

Creating Interactive Workbooks Using MS Excel

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Overview: MS Excel provides powerful calculation, statistical, graphing, and general data analysis and organizational tools for education, research, and business. When most people think of MS Excel, they think of spreadsheets, statistics, curve fitting, and general graphing of data. When people think of scrollbars, buttons, pop-ups, and general computer manipulatives, they think of Java or JavaScript applets. Since most educators do not know Java and JavaScript, they believe that they cannot create interactive workbooks that can be used for demonstrations, student assignments, and concept exploration by students. While one can create web pages that can be used to display movies created using a series of images, in general, the user must watch the preprogrammed sequence, unable to change or to control aspects of the individual variables. However, MS Excel can be used to create interactive workbooks that allow the user to control various aspects of information displayed in data, graphics, and even problems to be examined using the same type of scrollbars and buttons that one would expect in Java or JavaScript applets. The advantages to using MS Excel include the fact that, once downloaded, students can use the workbook without the Internet, students can easily download additional copies of the file if the workbook becomes corrupted by “play”, MS Excel is familiar and available software for most faculty and students, and no plug-ins are needed to use the files.

Imagine a file or web page that uses simple scrollbars to allow students

- to explore and to compare graphs of lines, $ax + by = c$, as they change the values of a , b , and c ,

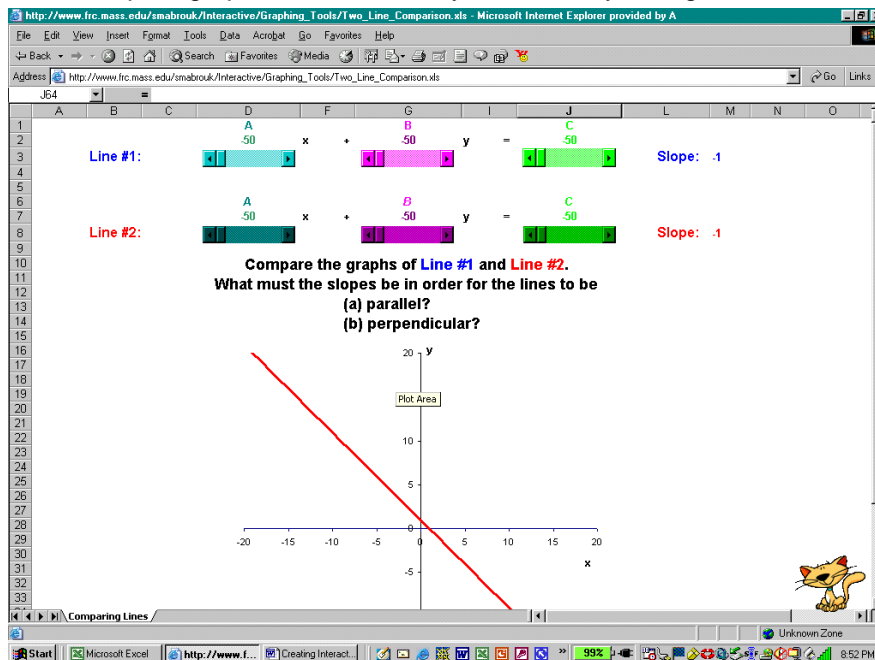


Figure 1

http://www.frc.mass.edu/smabrouk/Interactive/Graphing_Tools/Two_Line_Comparison.xls

- to examine the graphs of lines $ax + by = c$ as they change the values of a , b , and c , http://www.frc.mass.edu/smabrouk/Interactive/Graphing_Tools/Stdndrd_Frm_of_Line_Explrtn.xls;
- to compare the graph of a linear function $y = ax + b$ to the graph of $y = x$ and the graph of the quadratic function $y = ax^2 + b$ with $y = x^2$ as they change the values of a and b , http://www.frc.mass.edu/smabrouk/Interactive/Graphing_Tools/Lin_Quad_Fn_Comparison.xls;
- to examine the graphs of linear $y = ax + b$, quadratic $y = ax^2 + bx + c$, and cubic functions $y = ax^3 + bx^2 + cx + d$ as they change the various coefficient values, a , b , c , and d ;

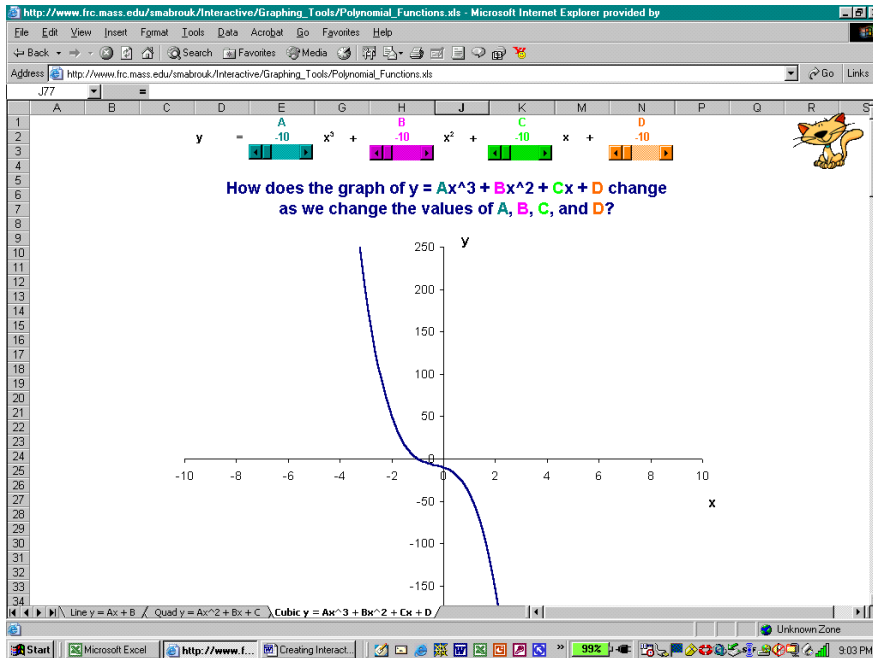


Figure 2

http://www.frc.mass.edu/smabrouk/Interactive/Graphing_Tools/Polynomial_Functions.xls

- to examine the graphs of quadratic functions $y = a(x - h)^2 + k$ as they change the values of a, h, and k,

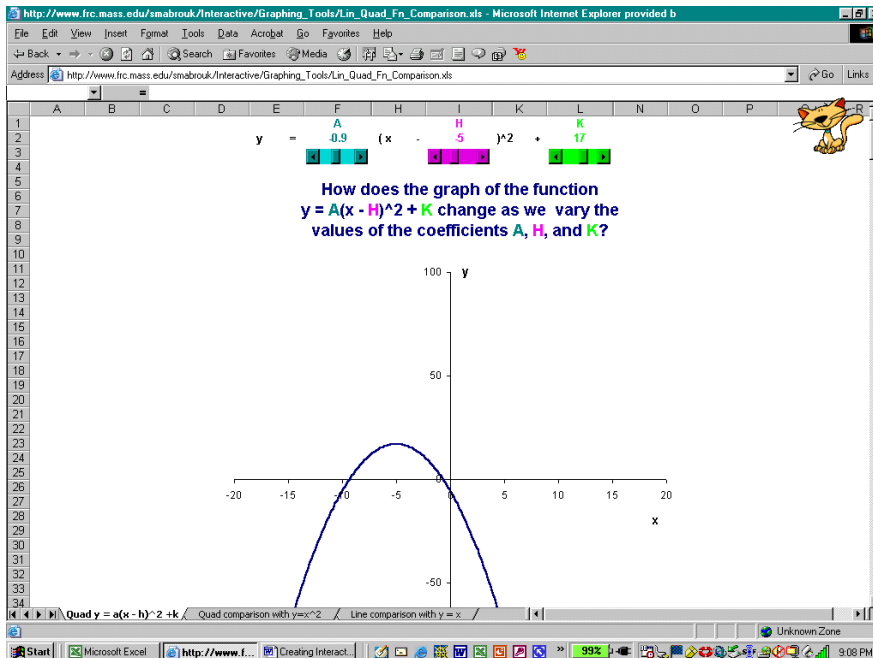


Figure 3

http://www.frc.mass.edu/smabrouk/Interactive/Graphing_Tools/Lin_Quad_Fn_Comparison.xls

- to examine the graphs of exponential functions $y = a^x$ and logarithmic functions $y = \log_a x$ as they change the value of the base a,
http://www.frc.mass.edu/smabrouk/Interactive/Graphing_Tools/Exp_Log_Comparison.xls; and

- to compare the graphs of exponential functions $y = a^x$ and logarithmic functions $y = \log_a x$ on the same axes as they change the value of the base a .

