ATSC 201 Fall 2019 Excel Tutorial

Tutorial Outline:

-Basic Introduction to Excel Terminology and Functions

-Example problems using equations and variables

-Format of Homework

Excel Terminology:

-Worksheet (spreadsheet): Your default display within excel containing a bunch of grid boxes called 'cells.'

-Cell: An individual box on a worksheet. A cell can contain three types of items: (1) text characters (ie words or sentences) , (2) numerical values, and (3) formulas. Each cell is identified by a column letter and row number. For example, the cell in the top left of the worksheet is called cell 'A1.' The cell immediately to the right is 'B1.' Underneath A1 is A2.

Using Cells:

Click in a cell and start typing words, numbers, or a formula. Let's start with text (no numbers). Click on cell 'A1' and type in your name. When you are done typing, hit enter. Note that your name may appear to also show up under column B if it is long enough but that the contents are still all contained within cell A1. Numerical values can be entered in the same manner (type in a value and hit enter).

Using cells as a means of calculation (inputing a formula):

Let's say we want to calculate the expression 579 + 621. Excel can do all this for you when the expression is entered correctly within one individual cell. Click on cell 'B3,' it is where we will do this calculation. We cannot just type in '579+621' and hit enter and expect Excel to solve the problem. Instead, for excel to know that this is a calculation, we must start with an '=', so within B3 should be typed '=579+621', then hit enter. Note that what we have entered has disappeared and what is left is the result, the answer!

Excel can handle more complex calculations as well involving sines, cosines, absolute values and exponents just to name a few. Note, however that angles must be given in **Radians, not Degrees**. If we wanted to find the cosine of an angle, say π, we would type '=cos(pi())'. Try it in an available cell. You should obtain the answer '-1.'

The table on the back of this sheet provides a partial list of Excel mathematical functions.

Mathematical expression	In Excel	Notes
+	+	
-	-	
x	*	
÷	/	
| a |	abs(a)	Absolute value
a^b	a^b	
sin(a)	sin(a)	Argument in radians
cos(a)	cos(a)	
tan(a)	tan(a)	
arcsin(a)	asin(a)	Returns in radians
arccos(a)	acos(a)	
arctan(a)	atan(a)	
π	pi()	No argument needed
e^b	exp(b)	To get value of e, use exp(1).
ln(b)	ln(b)	Natural log
log(b)	log(b)	Base 10
$\log_2(b)$	log(b,2)	Base 2 (2 can be replaced by other bases)
$1x10^{-3}$	1E-3	E means "times ten to the power of"
$(a)^{1/2}$	sqrt(a)	square root

Defining and using variables:
To learn how to define variables we will set up a sample problem. Our problem is:

"Plot the change in density of dry air with height in an isothermal (constant temperature) atmosphere. Use pressure (P) coordinates as a surrogate for height, with the highest pressure at the bottom of the vertical (y) axis. Plot for pressures of 100 - 0 kPa, at 10 kPa increments.
a) use T = 25 degC, and plot on a linear-linear graph
b) copy the graph from (a) and change the vertical (P) axis to be logarithmic. (i.e., semi-log graph)
c) copy the graph from (b) and use it to plot multiple semi-log graph curves. In addition to T = 25 degC already plotted, add the curves for T = 0 degC and T = -25 degC."

First, we need to set up the spreadsheet into an ideal printing format. Select Layout > Page Layout. This way, you can see how many columns will fit in one page.

When you have created all your answers, check all your pages to ensure that no lines extend into adjacent pages. Wrap your text or move your graphs as needed to avoid splitting the graph once you are ready to print the worksheet.
After you finished creating all your answers, save the excel spreadsheet as an xls or xlsx file, and save it again as a pdf file to print.

Now back to our exercise…

The Equation of State we will use to solve this problem is the Ideal Gas Law (eqn 1.18)

$P = \rho * R_d * T$

Where P is the total atmospheric pressure, ρ the dry air density, R_d the gas constant and T the temperature of the air in Kelvin.

The first thing we must do when starting a HW exercise is put our name, student number, homework number, date, etc in the header. Also, turn on page numbers in the footer.

