

## An Introduction to Winplot Sarah Mabrouk, Framingham State College

Winplot is a free program that can be downloaded from <http://math.exeter.edu/rparris/winplot.html>.

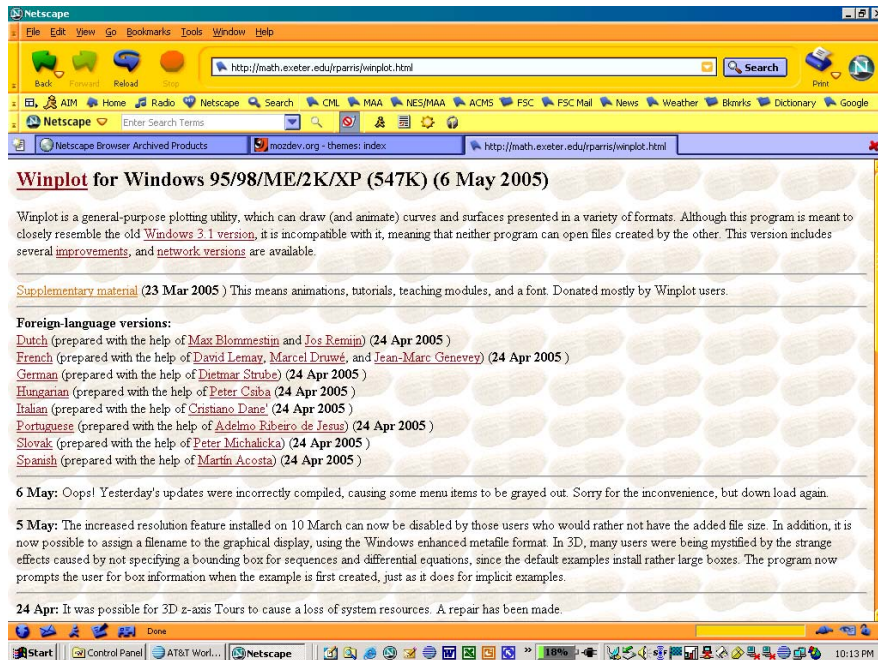


Figure 1: Winplot download.

Left-clicking the Winplot hyperlink at the top of the page, opens the Opening wp32z.exe dialog box. In order to install the program, you will need to save the zipped Winplot program file, wp32z.exe to your hard drive: select Save to disk in this dialog box and then click OK, use the Save in pull down menu to navigate to the folder in which you would like to save the file, and then click Save. The program download will begin automatically; it will take several minutes to download this program if you are using a dial-up connection. It is important to take note of the folder into which you save the program file so that you will be able to install it; you may find it helpful to create a folder such as the one used in Figure 3, My\_Download\_Programs.

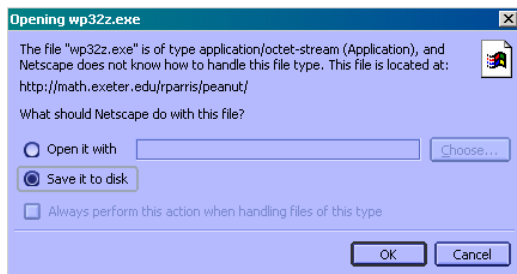


Figure 2: The Opening wp32z.exe dialog box.

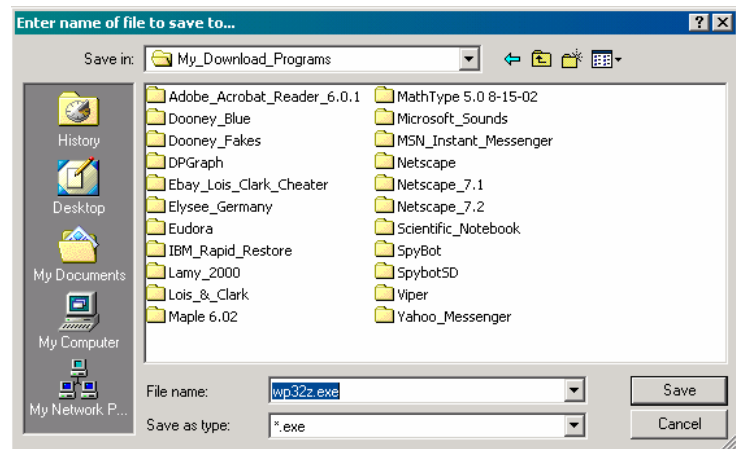


Figure 3: The enter name of file to save to dialog box.

Once the download is complete, you can unzip the program file: use Windows Explorer to navigate to the folder in which you saved the program file and double-click the program name/icon, wp32z.exe, within the

folder window. The WinZip Self-Extractor, Figure 4, will automatically open and the folder peanut will be generated on the hard drive; for most computers this file will be generated on the C-drive. If you prefer to choose another folder name or location, you may do so by clicking Browse and then using the Browse for Folder dialog box, Figure 5, to locate the folder that you desire; in general, it is best to use the program designated folder and location unless you already have a folder of the same name in the selected location.

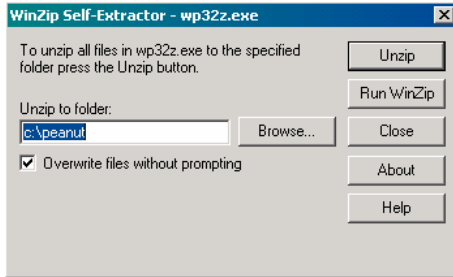


Figure 4: The WinZip Self-extractor dialog box.