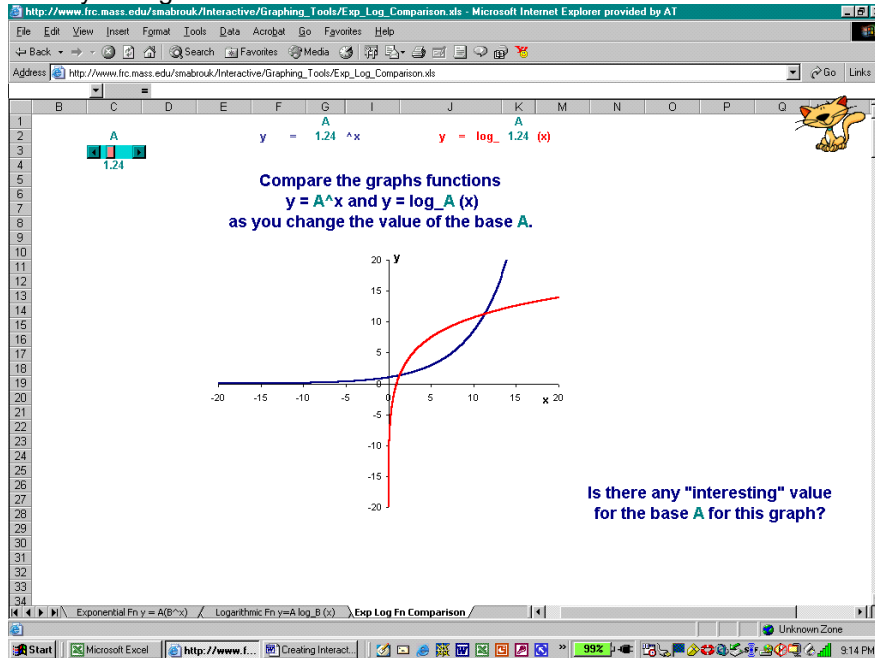


Figure 4

http://www.frc.mass.edu/smabrouk/Interactive/Graphing_Tools/Exp_Log_Comparison.xls

- to explore series and sequences and series, http://www.frc.mass.edu/smabrouk/Interactive/Sequences_Series_Tools/Sequence_And_Series_Exploration_1_over_n.xls;
- to explore percentages, http://www.frc.mass.edu/smabrouk/Interactive/General/Percentage_Investigation.xls;
- to explore applications of quadratic functions such as revenue and projectile motion, http://www.frc.mass.edu/smabrouk/Interactive/Quadratic_Fns/Monthly_Rental_Revenue.xls and http://www.frc.mass.edu/smabrouk/Interactive/Quadratic_Fns/Human_Cannonball.xls;
- to explore how changing one point affects linear regression, http://www.frc.mass.edu/smabrouk/Interactive/Statistics_Tools/Linear_Regression.xls;
- to explore the affects of outliers in normal, skewed, and multimodal distributions, http://www.frc.mass.edu/smabrouk/Interactive/Statistics_Tools/Outlier_Investigation.xls; and
- to explore how the mean and median are affected by changing one data value, http://www.frc.mass.edu/smabrouk/Interactive/Statistics_Tools/Mean_Median.xls.

All of these and many more are possible! I created and have used the above-described interactive workbooks using MS Excel. Students find these interactive workbooks easy to use and actually *fun* to use. Such workbooks are easy and fun to create.

These interactive workbooks can be used for demonstrations as well as for assignments, and one can design workbooks that include questions, graphs, equations, and explanations with the interactive aspects provided by buttons and scrollbars.

To make interactive workbooks using MS Excel, all you need to know are the basics of how to use MS Excel for calculations and graphing. To this, you simply add the Control Toolbox, one of the built-in toolbars. To display the Control Toolbox, you can use the Customize dialog box displayed in Figure 5, access through Customize on the Tools menu, or Control Toolbox on the Toolbars sub-menu accessed through the View menu displayed in Figure 6.

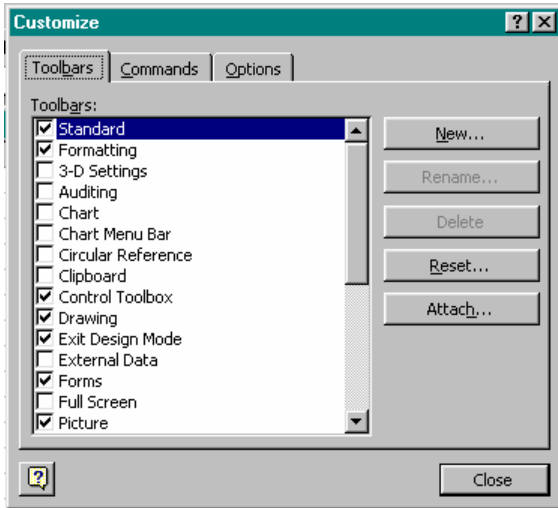


Figure 5: The Customize Dialog Box

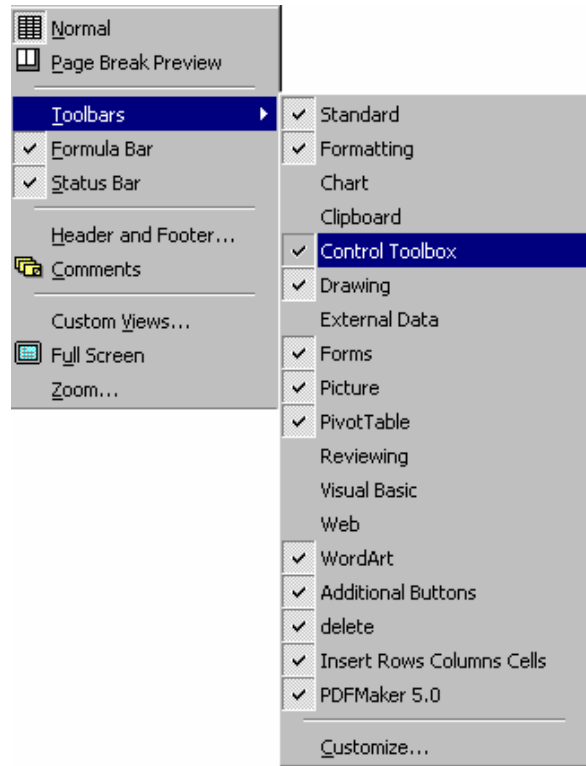


Figure 6: The Toolbars submenu access through the View menu.

Once you have added the Control Toolbar,



Figure 7: The Control Toolbox Toolbar

you can move it to any position on your screen or place it at the top of your screen with any other toolbars that you ordinarily use. The first button on the toolbar allows you to open and close the design mode. To create and to edit the components on the Control Toolbox Toolbar, you must be in design mode. The second button allow you to view the properties of any selected components on the page of the workbook while the third button allows you to edit the code associated with the components. The next buttons are used to create the check boxes, text boxes, command buttons, option buttons, list boxes, combo boxes, spin buttons, scroll bars, labels, images, and more controls, respectively.

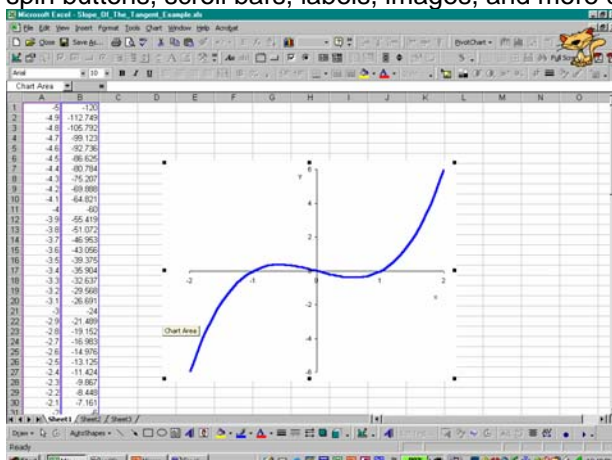


Figure 8: The graph and data for a slope of the tangent line analysis for the function $y = x^3 - x$.

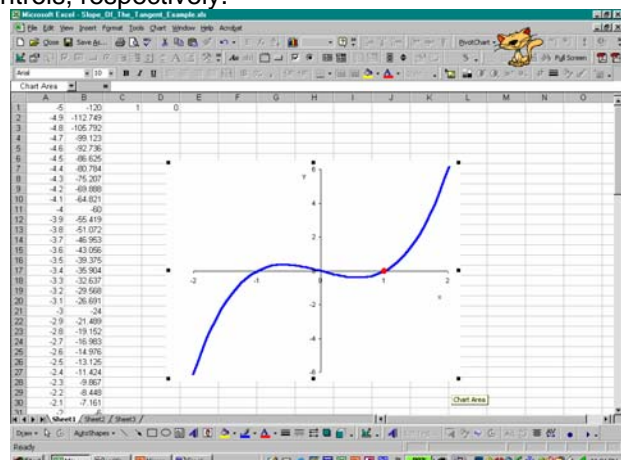


Figure 9: The point (1, 0) added to the graph.

So, let us create an interactive workbook that will allow students to explore the slope of the tangent line to a cubic function, the traditional changing of the secant line into a tangent line. To do this, we first must create the graph of the function for our analysis. Suppose we use $y = x^3 - x$ on the interval $[-2, 2]$. We create the graph in the same way in which we would create any other MS Excel graph as displayed in Figure 8. Suppose we examine the slope of the tangent line to the graph of the function at $x = 1$ and that we allow the students to explore the slope of the secant line as the second point varies as x changes from -2 to 2 in the interval, of course not allowing x to be 1. After adding the point $(1, 0)$ to the graph, we can add a scrollbar that we will use to move the second point along the curve. To do this, we must first enter design mode by left clicking the design mode button on the Control Toolbox Toolbar. Then, we can select to create a scrollbar by left-clicking the scrollbar button.

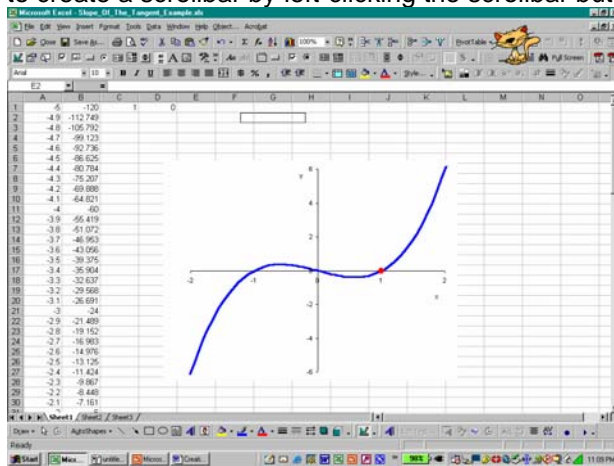


Figure 10: Creating the scrollbar by tracing it on the page.