Next, write the Chapter number and the exercise number. Then copy the problem statement into the excel worksheet. If the assignment is in our textbook, you can do a screen capture of the exercise and paste or drag the resulting image into the spreadsheet. Otherwise, insert a text box into the spreadsheet (click "insert" menu, then "text box", then use your cursor to click and drag to put the box where you want it in the spreadsheet). For this exercise, we need to use the text box method, and then click in the box and start typing the problem statement.

Now, underneath our problem statement, we define our known and unknown variables, and make any assumptions if needed. Then, write the equation number that you plan to use. If possible, make a screen capture of that equation and drag or paste it into your spreadsheet.
Your excel worksheet should look something like:

ATSC 201	HW #2	Your name
today's date 2019		Your SN

Chapter 1

1) Plot the change in density of dry air with height in an isothermal (constant temperature) atmosphere. Use pressure (P) coordinates as a surrogate for height, with the highest pressure at the bottom of the vertical (y) axis. Plot for pressures of 100 - 0 kPa, at 10 kPa increments.
a) use T = 25 degC, and plot on a linear-linear graph
b) copy the graph from (a) and change the vertical (P) axis to be logarithmic. (i.e., semi-log graph)
c) copy the graph from (b) and use it to plot multiple semi-log graph curves. In addition to T = 25 degC already plotted, add the curves for T = 0 degC & T = -25 degC.

Given:	P range =	100 to 0	kPa	
	Dry air			
	T =	25	degC	for (a)
Find:	rho vs. P	?	kg/m3	
Assume:	Ideal gas law			
Solution:	Use eq. (1.18)	$P = \rho \cdot \Re_d \cdot T$		
	solve for rho: rho = P/ (Rd * T)			
where	Rd =	0.287053	kPa·K–1·m3·kg–1	

Part (a) of the Exercise:
Skip down a few rows, and then in column B type the column header "P (kPa)". Under that header, type 100 as the first pressure. Under that, type 90 as the next pressure. Then, we can use the automatic sequence completion feature of Excel to enter the other pressures for us. To do that, click once in the center of the cell holding the 100 value, and drag the cursor to the center of the cell holding 90. Then let up on the cursor -- those first two pressure cells should have a box around them. If you position the cursor of the bottom right corner of that box, then you can drag that corner (called a "handle") downward to extend the pressure values to 0 pressure. (see example below).

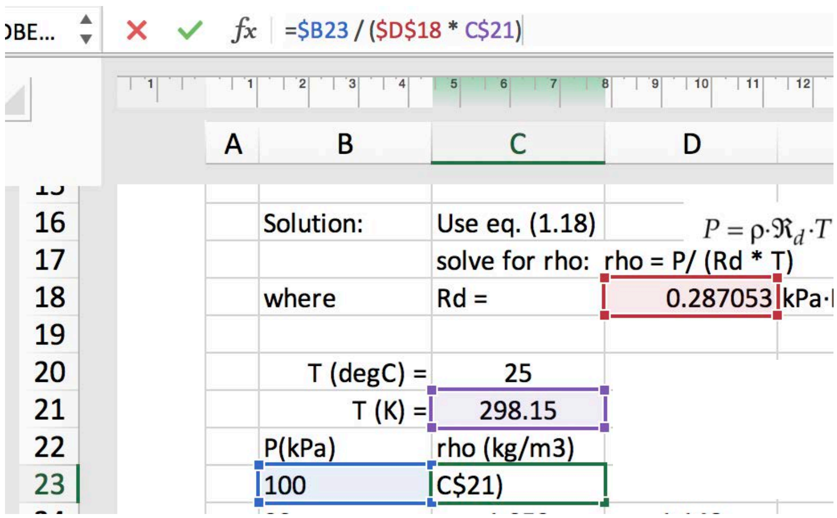
Now, let's use variables to start solving the problem. Planning ahead, we know that we will eventually need to plot 3 curves, one for each of the 3 temperatures in part (c). We can lay out the spreadsheet solve for part (a) while planning ahead for parts (b) and (c). To do this, two cells above the "P (kPa)", type the words "T (degC)". In the cell below that, type "T (K)". The reason for this is that thermodynamic equations almost always need to use temperatures in kelvin, so we will need to convert the temperatures that were given.