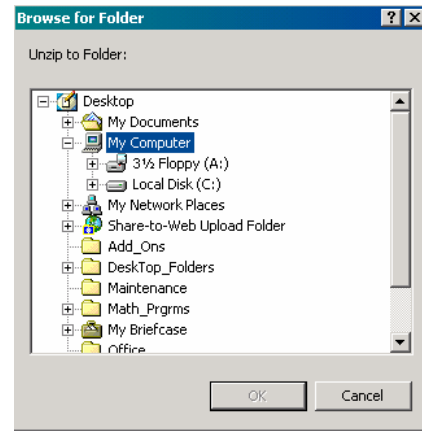


Figure 5: The Browse for Folder dialog box.

Once you have selected the location to which extract the program, you can select Unzip. Upon selecting Unzip, the folder peanut will be created on the C-drive and the winplot.exe program will be saved within this folder, Figure 6.

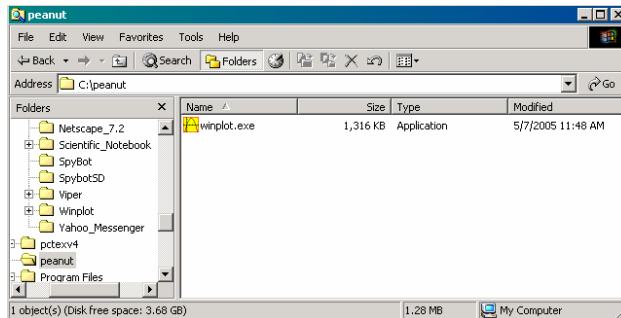


Figure 6: The peanut folder containing the Winplot program file.

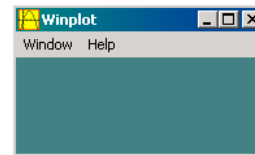


Figure 7: The Winplot program window.

Now that you have unzipped the program file, you are ready to “install” the Winplot. The program does not “install” as other programs but rather is opened/launched each time the program file is executed by double-clicking the program filename/icon in the peanut folder or by double-clicking a program shortcut that you add to the start menu or put on the desktop or in the taskbar; to create a program shortcut, simply right-click the program filename/icon in the peanut folder and drag the shortcut icon to the desired location, the desktop, start menu, or taskbar. Upon executing the winplot.exe program file, a Winplot window immediately opens, Figure 7. You are now ready to begin to explore Winplot!

While you could select to save the winplot.exe program file to the desktop, if you were to accidentally delete this file, you would delete the program. If you do not delete the original zipped program file then you can extract the program again. However, if you did delete the zipped program file, wp32z.exe, and the executable program file, winplot.exe, then you would need to download the zipped program file, wp32z.exe, and extract the program file, winplot.exe again. Creating a Winplot shortcut to winplot.exe will eliminate the possibility that you accidentally delete executable program file, and the Saving the zipped program file, wp32z.exe, will enable you to extract winplot.exe if you do accidentally delete the executable program file. In short, better safe than sorry; of course, you can always download the program again and you should check the Winplot page, <http://math.exeter.edu/rparris/winplot.html>, for updates.

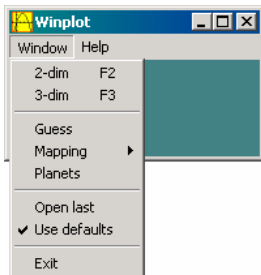


Figure 8: The Winplot Window menu.

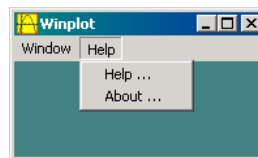


Figure 9: The Winplot Help menu.

Selecting the Window menu, Figure 8, provides you access to two-dimensional and three-dimensional graphing windows, the Guess option for exploring graphs, the Mapping option, and the Planets option which will also allow you to explore direction fields for first order differential equations. Selecting the Help menu, Figure 9, provides access to the general program help information using the Help option as well as the general program information through the About option; each program window has its own help information.

Let us begin by examining the Guess option on the Window menu. We begin with the Guess option since this is a nice tool for students to use in familiarizing themselves with various function types and function equations. In addition, exploring the Guess option provides a gentle introduction to some Winplot options/features. Selecting Guess on the Window menu opens the guess my equation window, Figure 10. Using Guess and Answer on the Equa menu, Figure 11, allows the user to input a “guess” for the equation corresponding to the displayed graph and to obtain the correct “answer” – the actual function equation – corresponding to the displayed graph, respectively; the guess my equation dialog box and an answer box are displayed in Figure 19.

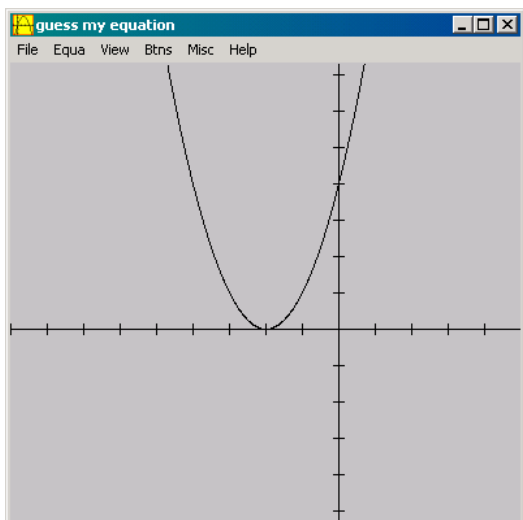


Figure 10: The guess my equation window.

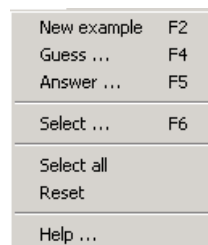


Figure 11: The Equa menu.

Select on the Equa menu allows the user to select the function type, Figure 14. The available function types are polynomial, rational, trigonometric, exponential, logarithmic, power, and absolute value.

The View menu, Figure 12, allows the user to control where the axes are displayed within the graph window using the View option, the magnification using the Zoom option, the grid type, rectangular or polar as well as the axes/scale options by selecting Grid to open the grid dialog box, Figure 15, and change the axis and grid lines using the Axes and Grid menus, respectively, Figure 16, as well as alter the graph display using the Connected dots option.

