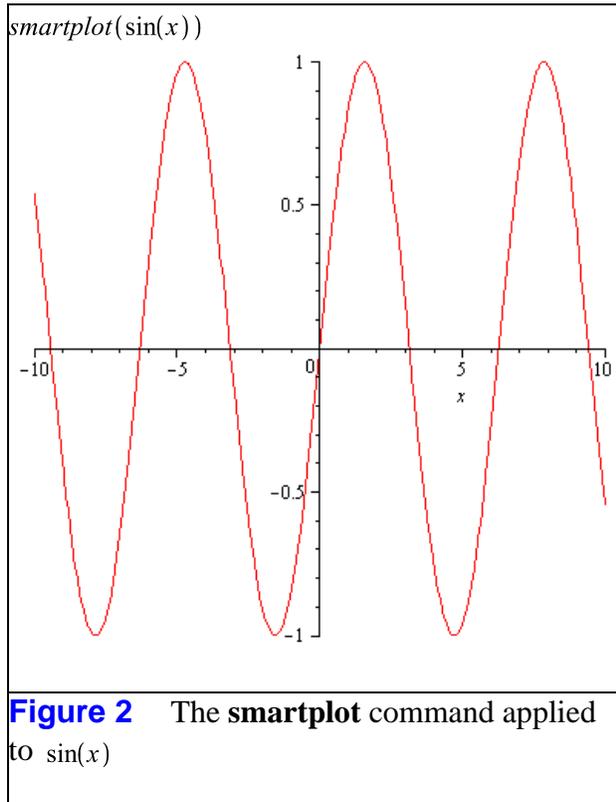


Figure 1 Options for plotting $\sin(x)$ via Context Menu: Plots

The functionality of the **plot** and **smartplot** commands differs slightly, and it is these differences we wish to explore.

The *smartplot* Commands

Figure 2 shows the application of the **smartplot** command to $\sin(x)$, the equivalent of selecting 2-D Plots in the Context Menu. The resulting graph is drawn on the default range $-10 \leq x \leq 10$. A range option for x cannot be given. The plot will always be drawn on this range.



To obtain the graph on, say, $0 \leq x \leq 2\pi$, use the Context Menu for the graph, selecting Axes/Properties as per Figure 3.

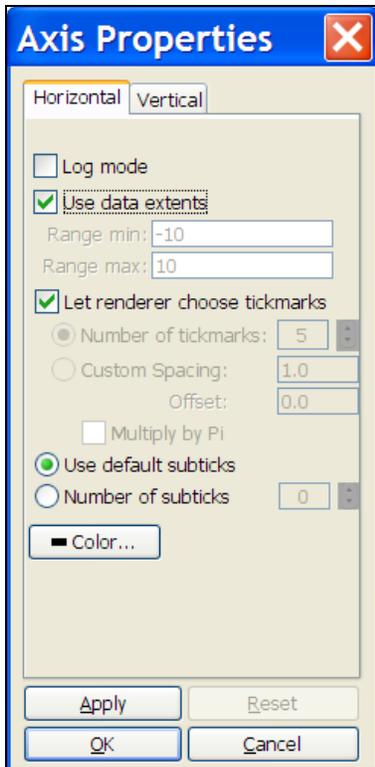


Figure 3 Axis Properties from the Context Menu of the graph in Figure 2

Uncheck the box to the left of "Use data extents" and type new endpoints into the boxes labeled "Range min" and "Range max". Note that 2π must be entered as 6.28 because (at the present time) the Context-Menu modifications can contain neither arithmetic calculations nor symbolic constants. Clicking the OK button will change Figure 2 to Figure 4.