Just to the right of the cell holding "T (degC)", type the temperature given for part (a): 25 . Then, in the "T (K)" row under the 25 value, enter the formula to calculate the kelvin temperature. Don't forget to start with an equal sign: "=(cell ID for temperature in Celsius)+273.15". After you hit "enter", the result of the calculation will appear in the cell. You can always go back and see the formula by clicker in the cell again.
The bottom part of you sheet should look like:

Solution:	Use eq. (1.18)	$P = \rho \cdot \Re_d \cdot T$	
	solve for rho: rho = P/ (Rd * T)		
where	Rd =	0.287053	kPa·K–1·m3·kg–1
T (degC) =	25		
T (K) =	298.15		
P(kPa)			
100			
90			
80			
70			
60			
50			
40			
30			
20			
10			
0			

If you click in the cell holding the kelvin temperature, it will make the terms and factors in your formula different colours, and will use those same colours to highlight the corresponding cells on your spreadsheet. This is very handy for debugging your spreadsheet, because you can see which cells were used in your formula.

Next, we need to enter the formula to calculate the first density. In the cell to the right of the 100 kPa value, click in it and start your formula with an equal sign.
= cell holding P / (cell holding Rd * cell holding T in kelvin) . Enter the appropriate cell addresses by clicking in those respective cells. On my spreadsheet, after I have entered the formula, I can click once in the "formula bar" above the ABCD column labels, to make the cells that I referenced show us in the same colours that are in the formula. See the example:



After viewing those coloured cells, hit "enter" to exit that colour display. Check to see that the calculated result for density is reasonable; namely, compare to Table 1-5 in the textbook.

Next, we can take advantage of an Excel shortcut to use that one equation that we typed in, and "fill it down" next to all the other pressures. To do this, click once in the center of the cell holding that first density, and you will see a box around it. Let up on the cursor, and then grab the handle at the bottom right corner of this box, and pull it down next to all the pressures. This action copies your one equation for density into all the other cells below it. That process is called "fill down". You can similarly "fill right", "fill up", etc.

When you finished filling down, you will probably get garbage or errors showing in those other cells. This is because of the fact that Excel uses "RELATIVE" references in the formula that you type in.

(Be sure to Save your work frequently.)

For example, using the figure above, my equation for density is entered into cell C23. It refers to the pressure one cell to its left, and to the temperature 2 cells above it, and to Rd which is one column to the right and 5 rows up. These are all relative to the location of the formula.

When you filled that equation down to the next cell below, the equation in that cell is looking for numbers in the same RELATIVE locations. Namely: the pressure one cell to its left, and to the temperature 2 cells above it, and to Rd which is one column to the right and 5 rows up.

Although this worked for pressure, it didn't work for T and Rd. We really wished that the formula referred to an ABSOLUTE reference for those variables. Namely, we want it to always look for T in cell C21 in my spreadsheet above, and for Rd in cell D18.

To fix this, click once in the center of the first equation that you had types, for density at P = 100 kPa. Double click to edit the formula, and put dollar signs "$" in front of the column letter and in front of the row number for those two cells. Namely, your density formula should refer to T in cell C21, and to Rd in cell D18 (or to the corresponding cells in your own spreadsheet). Hit enter.

Now, when you click once in the center of that first cell that you just fixed, when you fill it down again, all the densities should look reasonable, as shown below.

Solution:	Use eq. (1.18)		$P = \rho \cdot \Re_d \cdot T$
	solve for rho:	rho = P/ (Rd * T)	
where	Rd =	0.287053	kPa·K–1·m3·kg–1
T (degC) =	25		
T (K) =	298.15		
P(kPa)	rho (kg/m3)		
100	1.168		
90	1.052		
80	0.935		
70	0.818		
60	0.701		
50	0.584		
40	0.467		
30	0.351		
20	0.234		
10	0.117		
0	0.000		