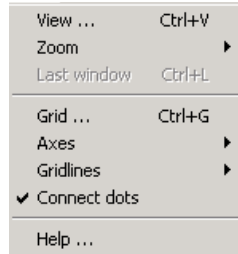


Figure 12: The View menu.

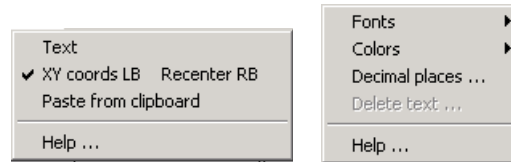


Figure 13: The Btns and Misc menus, respectively

The XY cords LB Recent RB option on the Btns (buttons) menu allows the user to displays the xy coordinates of any pixel on which (s)he left-clicks and to re-center the graph window on any pixel on which (s)he right-clicks. By exploring various points displayed on a graph, for example the x-intercept, the y-intercept, and other characteristic points for various graph types, the user can determine the function equation that can be entered in the guess my equation dialog box and checked against the actual function equation displayed in the answer box, Figure 19.

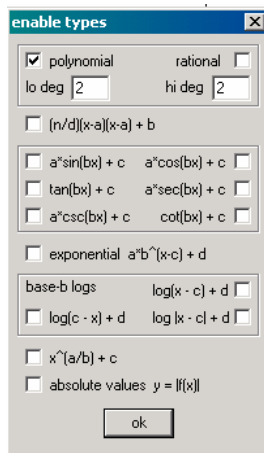


Figure 14: The enable types dialog box.

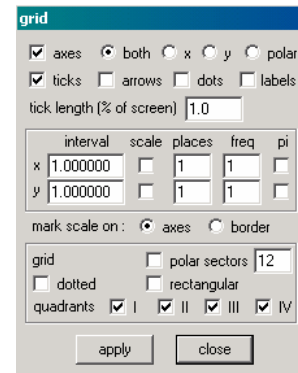


Figure 15: The grid dialog box.

With the Text option selected, right-clicking on the graph opens the edit text dialog box, Figure 17, which allows the user to add text with or without an opaque background, to select the angle at which the text is to be displayed as well as the font, type, size, and color, to what the text is “tied”, and left-clicking and dragging the text allows the user to position the text within the window; an example is provided in Figure 18.

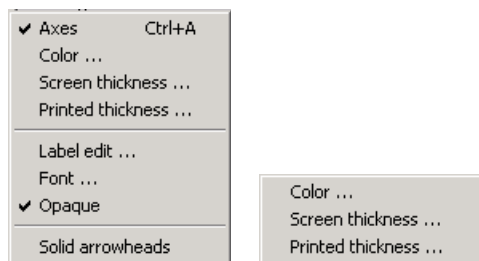


Figure 16: The Axes and Gridlines submenus.

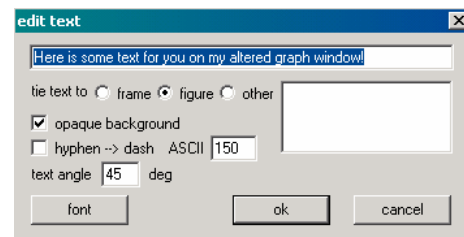


Figure 17: The edit text dialog box.

The Misc menu contains a Delete text option that allows the user to delete text that has been added to the graph; right-clicking the text when the Text option has been selected and deleting the text within the edit text dialog box allows the user to delete the text as well.

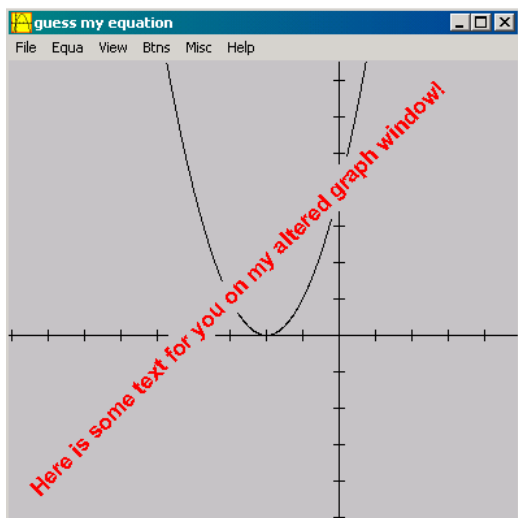


Figure 18: An example of a guess my equation graph with text.

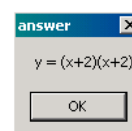
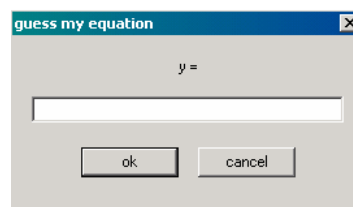


Figure 19: The guess my equation dialog box and an answer box.

The Misc menu allows the user to select fonts and colors for graph items using the Fonts and Colors submenus, Figure 20, and to select the number of decimal places to be displayed; the Decimal places option on the Misc menu opens the format dialog box, Figure 21.

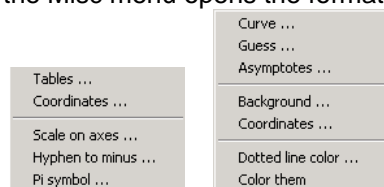


Figure 20: The Fonts and Colors submenus.

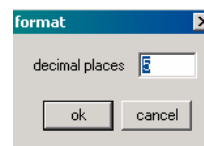


Figure 21: The format dialog box.

Examining the Equa menus for 2-dim and 3-dim graphing, Figure 22, we see that the user can select the equation type, for example, explicit, parametric, and implicit, as well as points, segments, recursive equations and differential equations, and user defined functions for each, lines and polynomials for 2-dim graphing and planes for 3-dim graphing. The Library contains information about the functions recognized by the program as well as the appropriate syntax.

