1. This exercise is about saving Sage graphics in the form of a pdf file.

   (a) Log in to the Sage server at `sage.colorado.edu` and open up the Sage worksheet "Functions" that you created in class on Tuesday. In this worksheet, find a cell (any cell!) that has some kind of plot command in it. For example, you should have a cell containing the code

   ```
   plot(x^2,-1,3,color='blue',axes_labels=['$x$','$y$'])
   +plot(3*x-2,-1,3,color='red')
   ```

   or something similar. Click anywhere in this cell, then evaluate the cell, to get your graph. (You may already have a graph below the cell, from the last time you ran this code. That's OK; run it again.)

   (b) Let's give it a name to the graph you just generated above. Here's how: enter the following code into the empty cell below the graph (if the cell below the graph is not empty, click on the little plus sign you see above the non-empty cell, and it'll create an empty one):

   ```
   CoolGraph=_
   ```

   (That's an underscore after the equal sign.) This code says: let's call the graph most recently generated "CoolGraph." You won't see any output; that's OK.

   (c) Now, in the empty cell below (again, if the cell below is not empty, click on the little plus sign to create an empty one), type

   ```
   CoolGraph.save('CoolOutput.pdf')
   ```

   This will save your graph in the pdf file "CoolOutput.pdf," and will output a link, which reads CoolOutput.pdf, to this output. You can click on this link to access the pdf file, which you may now save to your desktop and do whatever you wish with.

2. (For this exercise, you can continue working in the Sage worksheet "Functions" that you used for exercise 1 above. Scroll down to the bottom of this file; if there is not an empty cell at the bottom, click on the little plus sign to create one.)

   Sometimes we want to plot a function given by data points instead of a formula. The easiest way to enter data into Sage is in list format.

   (a) Suppose that you measured the outdoor temperature as 33°F at 1 p.m., then 30°F at 3 p.m., then 25°F at 5 p.m., and then 18°F at 8 p.m. Try entering this data into Sage as two lists (in the same cell):

   ```
   times=[1,3,5,8]
   Temps=[33,30,25,18]
   ```

   One you've typed this in, evaluate the box and move your cursor down to the next empty box. Your data is now stored in Sage.

   (b) To make a nice plot, type:

   ```
   Data=zip(times,Temps)
   list_plot(Data,axes_labels=['times (p.m.)','Temps (degrees F)'])
   ```

   and evaluate again. You should get a nice plot of the four data points.

   (c) Let's tweak the above graph: suppose you want to connect the dots. Cut, paste, and modify the second line above in a new cell, so that you now have this:

   ```
   list_plot(Data,axes_labels=['times (p.m.)','Temps (degrees F)'],
   plotjoined=True)
   ```

   and evaluate again.

   (d) Lastly, we might want to see our data displayed in a table. To do this, just use the command

   ```
   table(Data)
   ```

   in the next box. (This relies on the "Data" item that we defined in part (b) of this exercise by zipping together our two lists.) When you evaluate, you should see a nice table of your data, with time values in the first column and corresponding temperatures in the second column.

Before moving on to the next exercise, please press the "Save & quit" button at the top of your "Functions" worksheet.

3. For this problem, you will need the Sage program WaterDensity.sws, which you should have uploaded to your Sage account. This program will produce a plot of measured water density (in kg/m^3) as a function of temperature (in °C).

   (a) Open WaterDensity.sws and run the program, by placing your cursor in the cell containing the code and hitting "Evaluate" or Shift+Enter. This code should produce both a graph of data points and a table of data for you.

   What shape of graph do you get? What type of function does this look like?

   It looks like a parabola.

   (b) What is domain of this function (as shown)? What is the largest domain that might be physically reasonable?

   As shown, the domain is $[0, 10]$ (in degrees Celsius). But it might be reasonable for the domain to be $[0, 100]$, since the independent variable is water temperature, and outside of $[0, 100]$, water isn't water anymore. (Or is it $(0, 100)$?)

   (c) Use the *table* of data (not the graph) to find the density of water at a temperature of 3°C.

   Roughly locate the point on the graph corresponding to this temperature and density.

   The density at 3°C is about 999.965, as we can see from the table that Sage produces.

   (d) At what temperature(s) is the density equal to 999.955 kg/m^3?
   Is there only one temperature where this occurs, or are there several?

   From the graph or the table, we see that this density occurs roughly at 2.5 and 5.5 °C.

   (e) Would it make sense to say that temperature is a function of water density?
   Why or why not?

   No it would not make sense, because there does not correspond a *unique* temperature for each given density. For example, to the density 999.955 kg/m^3 there correspond the two temperatures 2.5 and 5.5 °C.

Please press the "Save & quit" button at the top of your worksheet. You're done!