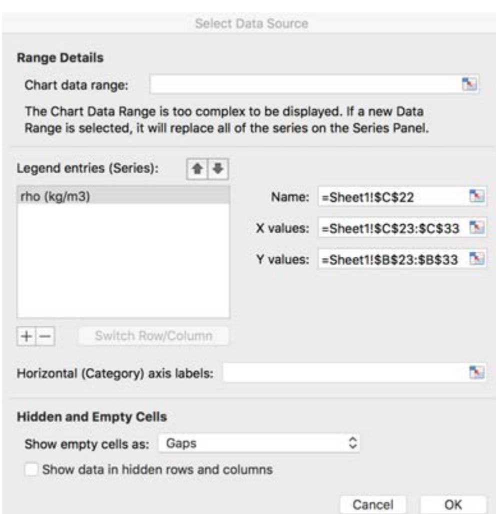
To plot these data, click once in the center of the cell labeled P(kPa), and drag down and to the right until you get to the last density value of 0.000 . All of those rows in those two columns should be selected. Next, use the "Insert" tab in the Excel window to insert a Chart. Be sure to

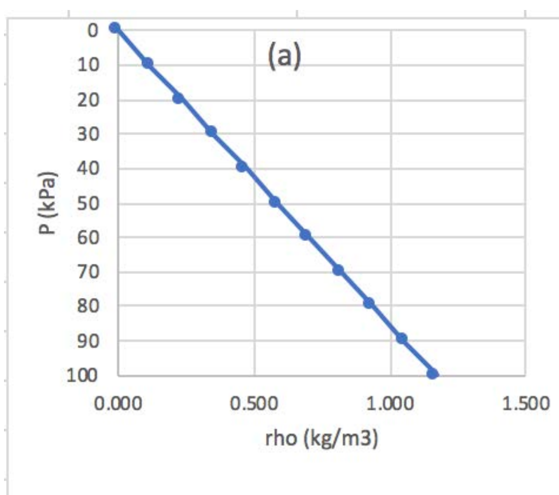
ALWAYS pick a scatter chart. Pick the scatter chart connected with straight lines. A chart will appear on your spreadsheet -- perhaps you can drag it to page 2.

What it will show should hopefully be a straight line, with pressure values along the bottom axis and density values along the vertical axis. But we want to switch the axes, and there is not a simple button to do this in Excel (don't use the "Switch row/column" button -- it doesn't do what we want). To make the switch, click once in the graph, which makes some new tabs appear at the top of your Excel window. Select the "Chart Design" tab, then hit the "Select Data" button.

A pop-up window will appear that shows the range of X values in column B, and the range of Y values in column C. But we want to switch the B's and C's. An easy way is to just type in this change. Alternately, you can use the little icons to the right of the X and Y value lines to view the original spreadsheet to select the appropriate column that you want for each axis. Regardless of how you do it, after switching the axis the resulting "Select Data Source" box should look something like the image at below left. Click the OK button.

Next, double click on the numbers in the vertical axis. This should cause a "Format Axis" box to appear. In the Axis Options section, near the bottom, click on the check box for "Values in reverse order". This will cause the high-pressure values to be at the bottom of the graph, to correspond to the high pressures at the bottom of the atmosphere. Your graph should look like the image below right (but without all the axis labels).





To make the axes numbers and labels look the way you want, first click once in the graph to get the "Chart Design" tab to appear at the top of your window. Then select that tab, and then see the "Add Chart Element" button at the left side of the chart design ribbon. When you click on it, it drops down to allow you to change things like chart title, axes titles, etc. Use these to make your graph look similar to the figure above right.

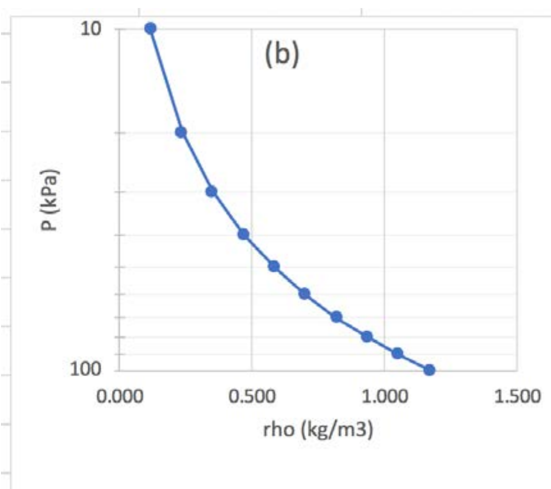
This completes part (a) of the exercise. Be sure to Save your work frequently.