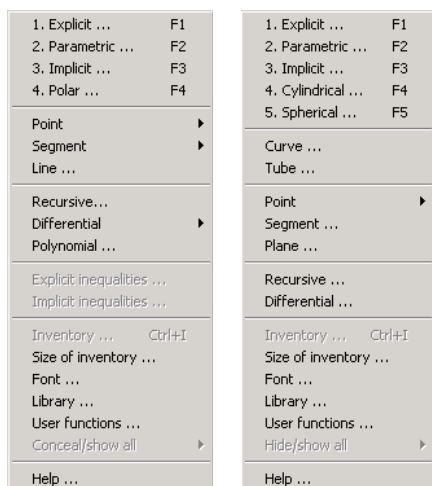


Figure 22: The Equa menu for 2-dim and 3-dim graphing.

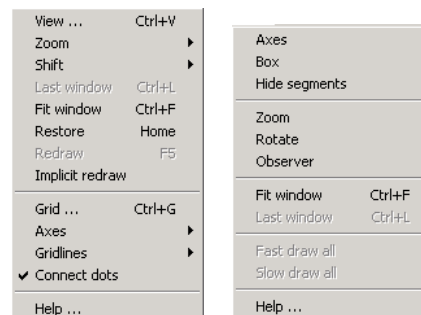


Figure 23: The View menu for 2-dim and 3-dim graphing.

The View menus, Figure 23, can be used to select desired window options for the 2-dim and 3-dim graphs.

Let us create a two-dimensional graph: to do this we select 2-dim on the Window menu or use function key F2. Suppose we would like to graph  $y = \sin x$  and the first three derivatives. We must first enter the function equation by opening the  $y = f(x)$  dialog box using the Explicit option on the Equa menu or function key F1. In the  $y = f(x)$  dialog box, Figure 24, we enter the function equation, set the maximum and minimum values  $x$ , select the pen width and the point density for the curve as well as the step tolerance (useful for discontinuities) and the color; the curve dialog box, Figure 24, opens when you click the color button in the  $y = f(x)$  dialog box. Here, the function,  $y = \sin x$ , will be in red with a pen width of 1, the first derivative will be in blue with a pen width of 2, the second derivative will be lime green with a pen width of 3, and the third derivative will be pink with a pen width of 4. We add the derivative functions using the inventory dialog box, Figure 25, that opens once you select ok in the  $y = f(x)$  dialog box. The derive button adds a derivative of the original function entered for each time that you click the button. As you add derivatives of the original function to the graph, each derivative is listed in the inventory dialog box and the attributes for each can be set using the edit button; a  $y = f(x)$  dialog box for each curve opens when you click the edit button for the selected (highlighted) equation. The function equations can be added to the graph using the show equation button for each selected (highlighted) equation.

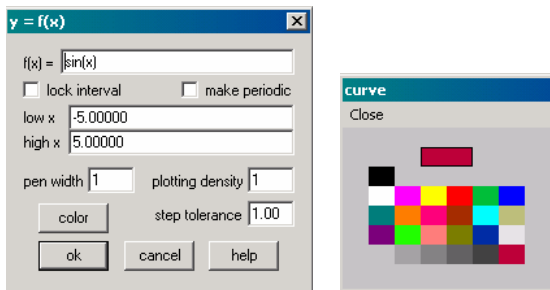


Figure 24: The  $y = f(x)$  dialog box and color select dialog box.

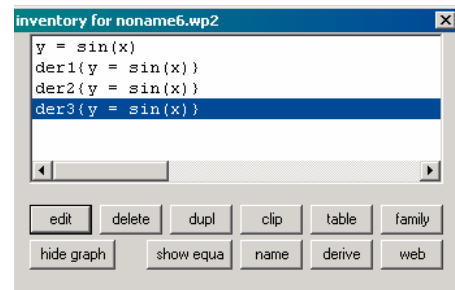


Figure 25: The inventory dialog box.

In Figure 26, we see the graphs of  $y = \sin x$  and the first three derivatives, each with the specified color and pen width as well as the associated labels in corresponding colors.

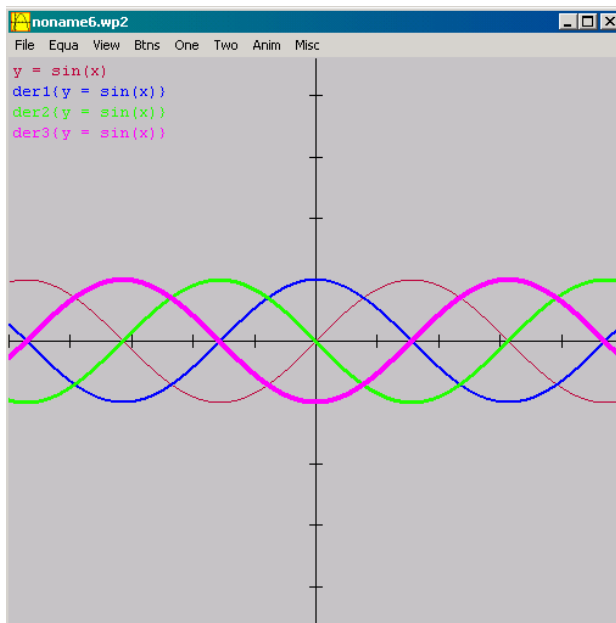


Figure 26: The graphs of  $y = \sin x$  with the first three derivatives.

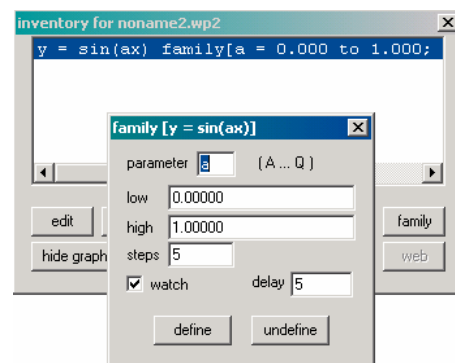


Figure 27: The family dialog box.