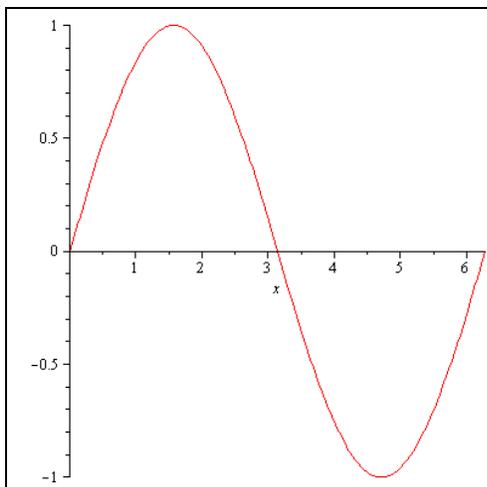


Figure 4 The Context-Menu modified version of Figure 2.

The inability to obtain a graph on precisely the interval $0 \leq x \leq 2\pi$, would seem to be a grave defect in the use of the **smartplot**. However, there is a significant redeeming feature of this command.

If the Context Menu option Axes/Properties is used to increase the range of the graph in Figure 4, say to $0 \leq x \leq 15$, the **smartplot** retains knowledge of the function $\sin(x)$ and the additional data points needed to draw the graph on the extended range can be recomputed. I call this the "re-scalable axis" property, and it is illustrated in Figure 5 where the Context Menu for Figure 4 was used to rescale the horizontal axis beyond even the original default bound.

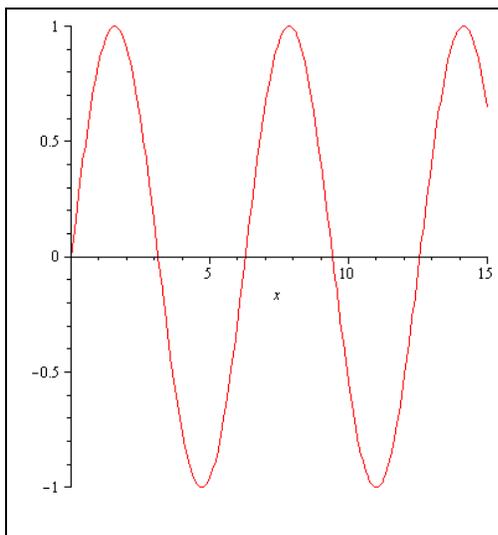


Figure 5 Horizontal axis in Figure 4 rescaled by Context Menu

Another strength of the **smartplot** command is its ability to graph implicitly. Figure 6 shows the result of applying this command to the equation of the unit circle. Again, application of this command is equivalent to selecting 2-D Plot from the Context Menu.

```
smartplot( $x^2 + y^2 = 1$ )
```

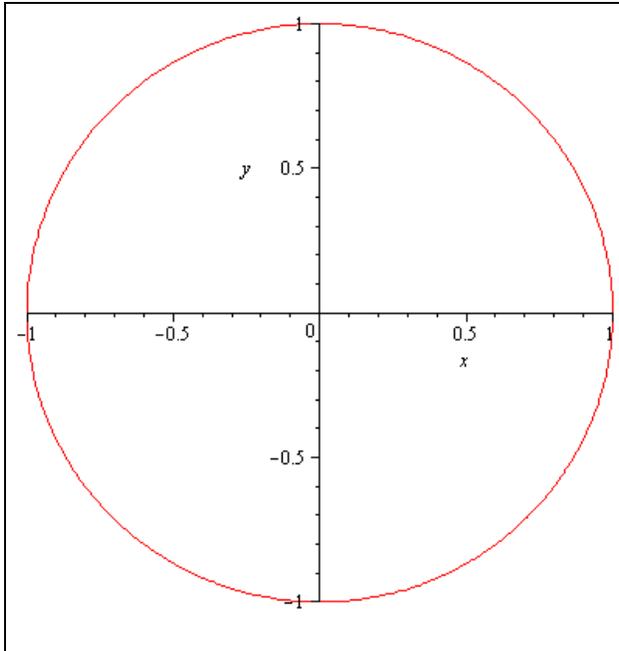


Figure 6 An implicitly drawn graph via the **smartplot** command.

A final feature of a graph generated by the **smartplot** command is the retention of the plot window under the drag-and-drop plotting option. Thus, to add the graph of an additional function to an existing graph, drag-and-drop (or copy/paste) the expression for the rule of the function onto the graph. Figure 7 shows the result of dropping x onto the graph in Figure 4; Figure 8, the result of dropping x onto the graph in Figure 6; and Figure 9, the result of dropping x onto a modified Figure 6.