<u>Part (b) of the Exercise</u>:

This part is easy. Click once in your graph from part (a) and copy it. Then click in an empty cell to the right of that graph, and paste. (Or you can click once in the first graph, and then hold down the option key (on a Mac) while you drag to an empty cell to the right.) The resulting graph should look just like the first graph. This is a good starting point.

Next, in the new graph, double click on the numbers along the vertical axis. In the Format Axis box that appear, near the bottom, click on the check box for "Logarithmic scale". It will give you a warning about not being able to plot "0" on a log axis. Respond with "OK", then it should produce the desired semi-log graph.

Click once on the chart, select the Chart Design tab, select Add chart element, and then add minor grid lines for the log axis. Also change to chart title to say (b), and make any other labels look nice. The result should look something like the figure below. Save your results.



Having achieved this is an important skill. We often plot Pressure in a reversed log axis in the vertical, as a surrogate for height in the atmosphere. So you will use this skill a lot for future homeworks.

<u>Part (c) of the Exercise</u>:

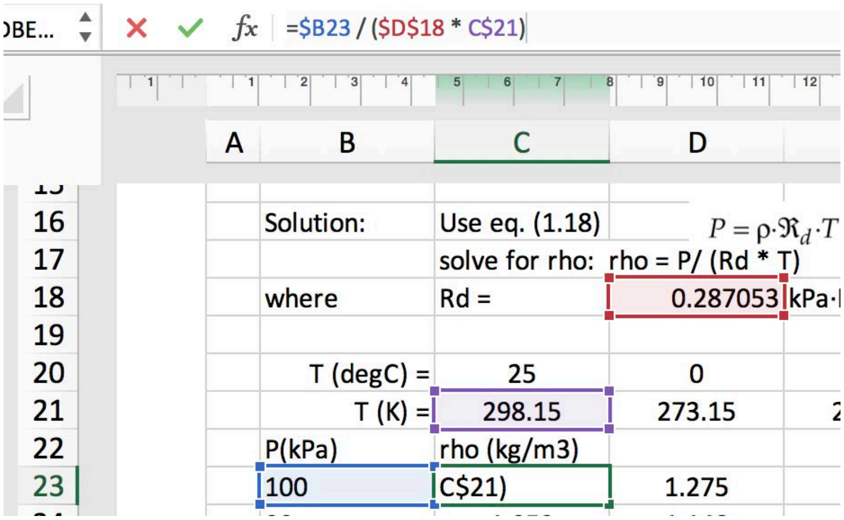
As a starting point, make a copy of your graph from part (b) and paste it in an empty part of page 2 of your spreadsheet.

On your own: in the cells to the right of the 25 degC temperature, add the other temperatures for 0 and -25 degC. Then use your new "fill" skills to take the formula for the first Kelvin temperature, and "fill right".

Next, click once in the center cell holding the first density value at P=100 kPa and T = 25 degC. Then click on the handle in the bottom right of that one cell, and drag it to the right to "fill right". The result should give you garbage, or unrealistic numbers. As you might guess, this relates to RELATIVE vs ABSOLUTE references. Namely, we indeed wanted the cell for Rd to be an absolute reference, but for pressure we had wanted only the column to stay constant, so it always look in column B for the pressure. So go back to the formula in the first density cell to edit it. We want a dollar sign "$" only in front of the column letter, not in front of the row number.

Similarly, in that same formula, we want it to always look for temperature in that one row, but for different columns. So, in the first density formula, put a dollar sign in front of the row number, but remove it from in front of the column letter.