The dupl. button in the inventory dialog box, Figure 25, can be used to add duplicate function curves. All attributes including the function equations for the duplicate functions of the original (non-derivative) function equation can be edited. However, only the display attributes, not the equations, for duplicate curves of derivative functions can be edited.

To create a family of curves with one parameter, we enter the function equation using the desired parameter, here  $y = \sin ax$  with parameter  $a$ , using the Explicit option on the Equa menu or F1 as before and then set the maximum and minimum values of the parameter as well as the number of steps (one less than the number of curves to be displayed); using values given in Figure 27, six curve will be displayed with five steps in the value of the parameter  $a$  from 0 to 1, that is, the values of  $a$  are 0, 0.2, 0.4, 0.6, 0.8, and 1.0.

Now, let us make a graph in 3-space. To do this, we select 3-dim in the Window menu or press function key F3. This opens a graph window displaying the x-axis, y-axis, and z-axis, Figure 28. To generate a specific graph, we select an option on the Equa menu as we did for 2-dim graphing. Here, let us select Parametric and let us graph the elliptic spiral determined by the vector-valued function of one variable  $\mathbf{r}(t) = \sin t \mathbf{i} - 3 \cos t \mathbf{j} + 2t \mathbf{k}$ .

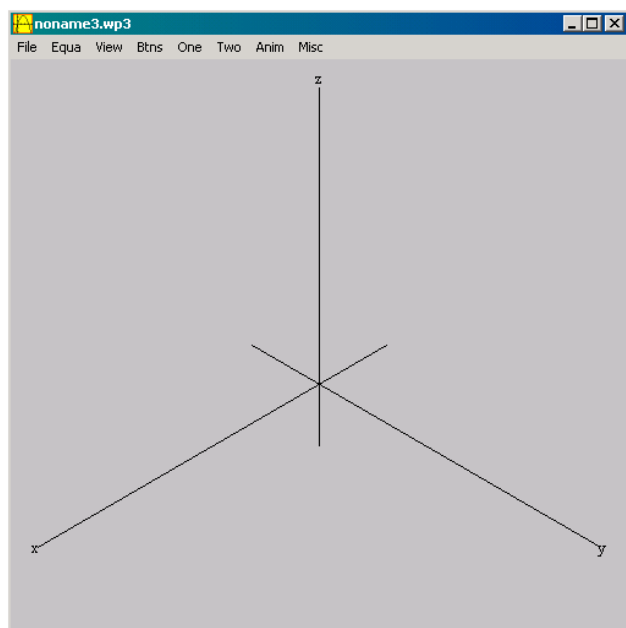


Figure 28: The 3-dim graph window.

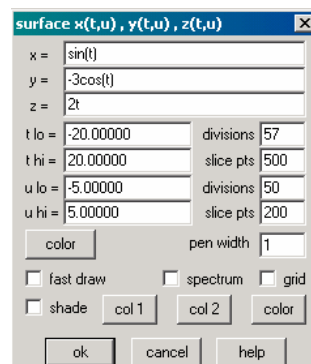
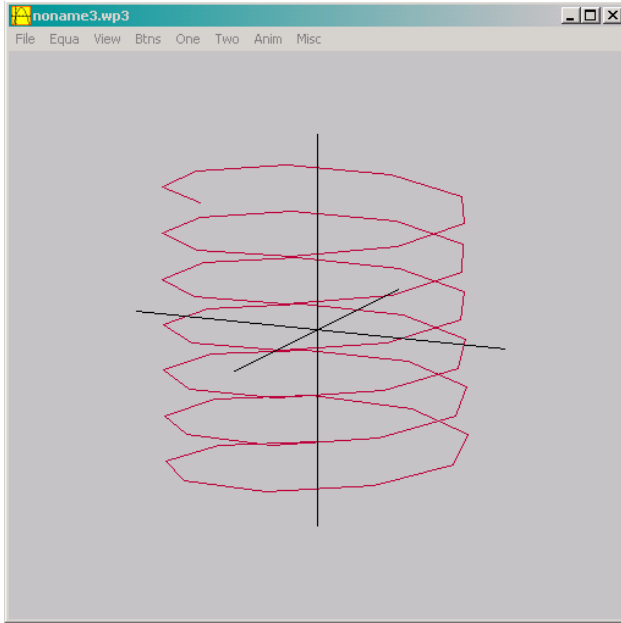


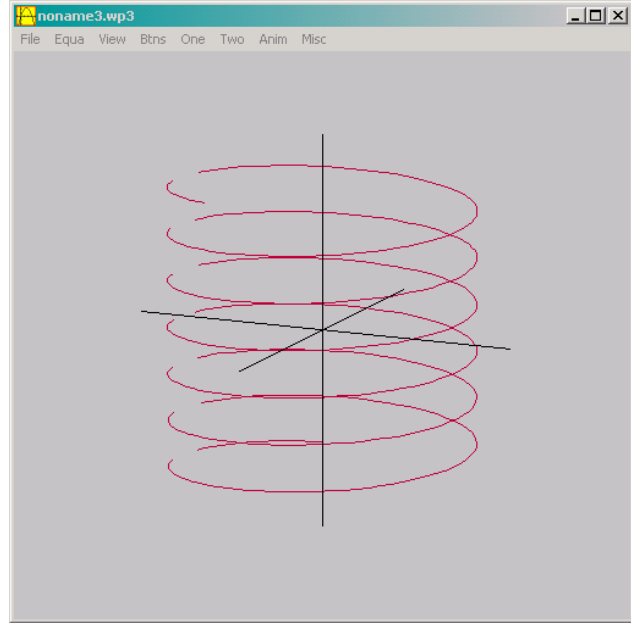
Figure 29: The surface dialog box.