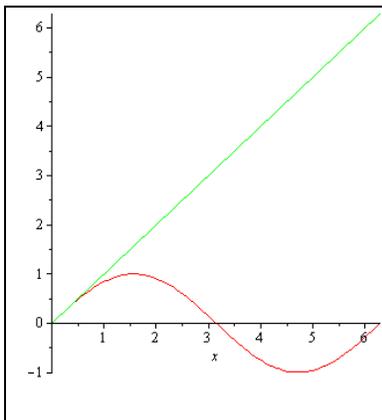


Figure 7 Drop x onto Figure 4

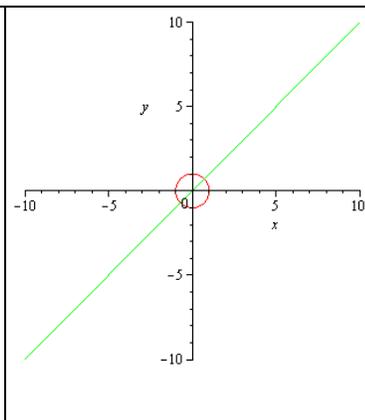


Figure 8 Drop x onto Figure 6

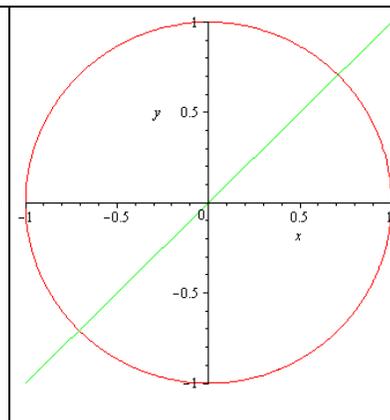


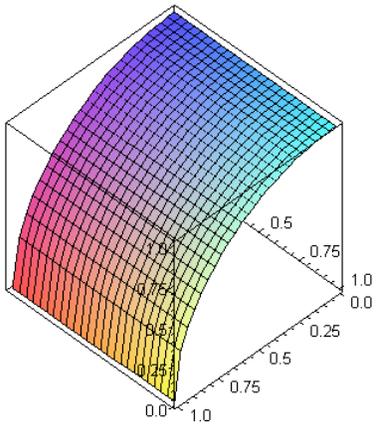
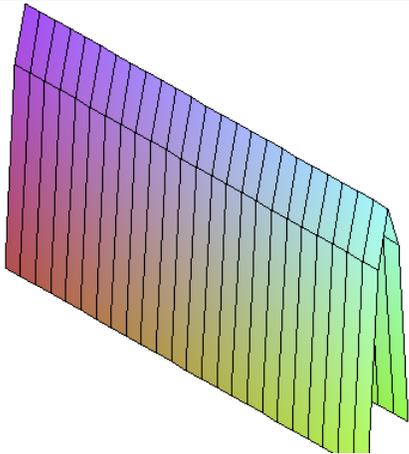
Figure 9 Drop x onto modified Figure 6

The modification of Figure 6 that results in Figure 9 is the "freezing" of the plot window in Figure 6. The Axes/Properties dialog must be invoked via the Context Menu, and as per Figure 3, the existing endpoints (both horizontal and vertical) of -1 and 1 , must be "locked in" by clicking the Apply button for both directions.

It is also possible to modify Figure 8 to look like Figure 9. Just use the Axes/Properties dialog from the Context Menu for Figure 8. Starting from Figure 6, the net amount of "work" needed to create Figure 9 is the same in either event. And clearly, the passage of Figure 4 to Figure 7 retained the plot window of Figure 4 because that window had been set by the adjustment to the default window that generated Figure 4.

The cylinder $z = \sqrt{1 - x^2}$, $0 \leq x, y \leq 1$, in Figure 10 can be drawn with the Context Menu by selecting Plots/3-D Plots/x,?, which implements the **smartplot3d** command. In general, $z = f(x, y)$ with either of x or y missing, defines a generalized cylinder, that is, a developable surface with generator parallel to the coordinate axis of the missing variable.