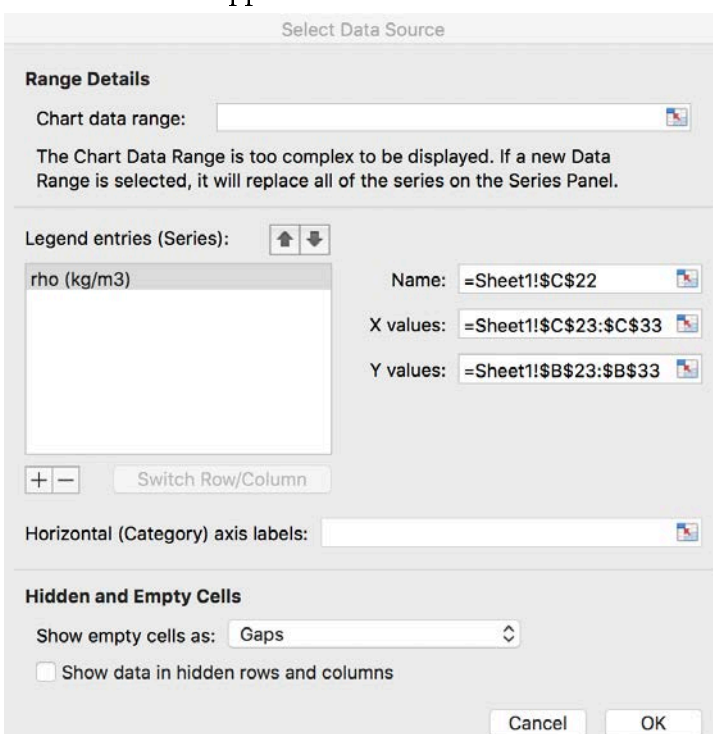
The net result for that formula in the first density cell should look like



Then, after hitting enter, you can fill that cell down. Then you can select the whole column of densities, and fill right into the next two columns. The result should not have changed the numbers in the first density column, but should have produce the additional two columns as shown below.

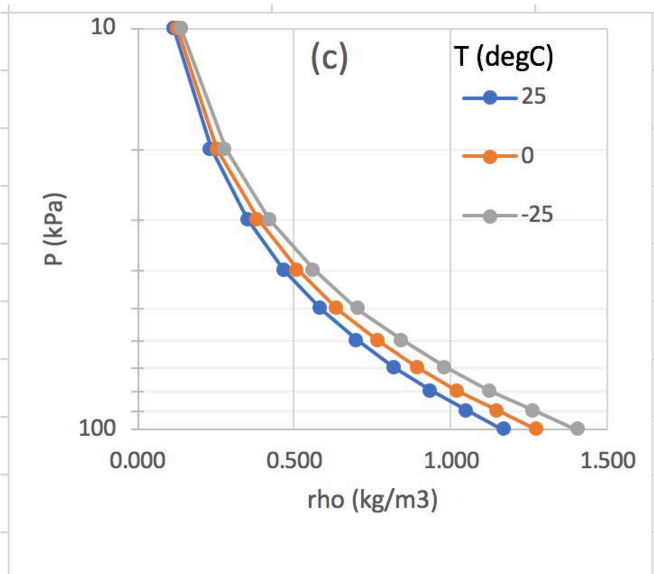
Solution:	Use eq. (1.18)	$P = \rho \cdot \Re_d \cdot T$	
	solve for rho: rho = P/ (Rd * T)		
where	Rd =	0.287053	kPa·K–1·m3·kg–1
T (degC) =	25	0	-25
T (K) =	298.15	273.15	248.15
P(kPa)	rho (kg/m3)		
100	1.168	1.275	1.404
90	1.052	1.148	1.263
80	0.935	1.020	1.123
70	0.818	0.893	0.983
60	0.701	0.765	0.842
50	0.584	0.638	0.702
40	0.467	0.510	0.562
30	0.351	0.383	0.421
20	0.234	0.255	0.281
10	0.117	0.128	0.140
0	0.000	0.000	0.000

The final step in part (c) is to add these 2 new curves to the plot. To do this, click once on the new graph that you had copied from part (b), then select the Chart Design Tab, and finally select the Select Data button. The box that appears is the same as we saw before ...