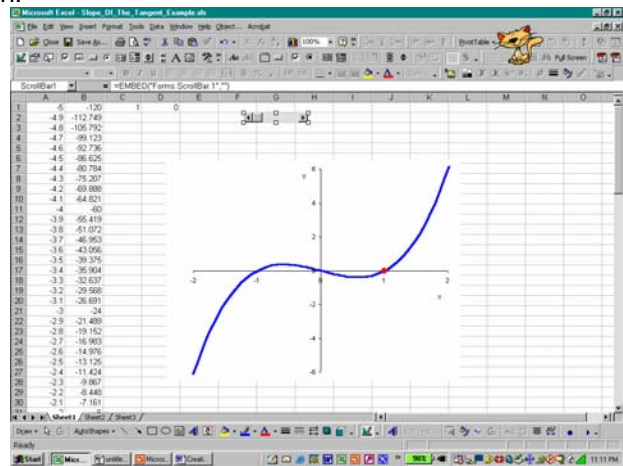


Figure 11: The scrollbar.

Then, we can trace our scrollbar on the page to the desired height either horizontally or vertically, Figure 10. When we release the mouse after tracing the scrollbar, we create a gray scrollbar on the page. We can then change the properties of the scrollbar including the color, size, and orientation as desired.

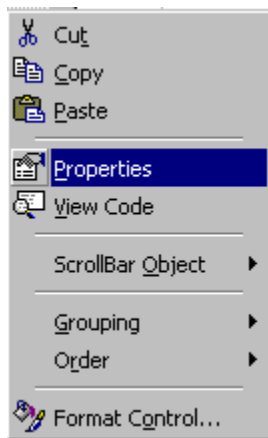


Figure 12: The Properties entry on the pop-up menu displayed by right-clicking the scrollbar.

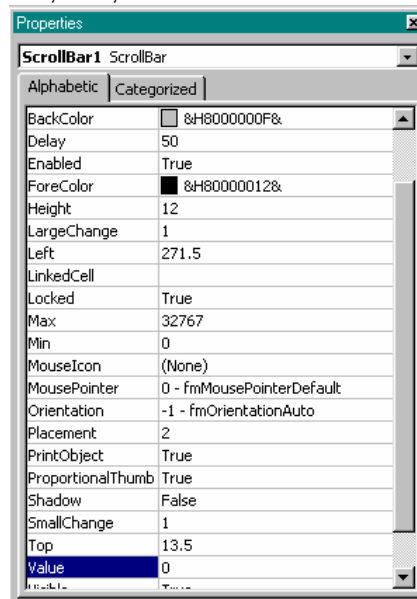


Figure 13: The Properties dialog box for the scrollbar.

To change the properties for the scrollbar, we can left-click the properties button on the Control Toolbox toolbar or right click the scrollbar. Either will open the Properties dialog box for the scrollbar. We can edit the properties using the alphabetical or the categoral listing of the properties, Figures 13 and 14. Here, we will use the categorized listing. To change any of these values, we will either left-click to select the property and enter the desire information or we will left-click to open the pull-down menu and select the desired entry.

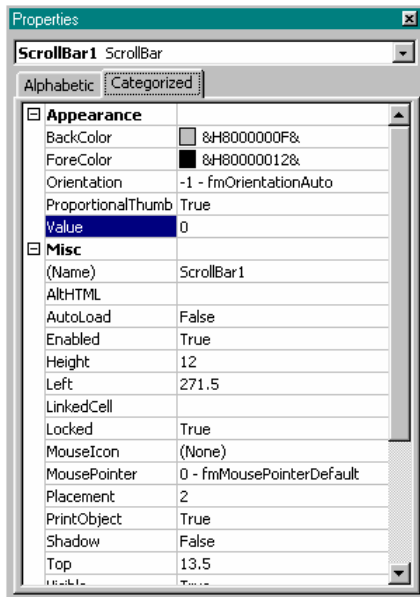


Figure 14: The Categorized tab of the Properties dialog box. Left-clicking the back color and the fore color entries allows us to select the colors for the scrollbar. If you would like to select colors other than shades of gray then use the Palette tab as displayed in Figure 16.

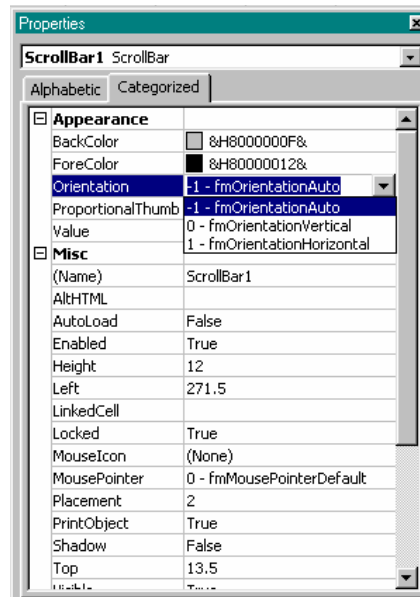


Figure 15: Changing the orientation for the scrollbar.

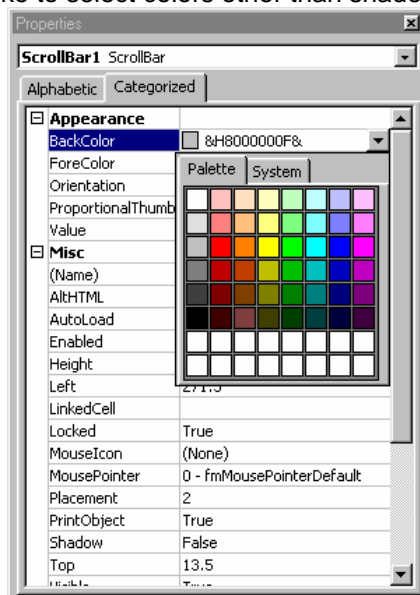


Figure 16: Changing the back color for the scrollbar using the pallet tab.

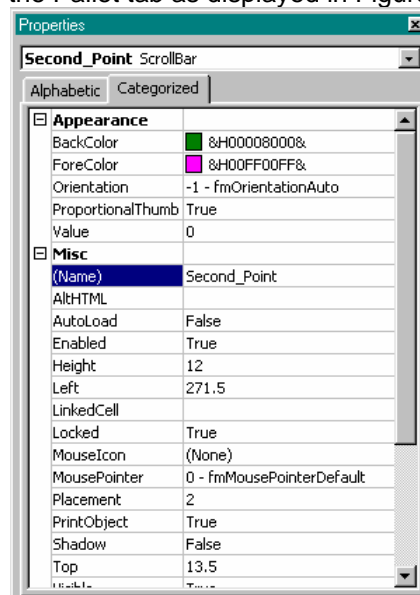


Figure 17: Naming the scrollbar.

After selecting these colors, we can name the scrollbar using the Name entry, Figure 17; we left-click and enter the desired name. While it is not necessary to name the objects as you create them, you will find it helpful if you have multiple scrollbars, for example, on a page. After naming the scrollbar, the new name will appear at the top of the Properties dialog box.

Next we set the maximum, minimum, and change values for the scrollbar. These must be positive numbers with, of course, the maximum larger than the minimum, and the change value must be a natural number. Here, we select a change of 1, a minimum of 0 and a maximum of 40, Figure 18. We will change these to the desired values using one of the cells. We must also choose a linked cell into which to put the value generated by the scrollbar. Since I prefer to display the values in our interval near the scrollbar, we will use cell E1 as our linked cell. If you would like to change the pointer, you can do that by selecting the mouse pointer menu. In addition to the listed pointers, you can select a pointer using the

last entry on the menu; for this, you must select a pointer from the available Windows pointers or an image that you have saved on your hard drive.

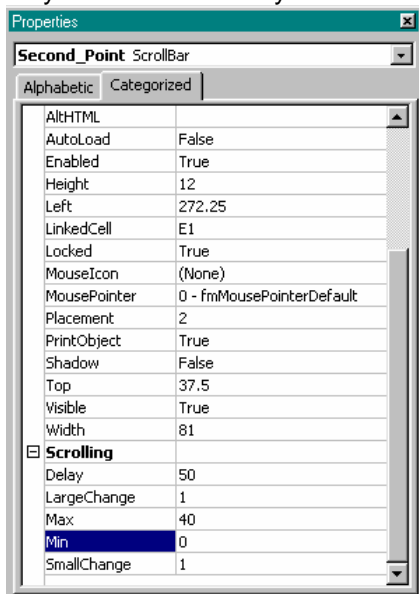


Figure 18: Setting the linked cell, the maximum value, and the minimum value for the scrollbar.

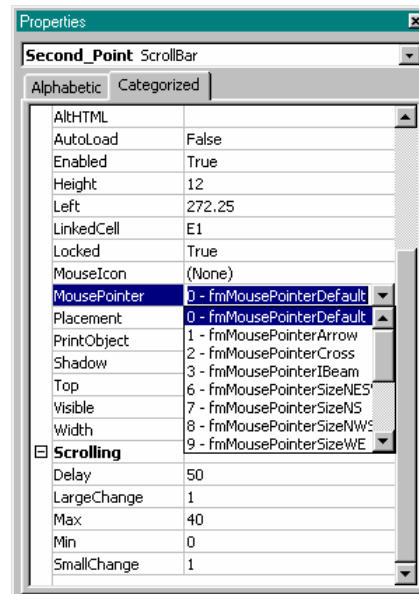


Figure 19: Changing the pointer.

When we have finished setting the desired properties, we exit design mode by left-clicking the design mode button on the toolbar. Once we have done this, we can examine the values of our scrollbar, Figure 20, checking to see that they vary from 0 to 40 in steps of 1 as set. Then, by entering a formula, here $(e1 - 20)/10$, to allow the values to change from -2 to 2 in steps of 0.1 . We can use similar formulas to allow the values to change using other increments as desired.