Initially, the graph is the one in Figure 11, but the Context Menu options for this graph can be used to transform the image to the one seen in Figure 10.

	
<p>Figure 10 The smartplot3d command draws the cylinder $z = \sqrt{1 - x^2}$, $0 \leq x, y \leq 1$</p>	<p>Figure 11 The initial graph of the cylinder $z = \sqrt{1 - x^2}$, $0 \leq x, y \leq 1$, provided by the smartplot3d command</p>

The Plot Builder

When $\sin(x)$, $0 \leq x \leq 2\pi$, is graphed by the Plot Builder launched from the Context Menu, it is possible to set the plotting range before generating the plot. Moreover, endpoints such as 2π

or $\sqrt{2}$ are admissible. Figure 12 shows the Plot Builder settings that produce the desired graph.

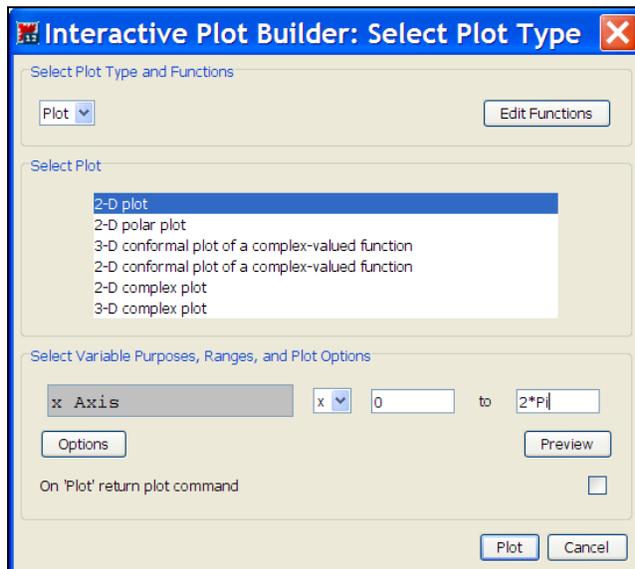


Figure 12 Context-Menu launched Plot Builder for $\sin(x)$

The Preview button on the lower right provides a preview of the graph. When the preview pane is closed, control is returned to the Plot Builder so additional modifications can be made. Thus, before the graph is embedded in the worksheet, the plot and the plot window can be adjusted until they are optimal.

The graph of $\sin(x)$ produced by the Plot Builder is generated with the **plot** command. At the present time, such plots do not retain the rule of the function in the plot data structure. Hence, interactive rescaling changes an axis, but does not recompute any new points from which a new graph is to be drawn. For example, if x^2 is graphed on $0 \leq x \leq 1$, and then the Context Menu for this graph used to change the plot window to $-1 \leq x \leq 1$, the result will be the graph shown in Figure 13.

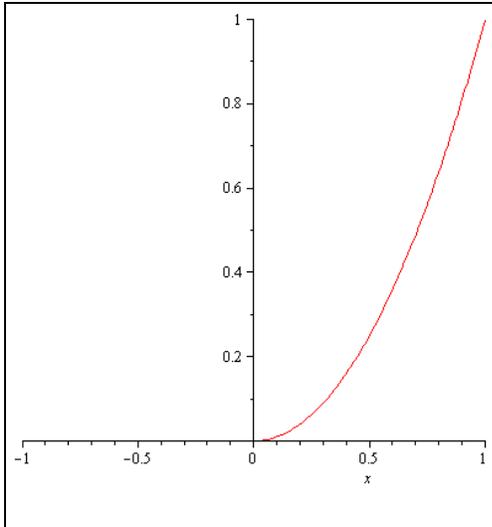


Figure 13 Interactively enlarging plot window in a graph generated by **plot** command

In essence, this observation suggests that when using the Plot Builder, it's best to use the Preview option to set the plot window appropriately before embedding the graph. Enlarging the plot window via the graph's Context Menu does not work, but shrinking it (where no new points need to be computed) certainly does work.