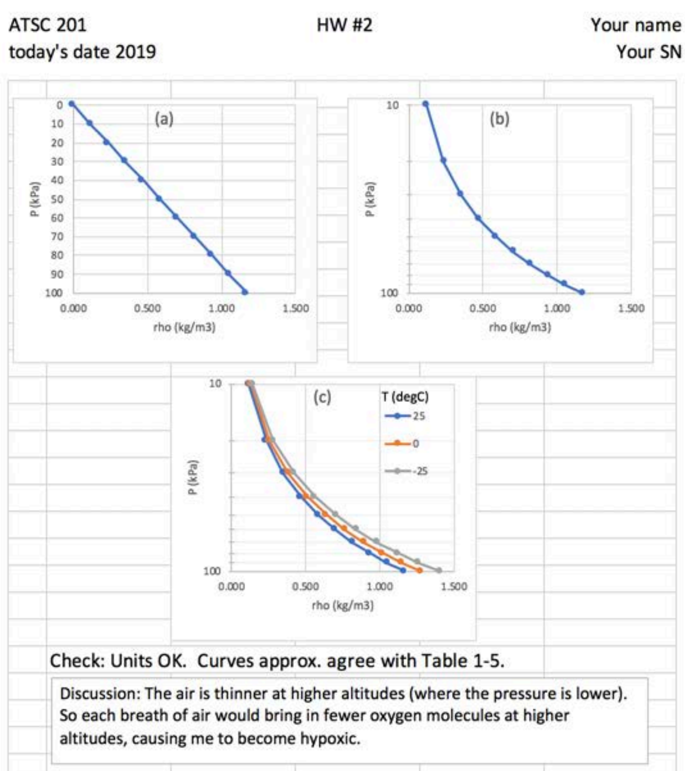


... but now focus on the "+" button near the left edge. Click on it to add another curve to the graph, and then select the appropriate spreadsheet columns for the X and Y values. Do this again to add a third curve.

The result should show all 3 curves in this part (c) graph. Finally, click once on this graph, and in the Chart Design tab select the "Add chart element" button, and select "Legend". After adding a legend your result should look more or less like the graph below.



You are nearly done. The last steps are to add the "Check" information like you do for all homework exercises, and insert a "text box" to add your Discussion.



Your final result should look similar to the pages at the end of this document.

Appendix. Summary of Plotting instructions using MS Excel (XY Scatter):

Many HW assignments ask for plots to support your answer and most all of them are referring to an XY Scatter type plot within Excel. Use these directions to guide your current and future work.
These directions assume you already have plotable data sorted into columns.

Step 1: Click on a blank cell on your worksheet.

Step 2: At the top of the program click on the insert tab, then on the 'scatter' button and select the appropriate type of scatter plot. I suggest 'scatter with straight lines and markers.'. A blank frame should appear so don't worry, you are doing this correctly!

Step 3: Right-click on this blank frame and click on 'select data.'

Step 4: A box titled 'Select Data Source should appear with two columns: Legend Entries (Series) and Horizontal (Category) Axis Labels. Under 'Legend Entries' click on the 'Add' button.

Step 5: A new box titled 'Edit Series' should pop up. It is from this dialogue where the data is selected to place on your set of axes. We will do this step 3 times to produce 3 lines on one plot (Solar elevation angles for 21-Dec, 23-Mar and 22-Jun).

Step 6: In the 'series name' box type in 21-Dec.

Step 7: In the 'series X values' box, click in the white area, then push the little button with the red, upward pointing arrow immediately to the right.

Step 8: A new 'edit series' box will appear. It is here that we will select our x-coordinate data: the local time of day. Highlight all of the local time data, not including the column title. Note Excel has inputted a formula into the Edit series box for you. All that you need to do once this data is selected is push the button in 'edit series' box with the downward red arrow. You should be brought back to the original 'edit series' box.

Step 9: Repeat steps 7 and 8, except for the 'Series Y values' this time. You should delete the ={1} before proceeding with selecting the data.

Step 10: Hit the 'OK' button on the main 'edit series' box and a graph will be generated. Note this is for only the 21 December data. Start again with the 'Add' button from the Select Data Source box, which should still be open, and follow steps 4-10 again for the other two cases. Then hit 'OK' on the Select Data Source box and you will see your whole plot.

All plots should be edited to have appropriate axis labels, units and legend. We will go over this once everyone has reproduced the raw figure.

ATSC 201 HW #2 Your name

today's date 2019 Your SN

1) Plot the change in density of dry air with height in an isothermal (constant temperature) atmosphere. Use pressure (P) coordinates as a surrogate for height, with the highest pressure at the bottom of the vertical axis. Plot for pressures of 100 - 1 kPa, at 10 kPa increments.
a) use T = 25 degC, and plot on a linear-linear graph
b) change the vertical (P) axis to be logarithmic. (i.e., semi-log graph)
c) plot on the same semi-log graph multiple curves. In addition to T = 25 degC, also plot for T = 0 degC and T = -25 degC.