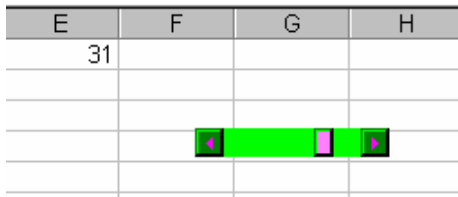


Figure 20: The scrollbar produces values from 0 to 40.

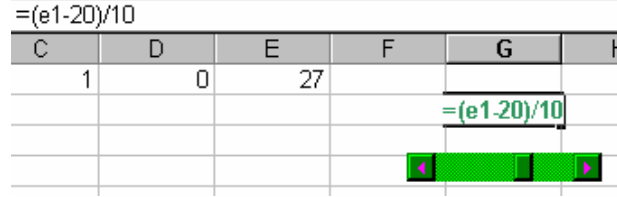


Figure 21: Creating the values that range from -2 to 2 .

So, as we see in Figure 22, the values in cell G2 vary from -2 to 2 as desired. Once we have the scrollbar values set, we can format and color the displayed number and use it to create the slope, Figure 23, as well as data with which to graph the secant line.

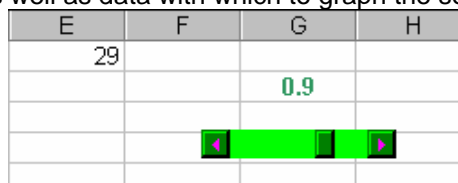


Figure 22: Values from -2 to 2 .

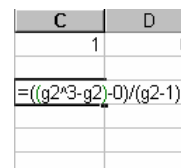


Figure 23: Creating the slope of the tangent line in cell C3.

In Figure 24, we set up the data for the secant line. As with any graph, you can choose how much data to use. Here, we will graph the scrollbar from $x = -2.3$ to $x = 2.3$ so that it will be easy to see on the graph for all values. If we would like to “cause trouble” for the students we can create the data allow the division by zero in the slope that will occur when the scrollbar value is 1. One advantage to doing this is that it allows for a lot of discussion and *explain* questions if you use the workbook as part of an assignment. The disadvantage is that without guidance, students will accept the graph of the tangent line that MS Excel produces without question. If you choose to display this line, I recommend that you post questions on the page that will guide the students and help them to see the graph of this secant line to be incorrect. So, for this scenario, every value produced by the scrollbar will have a corresponding secant line in the graph.

M	N	O
-2.3	=C\$3*(m1-1)	
-2.2		

Figure 24: Create the data to graph the secant line.

If you choose to eliminate the erroneous secant line, you can do this quite easily using an if function when you enter the formula to generate the y-coordinate of the secant line data as displayed in Figures 26 and 27. It is important to remember to use appropriate notation, \$'s, to keep the scrollbar value and the slope value from changing when you use the automatic fill on the spreadsheet.

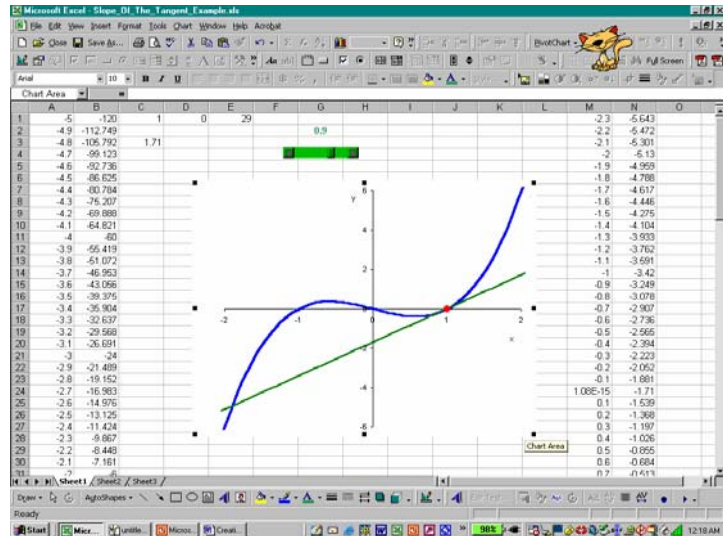


Figure 25: The secant line.

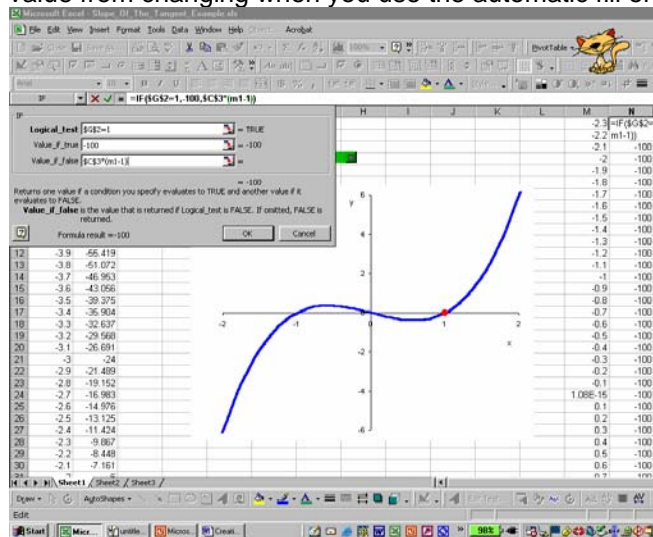


Figure 26: Using an If function to eliminate the graph when the scrollbar value is 1.

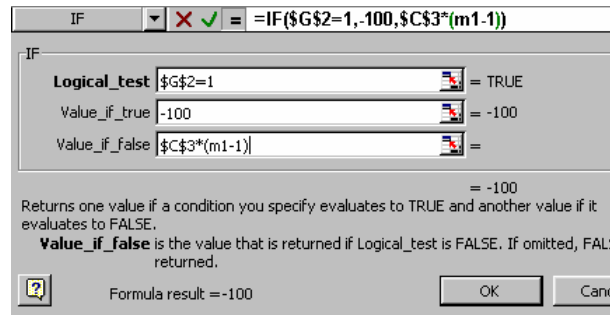
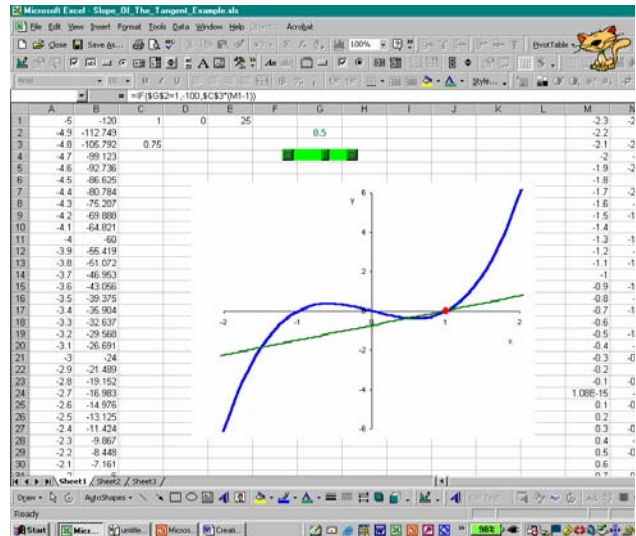
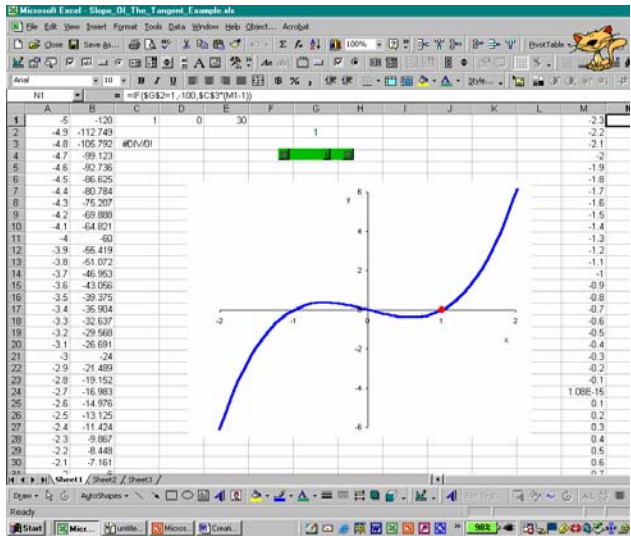


Figure 27: The If function.

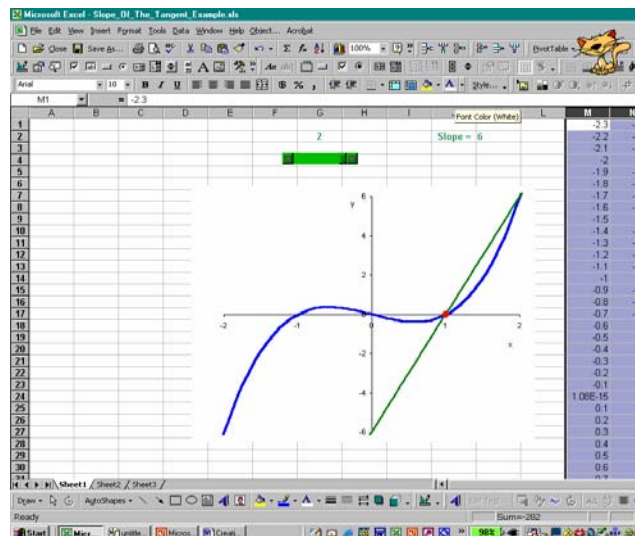
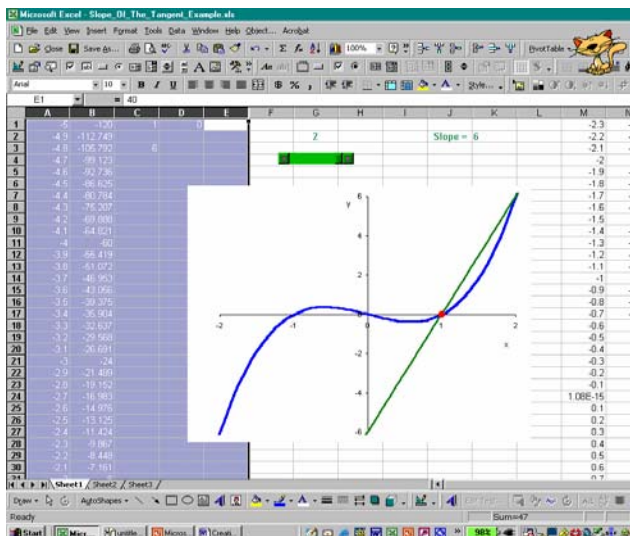
Setting the true-value in the if function allows us to prevent the graph from being displayed when the scrollbar value is 1. So, when the scrollbar value is 1, no graph will be displayed for the secant line as displayed in Figure 28 while all other secant line graphs will be displayed, Figure 29.