A graph drawn by the **plot** command will retain its plot window under drag-and-drop plotting. Figure 14 shows the result of dropping x onto the graph of $\sin(x)$, $-\pi \leq x \leq \pi$, that was drawn by the Plot Builder (which itself uses the **plot** command).

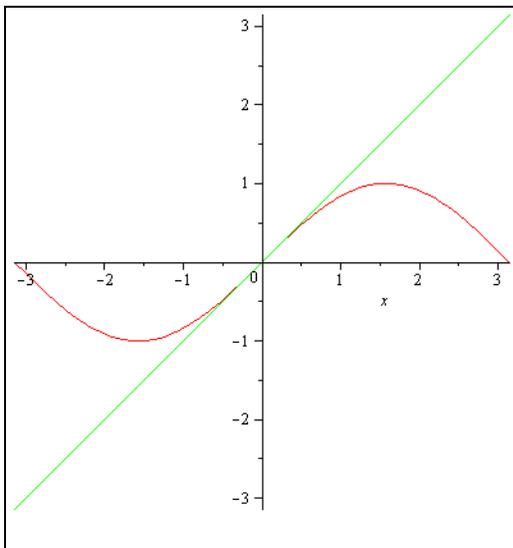
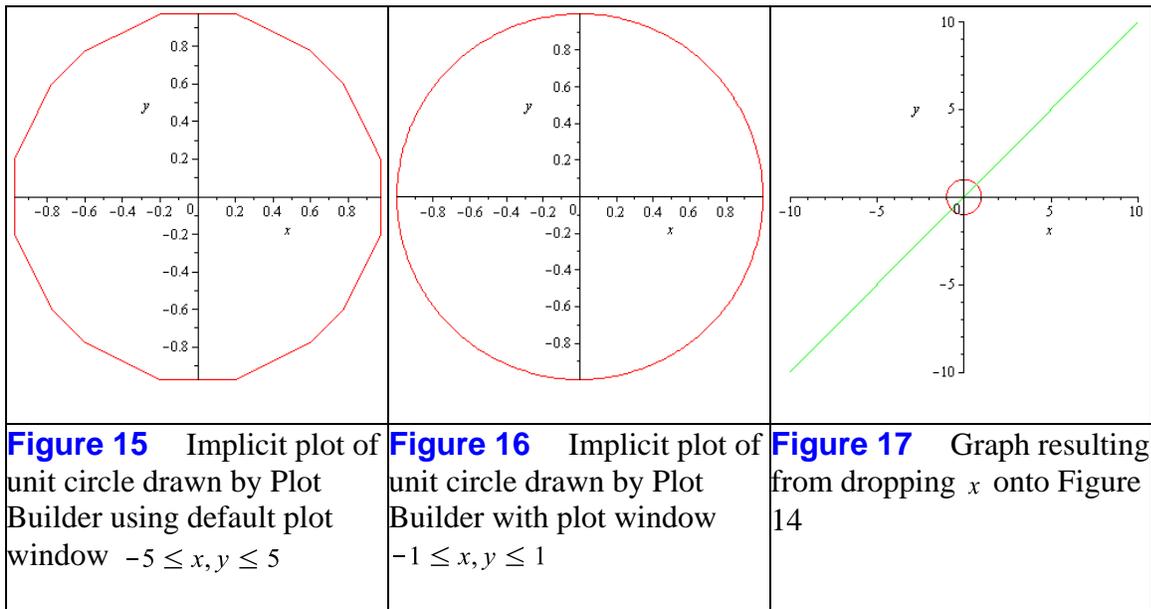


Figure 14 Drag-and-drop x onto graph of $\sin(x)$, $-\pi \leq x \leq \pi$, drawn by

plot command

The plot window does not revert to the default interval $[-10, 10]$. Unfortunately, this is not the case for the implicit plot, based on the **implicitplot** command, drawn by the Plot Builder. Figure 15 shows the Plot Builder's Preview for $x^2 + y^2 = 1$, the unit circle. The default plot window is $-5 \leq x, y \leq 5$, and the test points used by the **implicitplot** command are uniformly distributed over this region. Hence, too few fall on (or near) the circle. Figure 16 shows the graph that results when the plot window is changed (in the Plot Builder) to $-1 \leq x, y \leq 1$. Finally, Figure 17 gives the result of dropping x onto Figure 16.