Given:	P range =	100 to 0	kPa	
	Dry air			
	T =	25	degC	for (a)
Find:	rho vs. P	?	kg/m3	
Assume:	Ideal gas law			

Solution: Use eq. (1.18) $P = \rho \cdot \Re_d \cdot T$

solve for rho: rho = P/ (Rd * T)

where Rd = 0.287053 kPa·K–1·m3·kg–1

T (degC) =	25	0	-25
T (K) =	298.15	273.15	248.15
P(kPa)	rho (kg/m3)		
100	1.168	1.275	1.404
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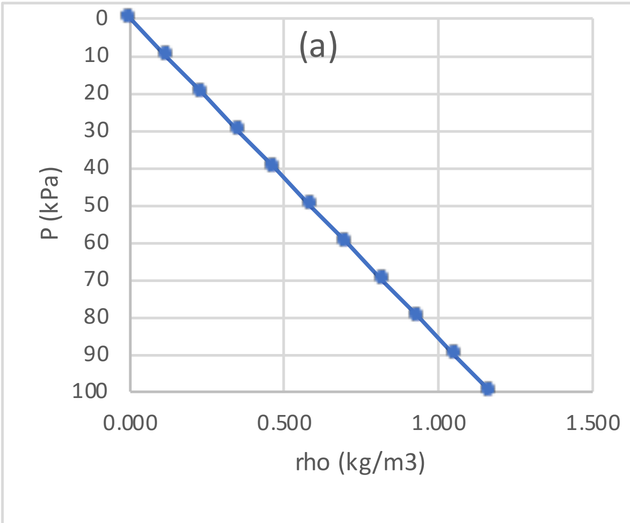
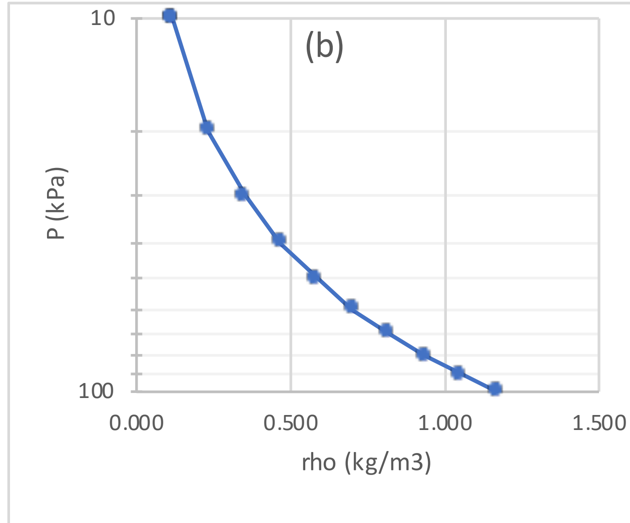
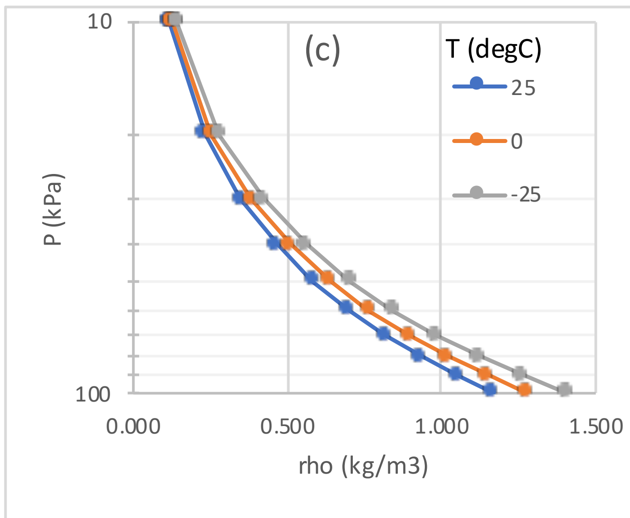
40	0.467	0.510	0.562
30	0.351	0.383	0.421
20	0.234	0.255	0.281
10	0.117	0.128	0.140
0	0.000	0.000	0.000







Check: Units OK. Curves approx. agree with Table 1-5.

Discussion: The air is thinner at higher altitudes (where the pressure is lower). So each breath of air would bring in fewer oxygen molecules at higher altitudes, causing me to become hypoxic.