This too has its downside since students may not question why or even notice that there is no secant line displayed when the scrollbar value is 1. Again, a few well-designed questions will help a great deal and guide them to do the appropriate thinking and analysis.

With the scrollbar complete, we can hide the graph data, and eliminate the grid. What we need to do is make the background and the font colors match. Since I prefer a white background, we will simply make the font for the graph data be white and then we only need to turn off the grid.



So, as in Figure 30 and Figure 31, we select the desired columns and then change the color of the font.



After changing the font color for the data and turning off the grid, we have can name the page, and if we are not going to use the other pages in the workbook, delete the extra pages.

We can add other objects such as check boxes, text boxes, command buttons, option buttons, list boxes, combo boxes, toggle buttons, and spin buttons and pages with multiple activities to our workbook to create guided learning experiences for students as well as workbooks that can act as stand-alone assignments and projects.



Figure 7: The Control Toolbox Toolbar

check boxes text boxes command buttons option buttons

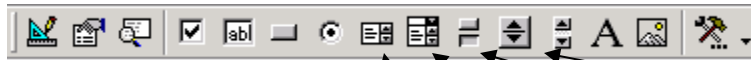


Figure 7: The Control Toolbox Toolbar

list boxes combo boxes toggle buttons spin buttons

For now, ...

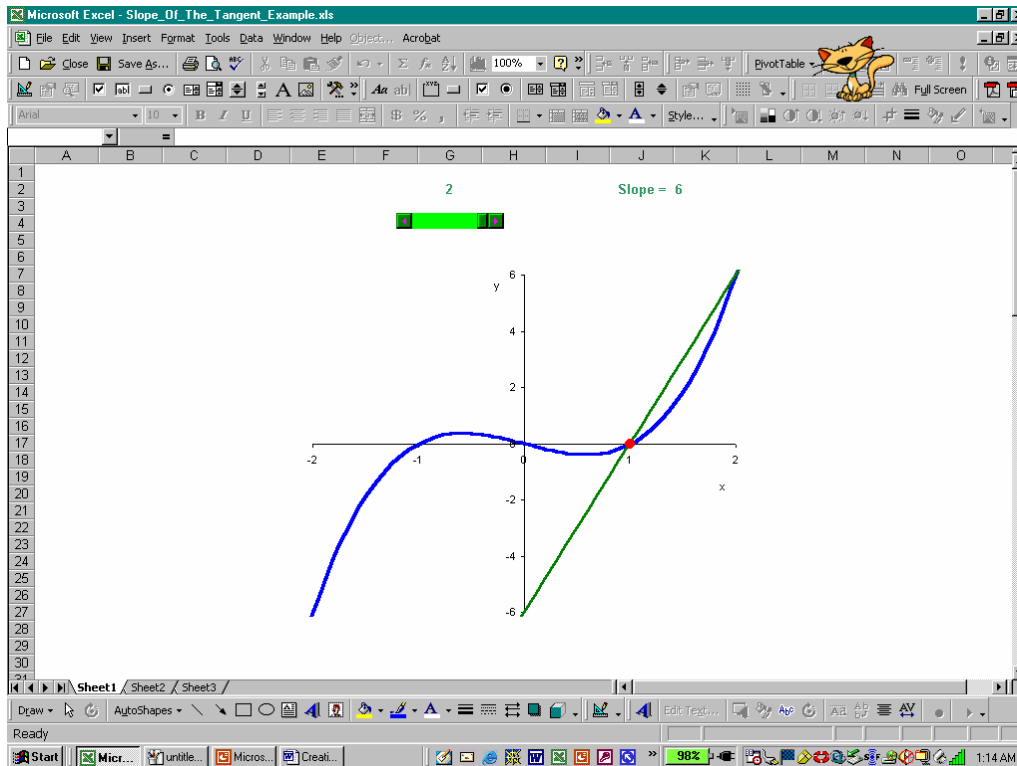


Figure 32: Turn off the grid to make the background white.

We see our completed workbook in Figure 34. While we can hide the data for the graph by changing the font color to match the background, we can also simply hide the columns that contain the data as well.

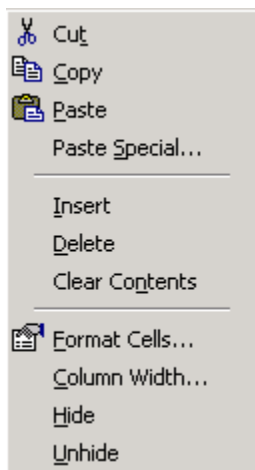


Figure 33: The pop-up menu displayed when you right-click a column in MS Excel

Hiding the columns can be beneficial if you plan to show the data since you will be able to unhide the columns easily. To hide columns in MS Excel, simply select the columns by left-clicking-holding-and dragging the cursor until the desired columns are highlighted and then right-click this section to display the pop-up menu displayed in Figure 33. To hide the selected columns, we select the Hide option on the menu. When we want to unhide the columns, we select the columns around the hidden columns and then right-click this section to display the same menu on which we would now select the Unhide option.

In general, I find it best to hide the data by making the data the same color as the background since hiding columns can affect graphs and objects in the same region as the hidden columns. In addition, except for when I am showing others how to create interactive workbooks, I rarely show the underlying data.

It is always a nice finishing touch to rename the sheet in a meaningful way and to delete any sheets that are not used in the workbook. If you create a workbook for which the user needs special instructions, it is always helpful to provide information/instructions for the use of the workbook. Using one sheet, the sheet

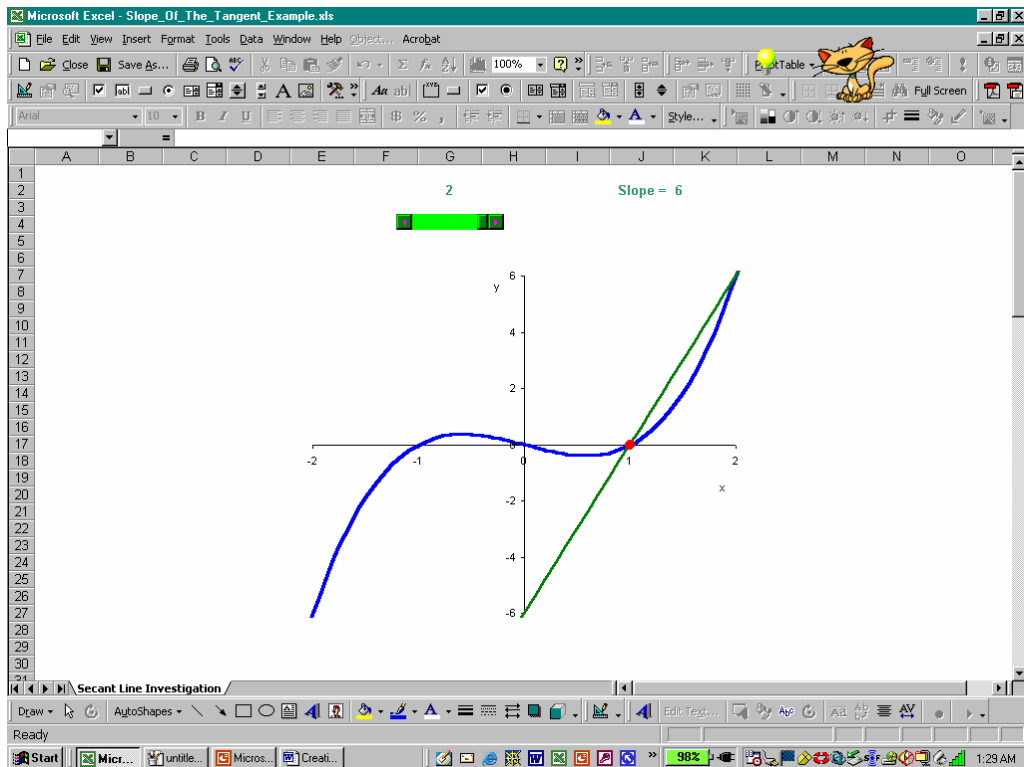





Figure 34: The workbook with one page.

to which the workbook first opens, as an instruction page will make the workbook more user-friendly. Finally, before you save and close the workbook, it is very important to make sure that you have set the scrollbar to the first value that you would like the user to see and select the page to which you would like the workbook to open. With this done, the workbook can be saved and closed, and then, the workbook is ready for use.