The plot window for the implicitly drawn graph reverts to the default window of the function added to the graph. In this case, the default is that of the **plot** command, namely, the interval $[-10, 10]$.

Figure 10 can be drawn with the Plot Builder if the Edit Functions button is clicked. Figure 18 shows the pane that opens, and in which y is added as a second variable in the Add Variables region.

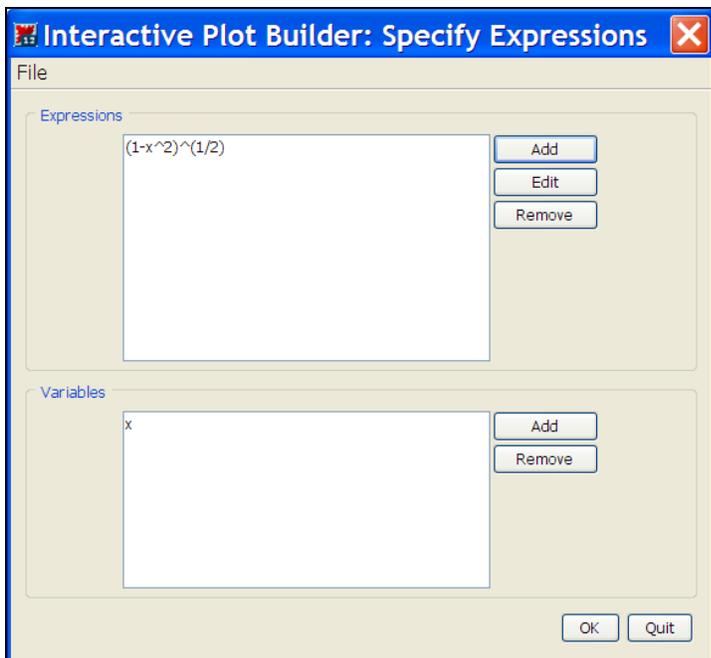


Figure 18 Adding y to the list of variables in order to draw the cylinder $z = \sqrt{1 - x^2}$, $0 \leq x, y \leq 1$, with the Plot Builder

Summary

Table 1 summarizes our findings for the **plot** (and **implicitplot**) commands behind the Plot Builder option in the Context Menu/Plots choices, and for the **smartplot** behind the 2-D Plot option (or **smartplot3d** behind the 3-D Plot option).

Property	Plot Builder		smartplot	
	plot	implicitplot	explicit	implicit
Re-scalable axis	no	no	yes	yes
Window safe under drag-and-drop	yes	no	yes	yes (*)
	yes	yes	no	no
Algebraic or symbolic endpoints	yes	N/A	yes	N/A
Cylinder				

Table 1 Comparison of Plot Builder and smartplot options in the Context Menu selection Plots. (*) - the functionality is available only if the plot window has been "frozen".		

The **smartplot** and **smartplot3d** commands:

- (+) expanding the horizontal axis "grows" the graph of the function
- (+) if first "frozen," plot window is preserved under drag-and-drop plotting
- (-) algebraic and symbolic endpoints not allowed
- (-) Axes/Properties dialog not user-friendly
- (-) Context Menu modifications must be applied one-by-one, each requiring a re-launch of the Context Menu

The Plot Builder:

- (+) plot window for explicit plot preserved under drag-and-drop plotting
- (+) algebraic and symbolic endpoints are allowed
- (+) Preview button and range-change dialog very user-friendly
- (+) all plot options available in one pane via the Options button
- (-) plot window for implicit plot not preserved under drag-and-drop plotting
- (-) expanding the horizontal axis does not "grow" the graph of the function after leaving the Plot Builder

Consequently, it was, and still is, this author's opinion that the Plot Builder is the tool-of-choice for interactive graphing.

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