Selecting the Parametric option on the Equa menu opens the surface dialog box, Figure 29; examining the surface dialog box, we see that we can graph functions containing two parameters,  $t$  and  $u$ . Since for our elliptic spiral,  $\mathbf{r}(t) = \sin t \mathbf{i} - 3 \cos t \mathbf{j} + 2t \mathbf{k}$ ,  $x = \sin t$ ,  $y = -3 \cos t$ , and  $z = 2t$ , we enter these for  $x$ ,  $y$ , and  $z$ , respectively. Experimenting with the divisions for this function, you will find that the maximum number of divisions that you can use is 57. Examining Figures 30 and 31, we see the difference between using and not using the fast draw option within the surface dialog box.

Since we have discussed several graphs, this would be a nice point at which to mention the background color options available on the Misc menu; these options as well as others specific to each window are included in the Misc menus. Using this option, we can change the background from its current gray to another color, for example, white. As for changing other color options, a color dialog box similar to that displayed in Figure 24 opens and the user can select her/his desired color. Using different colors for the background and gridlines for 2-dim graphing will, of course, be helpful for exploring graphs.

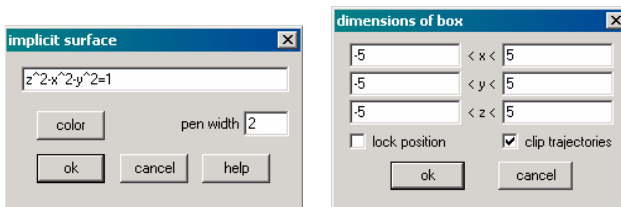


**Figure 30:** The graph of  $r(t) = \sin t i - 3 \cos t j + 2t k$  generated using the fast draw option in the surface dialog box.

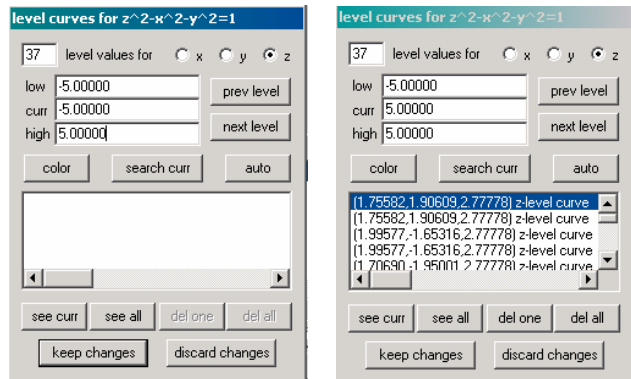


**Figure 31:** The graph of  $r(t) = \sin t i - 3 \cos t j + 2t k$  generated without using the fast draw option in the surface dialog box.

Now let us graph a hyperboloid of two sheets,  $z^2 - x^2 - y^2 = 1$ . To do this, we use the Implicit option on the Equa menu and enter the equation in the implicit surface dialog box, Figure 32. After we click Ok, the dimensions of box dialog box, Figure 32, opens: we use this dialog box to set up the box, the x-, y-, and z-intervals, for the graph of the function. Upon clicking Ok, no graph is generated: we must open the inventory dialog box using the Inventory option on the Equa menu and generate the level curves.



**Figure 32:** The implicit surface dialog box and the dimensions dialog box.

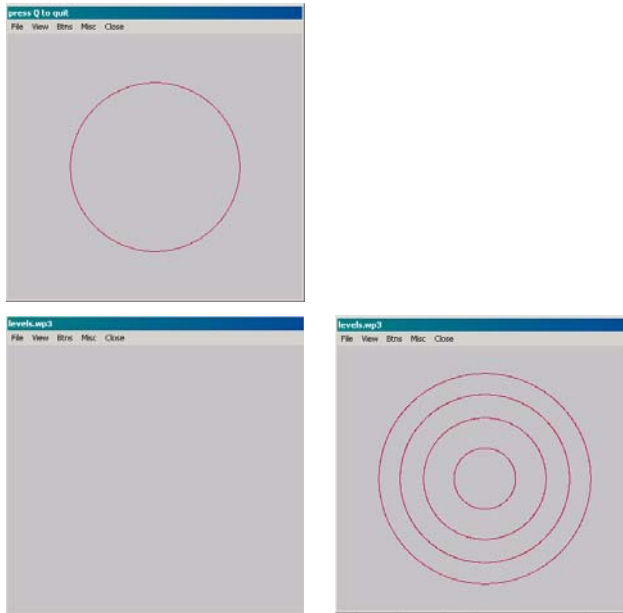


**Figure 33:** The level curves dialog box before and after automatically generating the level curves.

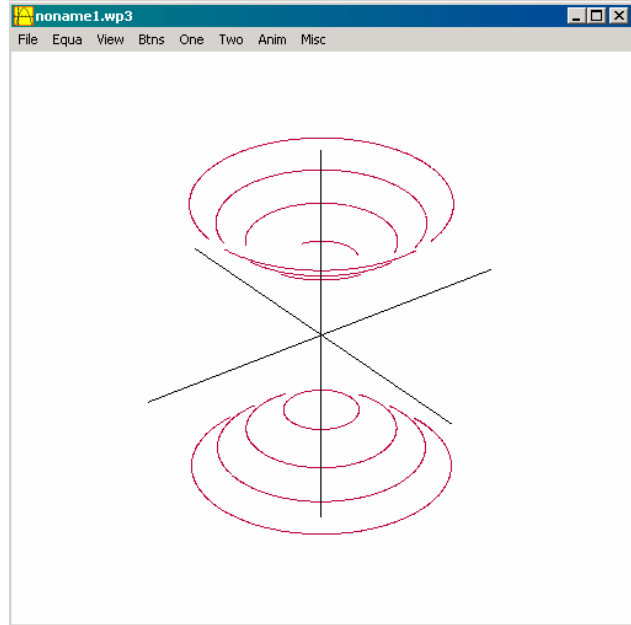
In the level curves dialog box, we must set the low, current, and high values for the level curves for one variable; here, Figure 33, these values are set as -5, -5 (the first value), and 5, respectively. Then, we click auto to automatically generate these values. As the level curves are generated, they are displayed in the levels window that is automatically displayed, Figure 34. Selecting see all in the level curves dialog box, allows the user to view all the level curves in the levels window, the right-hand image in Figure 34. We select keep changes to complete the process and to generate the graph, Figure 35.