Now that we have created our first workbook with one element, a scrollbar, let us create a second workbook that contains three scrollbars, a pop-up text box, and a command button. Suppose you would like to create an interactive workbook that will allow students to explore the standard form of a quadratic function. Since the standard form for a quadratic function is $y = a(x-h)^2 + k$, we need a scrollbar for a ,

h , and k . As before, we "turn on" the Design mode by left-clicking the  Design Mode button on the Control Toolbox Toolbar, and then left-click the  Scrollbar button. We select the location, direction, and dimensions for the scrollbar by tracing the desired scrollbar on the worksheet; we release to generate the scrollbar. If you would like to generate three scrollbars of the same size then it is best either to copy the scrollbar twice more onto the worksheet or to set the dimensions of the other scrollbars to match the first when you are editing the scrollbar properties. For this scrollbar, Figure 35, we will create the first scrollbar, edit its properties, and then generate the second and third scrollbars by copying the first scrollbar and editing the properties of the new scrollbars.

To set the properties for the scrollbar, we can right-click the scrollbar and select Properties on the pop-up menu displayed in Figure 36 or left-click the Properties button, , on the Control Toolbox Toolbar. If you left-click the Properties toolbar button without selecting the scrollbar first, the Properties dialog box will display the properties of the worksheet rather than the properties of the scrollbar. This is not a problem since we can view the scrollbar properties using the pull-down menu at the top of the dialog box; these are displayed in Figures 37 and 38.

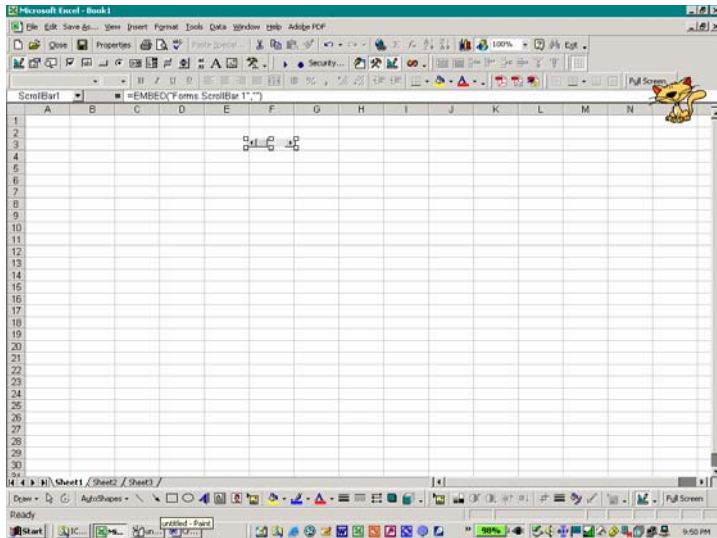


Figure 35: The newly generated scrollbar for which the properties must be set.

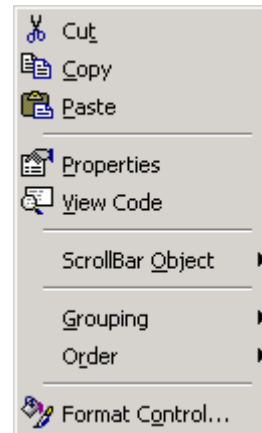


Figure 36: Pop-up menu displayed when you right-click the scrollbar.

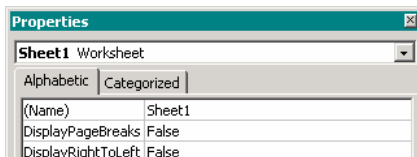


Figure 37: The properties dialog box displays the properties for the worksheet if the worksheet was selected.

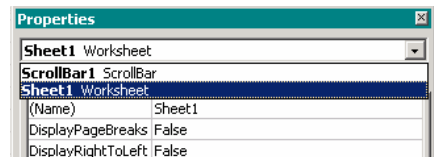


Figure 38: To display the properties for the scrollbar, we use the pull-down menu at the top of the properties dialog box.

Now, we set the colors, the scrollbar name, if desired, the linked cell, and the maximum, minimum, and change values for the scrollbar. We can select a mouse icon for the scrollbar as well as add visual effects such as a shadow.

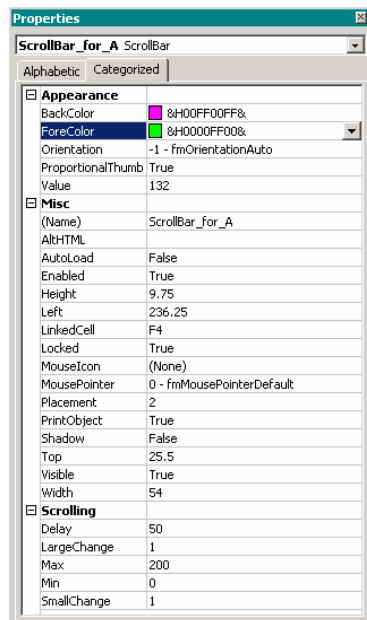



Figure 39: The properties for ScrollBar_for_A.

Here, we have set the background color to magenta, the foreground color to be a lime green, named the scrollbar ScrollBar_for_A, chosen cell F4 as the LinkedCell, set the maximum value for the scrollbar to be 200, the minimum value to be 0, and the increment as 1. When we copy this scrollbar, we must change the LinkedCell and, if desired, the maximum, minimum, and increment amounts for the scrollbar. For these scrollbars, although I will select different colors, I will use the same maximum, minimum, and increment values.

After creating the scrollbars and editing the properties for each, it is important to test them. To do this, we must exit Design mode by left-clicking the depressed

Design Mode toolbar button, . Then, using the bar or the arrows in the scrollbar, we see that the scrollbar works

Appropriately, displaying a minimum value of 0 and a maximum value of 200 for each in the linked cell as displayed in Figure 40.

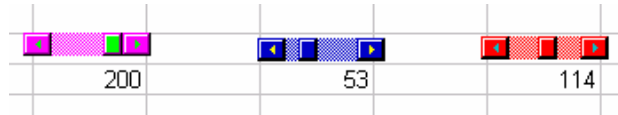


Figure 40: The tested scrollbars.

Since the maximum and minimum values for the scrollbar must be between 0 and 32,767, inclusive, we must use a formula to generate negative values, if desired. Since I would like these scrollbars to vary from -10 to 10 by tenths, I used the formula $=(J4-100)/10$ in cell J2 and similar formulas in cells F2 and H2; this is one of the many possible formulas. Now, testing the scrollbars, I find that they vary, as desired, from -10 to 10 in increments of 0.1 .

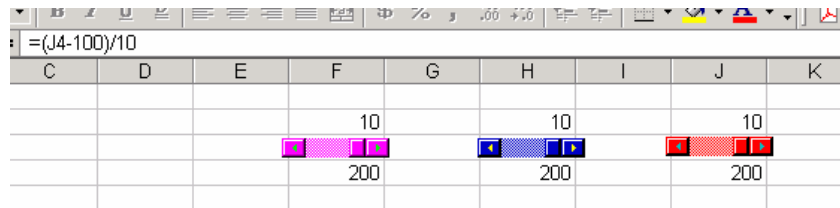


Figure 41: The scrollbars and the formula entered in cell J2.

Since we have created and set the scrollbars for the function coefficients A, H, and K, we are ready to create the data and the graph. We create the data so that the function the coefficient values for A, H, and K in cells F2, H2, and J2, respectively. Since the input values will be entered in column A, we use the formula $=\$F\$2*(A1-\$H\$2)^2+\$J\2 in cell B1; we must use the dollar signs (\$) around the column names for the cells containing the function coefficients since we want to fix these cell locations in the formula.

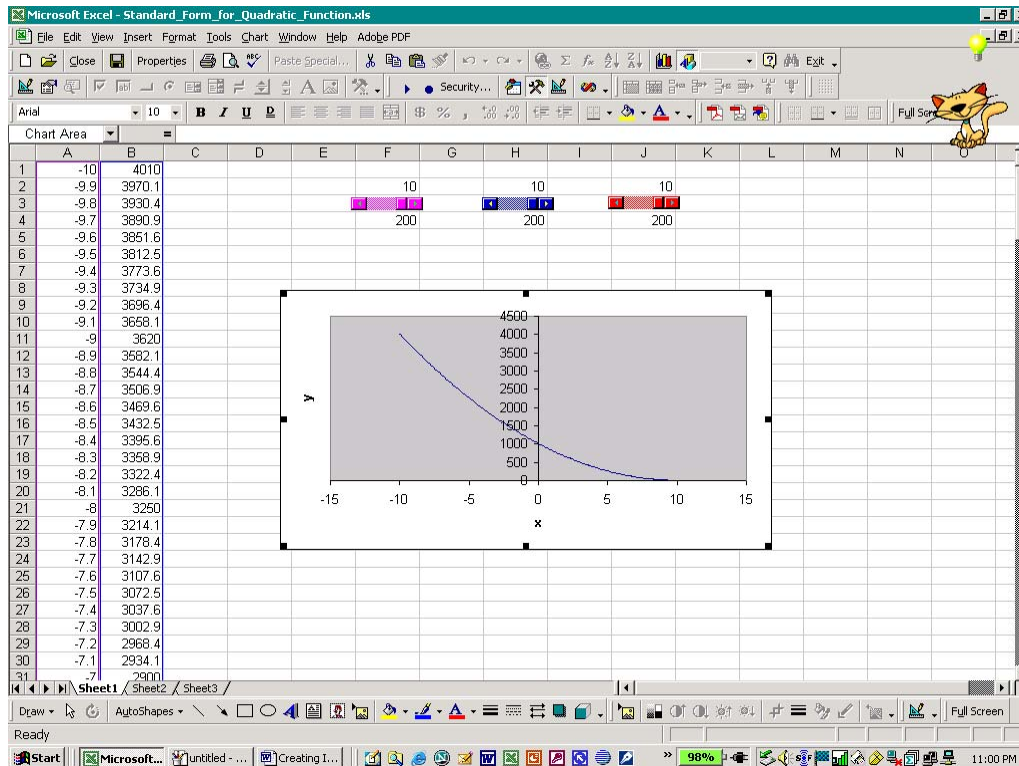


Figure 42: The worksheet with data and graph.

In Figure 42, we see the data and the graph for the data in the worksheet. Here, the data changes in increments of one-tenth. While some like to allow the axes to change as the user changes the parameter values, I prefer to fix the graph window to allow the user a more “continuous” view. It is important to note that if the graph window is not set then the graph window will change to accommodate the changing data values; this can be very distracting for the user.

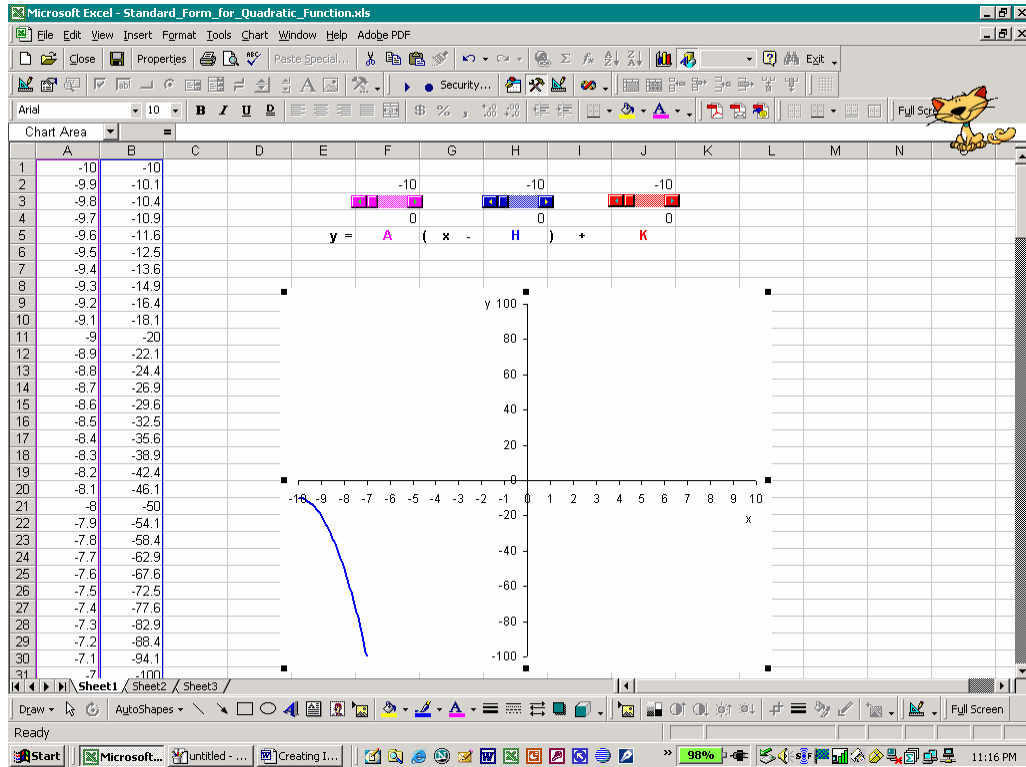



Figure 43: The worksheet with modified graph and function equation.

Figure 43 displays the worksheet with the modified graph: the graph window set to display inputs between -10 and 10 , inclusive, and function outputs between -100 and 100 , inclusive, the graph background has been set as white, the curve weight and color have been changed and a color-coded equation has been added near the scrollbars.

We are now ready to add the command button that will generate the pop-up text box. To create the command button, we enter Design Mode and left-click the Command Button toolbar button, , on the Control Toolbox Toolbar. We trace the button in the desired location as we traced the size of the scrollbar before. We will select text for the button and set the properties as we did for the scrollbars. Here, we will create a command button that can be used to provide help. The caption of the button has been set as “Do you need help?”.

To generate the pop-up text box, we must create a macro. To create a Macro, we determine what we would like to generate and then “record” the creation of this element. Then, we can attach this macro to the button so that when the user left-clicks the button the text box will appear on the screen. Before beginning the macro, it is important to make sure that all the elements are in their desired locations; I changed the position of the Help_Button slightly from that displayed in Figure 44.

With all the elements in their desired locations, we can begin the macro. We exit the Design Mode and select Macro on the Tools menu; the Tools menu is displayed in Figure 45. On the Macro submenu, we select Record New Macro. In the Record Macro dialog box, we name the macro and click Ok to begin.

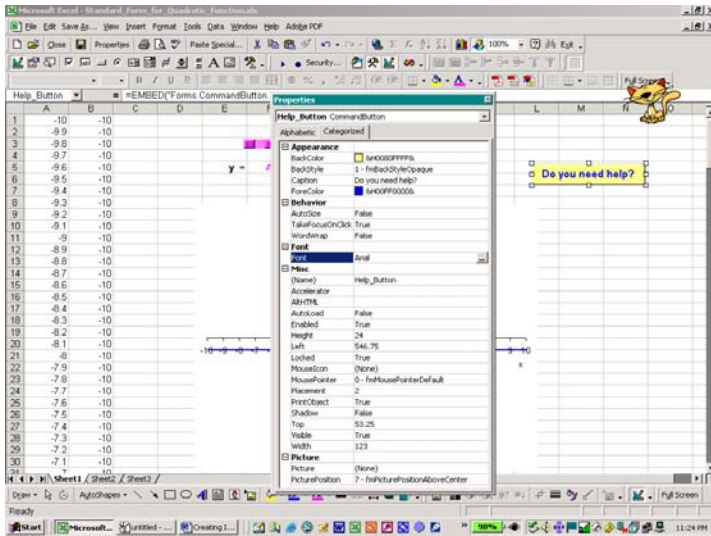


Figure 44: The Properties for the Help_Button.

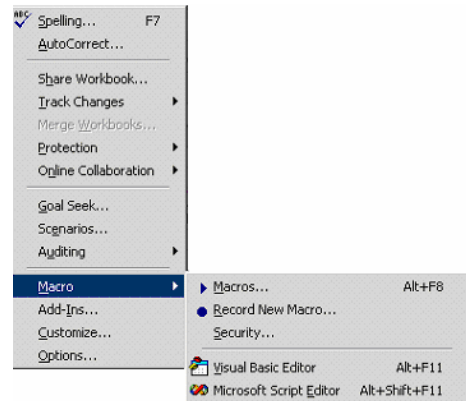


Figure 45: The Tools menu.

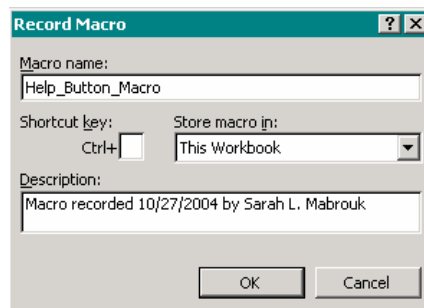




Figure 46: the Record Macro dialog box.



When we finish generating the macro, we click the stop button, . We use the text box button, , to generate a text box; as with other elements on the sheet, we left-click and drag to generate the box of the desired size and shape. Then with the box placed, we add the desired text, in this case instructions on how to use the scrollbars to change the function coefficients, and select the font and font

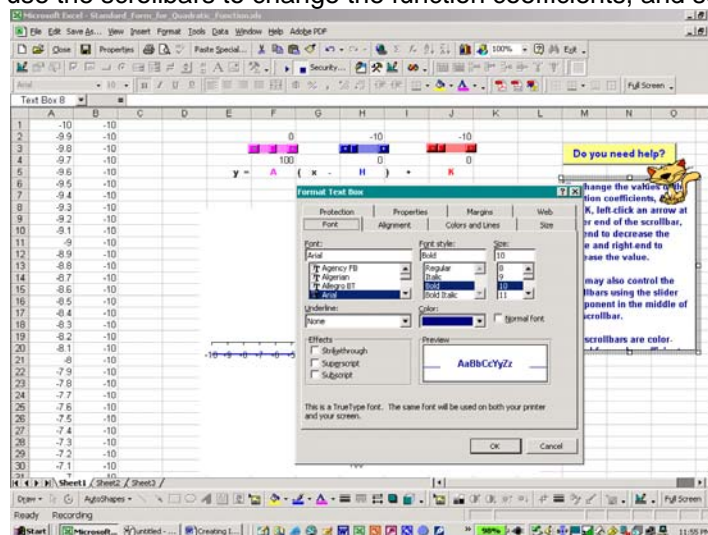


Figure 47: The Format Text Box dialog box.

color for the text; right-click the text box edge, and select Format Text Box change the text box properties in the Format Text Box dialog box. Here, I have set the text box colors to be the same as the Help_Button colors.

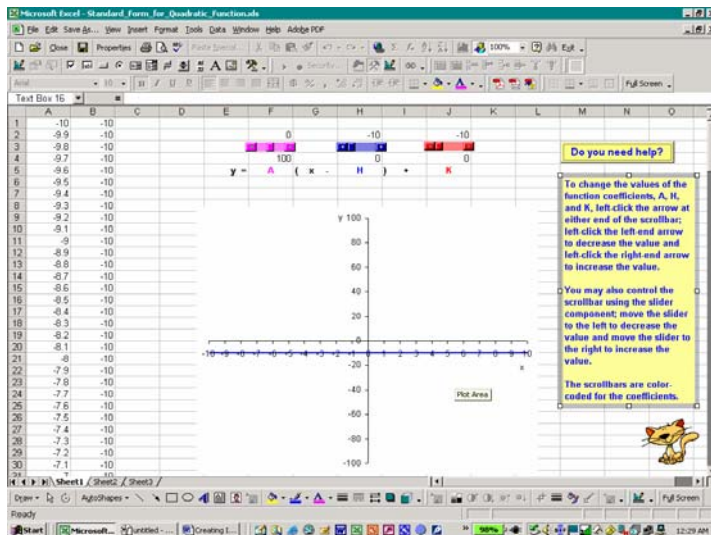


Figure 48: The new text box.