Using the Axes option on the View menu, we can select to display or not display the axes and axis labels as well as edit the axis labels and change the fonts and the colors for the axis labels.





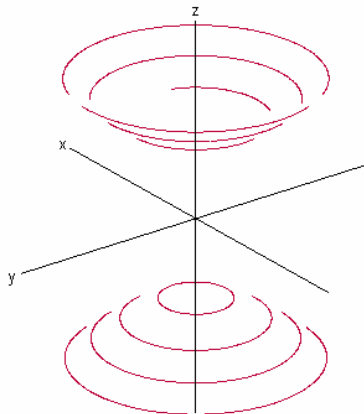
**Figure 34:** The levels for the graph display rapidly and the levels window is empty once the process has been completed.



**Figure 35:** The completed graph of  $z^2 - x^2 - y^2 = 1$

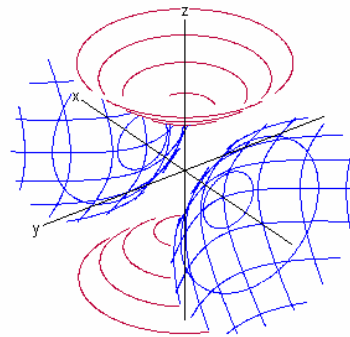
Other options such as Zoom, Rotate, and Observer are also available on this menu. These can be used to change the zoom factor, the angle at which the graph is displayed, and the view for the observer.

$$z^2 - x^2 - y^2 = 1$$



**Figure 36:** The *picture* image for the graph of  $z^2 - x^2 - y^2 = 1$  inserted using Paste Special in MS Word.

$$\begin{aligned} z^2 - x^2 - y^2 &= 1 \\ x^2 - z^2 - y^2 &= 1 \end{aligned}$$



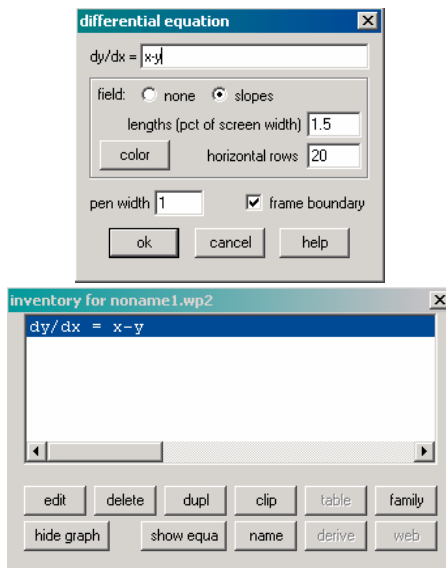
**Figure 37:** The *picture* image for the graphs of  $z^2 - x^2 - y^2 = 1$  and  $x^2 - z^2 - y^2 = 1$ .

Once you have generated a graph that you would like to include in a document, you can choose the image size using the Image size option on the File menu and copy the image using the Bitmap to clipboard option on the File menu.

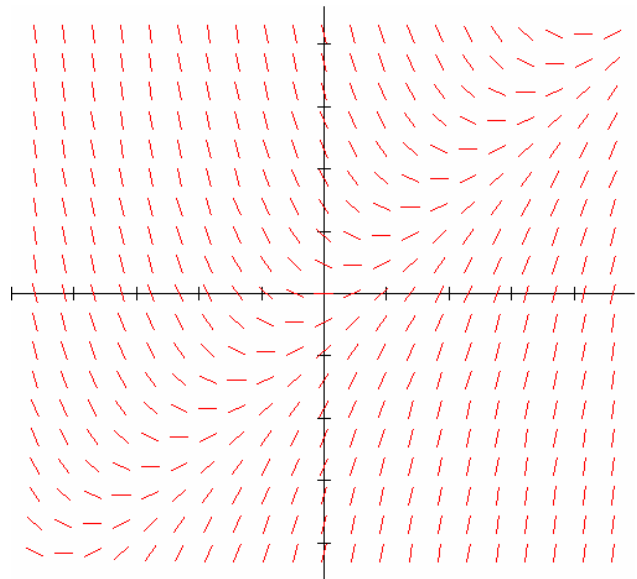
It is important to mention that using a bitmap increases the size of the file into which you copy the image. If you are using MS Word, a handy trick that will help to keep your files of manageable size is to cut the image, Cntrl X, and then use Paste Special to paste in the image as a picture. You will also notice a

difference in the sharpness of the image for a picture in comparison to a bitmap – the picture image is sharper.

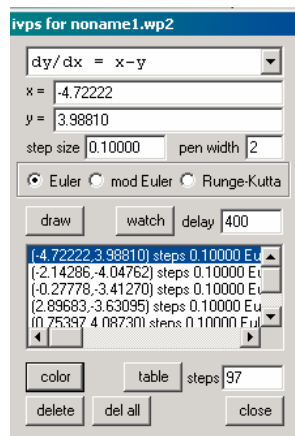
It can be helpful to view multiple graphs in the same graph window as in Figure 37. If, for example, the user wants to view the level curves for  $x$ ,  $y$ , and  $z$ , (s)he can select each variable individually and generate the level curves in the same way as previously discussed. Selecting keep changes in the levels dialog box after the desired level curves have been generated will produce a graph similar to that of  $x^2 - z^2 - y^2 = 1$  displayed in Figure 37.



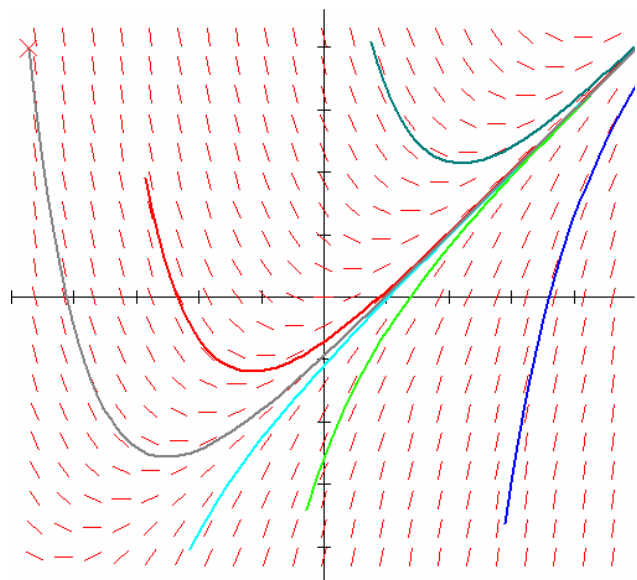
**Figure 38:** The 2-dim differential equation dialog box and the inventory dialog box for the differential equation  $\frac{dy}{dx} = x - y$ .



**Figure 39:** The 2-dim slope field for the differential equation  $\frac{dy}{dx} = x - y$ .



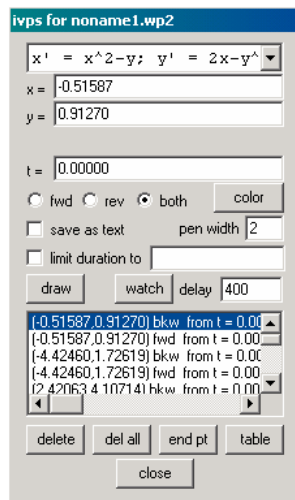
**Figure 40:** The ivps dialog box.



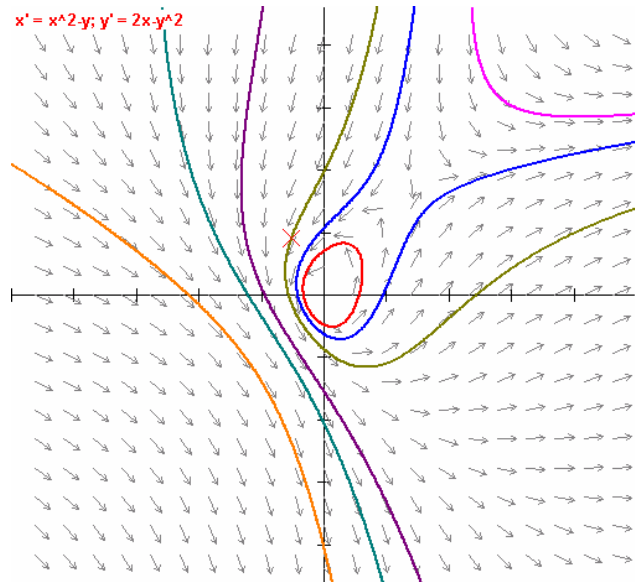
**Figure 41:** The picture of the graph of the slope field for  $\frac{dy}{dx} = x - y$  with six trajectories.

Finally, let us examine the slope field and some trajectories for the differential equation  $\frac{dy}{dx} = x - y$ . To do

this, we select Differential on the Equa menu and enter the differential equation and desired options such as color, number of horizontal rows, and pen width in the differential equation dialog box. Then, to view trajectories for this differential equation, we select dy/dx trajectory on the One menu. The user can enter the coordinates of the desired initial value or left-click on the slope field to select the initial value; a different color, pen width, and numerical integration method, Euler, Modified Euler, or Runge-Kutte, may be chosen for each trajectory as generated. As the trajectories are generated, they are displayed in the ivps dialog box, Figure 40, and the trajectories are displayed in the graph window, Figure 41. Using the delete button in the ivps dialog box, individual trajectories can be deleted or all trajectories can be deleted using the delete all button.



**Figure 42:** The ivps dialog box used to generate the trajectories for the system of differential equations  $\frac{dx}{dt} = x^2 - y$ ,  $\frac{dy}{dt} = 2x - y^2$



**Figure 43:** The picture of the graph of the vector field and trajectories for the system of differential equations

$$\frac{dx}{dt} = x^2 - y, \quad \frac{dy}{dt} = 2x - y^2$$

In a similar manner but using the dy/dt option on the Differential submenu of the Equa menu, we can generate the direction field for the system of differential equations  $\frac{dx}{dt} = x^2 - y$ ,  $\frac{dy}{dt} = 2x - y^2$ ; Figure 42 displays the ivps dialog box and Figure 43 displays the picture for seven trajectories and the direction field for the system of differential equations  $\frac{dx}{dt} = x^2 - y$ ,  $\frac{dy}{dt} = 2x - y^2$ . Setting the loop closing tolerance (here, set to 1) in the Misc menu or limiting the duration within the ivps dialog box can be used to avoid infinite loops within trajectories; without using at least one of these limitations, Winplot will not end a loop within a trajectory.



I hope that you have found this introduction to Winplot helpful. There are more settings and capabilities to explore – the best way in which to learn this program, as with others, is to simply “play” with it. Please remember to save your “explorations” since you may find them to be helpful/useful in the future.

I hope that you found this handout helpful. Please feel free to contact me, [smabrouk@frc.mass.edu](mailto:smabrouk@frc.mass.edu), if you have any questions.