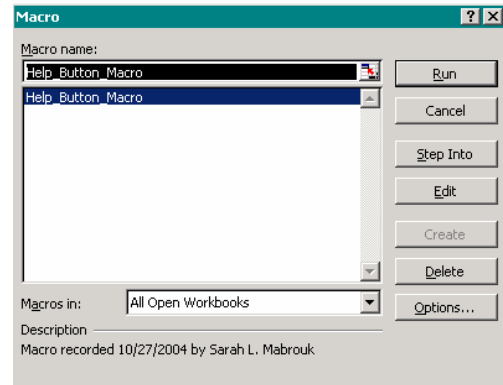


Figure 49: The Macro dialog box.

Now that the text box is in place. I will stop recording the macro by left-clicking the Stop button. To view the macro code and to attach this macro to the button, we select Macro on the Macro submenu of the Tools menu and then left-click the Edit button. All we need to do is copy the Visual Basic code for the Macro into the corresponding location for the Help_Button in the MS Visual Basic Editor. If the Help_Button window is not open in the Visual Basic editor, you can enter Design Mode and double-left-click the Help_Button to open it. We copy all the code between "Sub Help_Button_Macro()" and "End Sub" and copy this code between the corresponding beginning and end code for the button, "Private Sub Help_Button_Click()" and "End Sub", respectively.

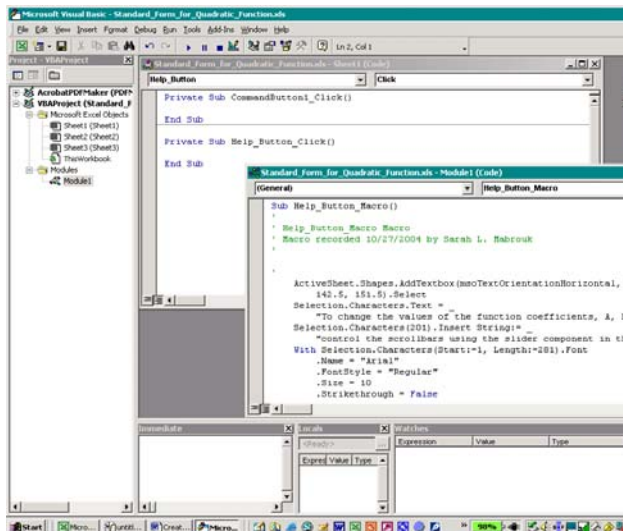


Figure 50: The MS Visual Basic Editor.

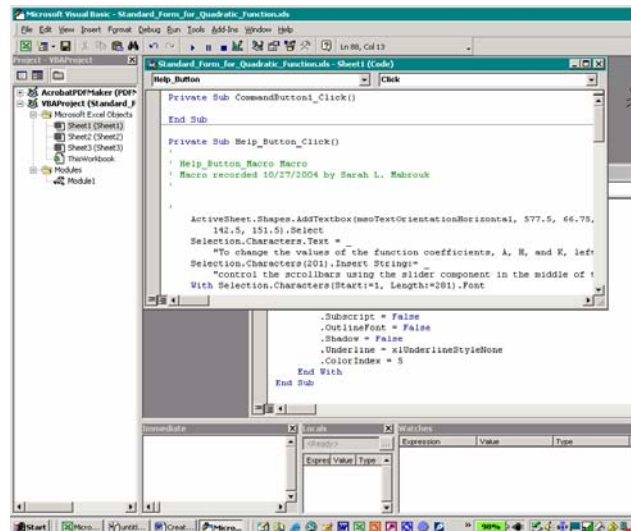


Figure 51: The Help_Button window in the MS Visual Basic Editor.

After pasting the macro code into place, we can close the Visual Basic editor and test the Help-Button. In this case, when we left-click the Help-Button, the text box will appear and remain selected within the worksheet. Leaving the text box selected provides added highlighting for the text. Adding a Close-Box is an added touch that the user may appreciate.

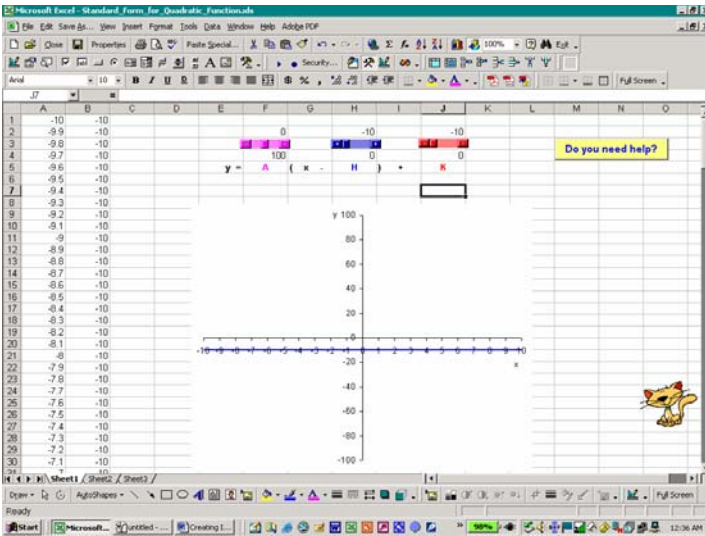


Figure 53: Left-clicking the Help-Button produces ...

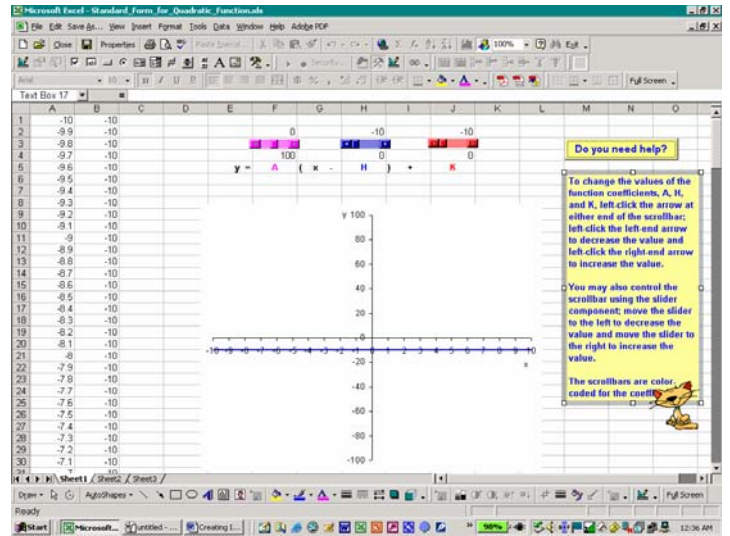


Figure 54: The text box generated using the Help_Button.

Final touches for the workbook include hiding the data, here using a white font to match the background, deleting the text box, deleting the extra sheets, naming this sheet, and color-coding the displayed values of the coefficients, hiding the values in the linked cells using a white font, eliminating the grid, and setting the initial values for the scrollbars.

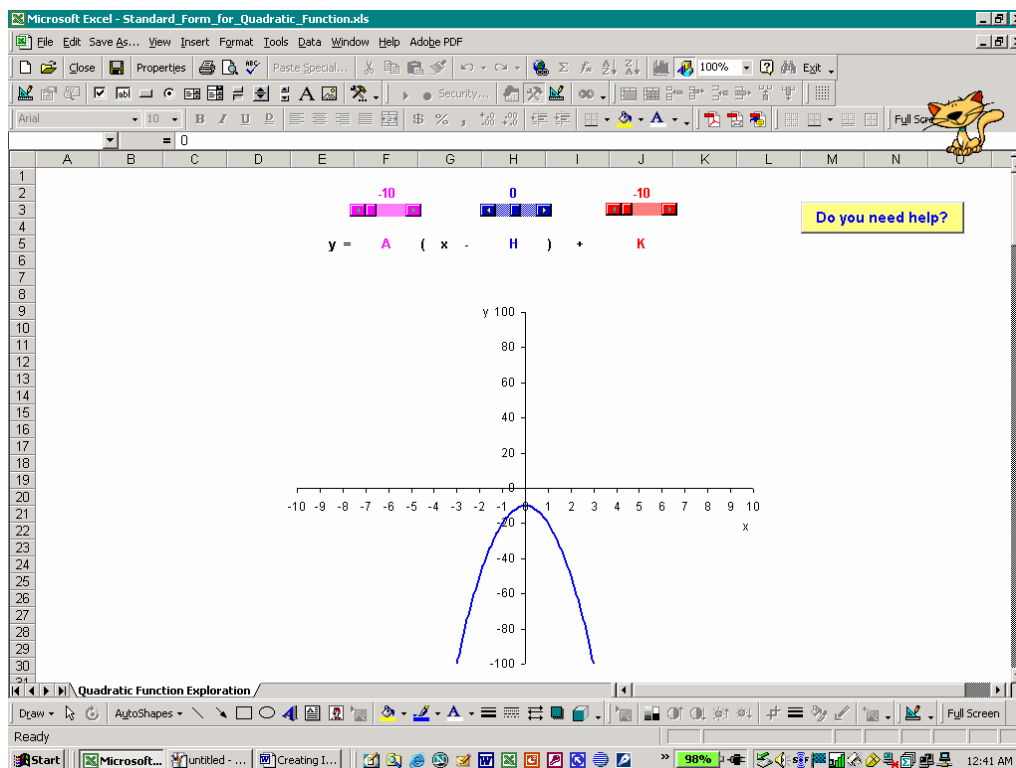


Figure 55: The finished interactive workbook.

The other elements on the Control Toolbox Toolbar are created in a similar manner, and macros can be recorded for and attached to these as well.

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