Appendix C: Using Excel

The laboratory portion of PHYS 211-212 will frequently involve using the computer software Excel. Excel is a powerful tool that makes doing large amounts of calculations easier, and it is also useful for tasks like plotting and analyzing data. This brief guide will show you how to do many of the tasks that you will be using Excel for in this course.

Understanding the Excel interface

Opening Excel

To open Excel, go to the `Windows (Start)` menu and you should find Excel on the right side of the menu window that pops up. If Excel isn't there, scroll down in the applications list to the "E" folder that holds Excel. After opening the application, you will be able to open a blank workbook. Figure C.1 shows the typical layout of a new blank workbook in Excel.

Notice that the workbook is divided into a grid. Each of these sections is called a "cell." Cells can be referred to by their coordinates, that is the column letter and the row number. For example, the leftmost, topmost cell would be the `A1` cell.

Entering data

To enter data into a cell, simply click on the cell you wish to type into. Once you begin typing, the cell will populate with whatever you type, be it letters, numbers, or symbols. You can also double-click the cell and type into it. Note that in order to edit a cell's contents without erasing the contents entirely, you must double-click the cell you wish to edit. Otherwise, whatever you type will overwrite the current contents of the cell.

For cutting, copying, and pasting (as you might expect), you select a cell (or several cells) using your left mouse button, and then you copy or cut it, using the right mouse button (or `Ctrl+c`). You then can paste the cell contents into another cell (or several cells) anywhere you like using your right mouse button (or `Ctrl+v`).

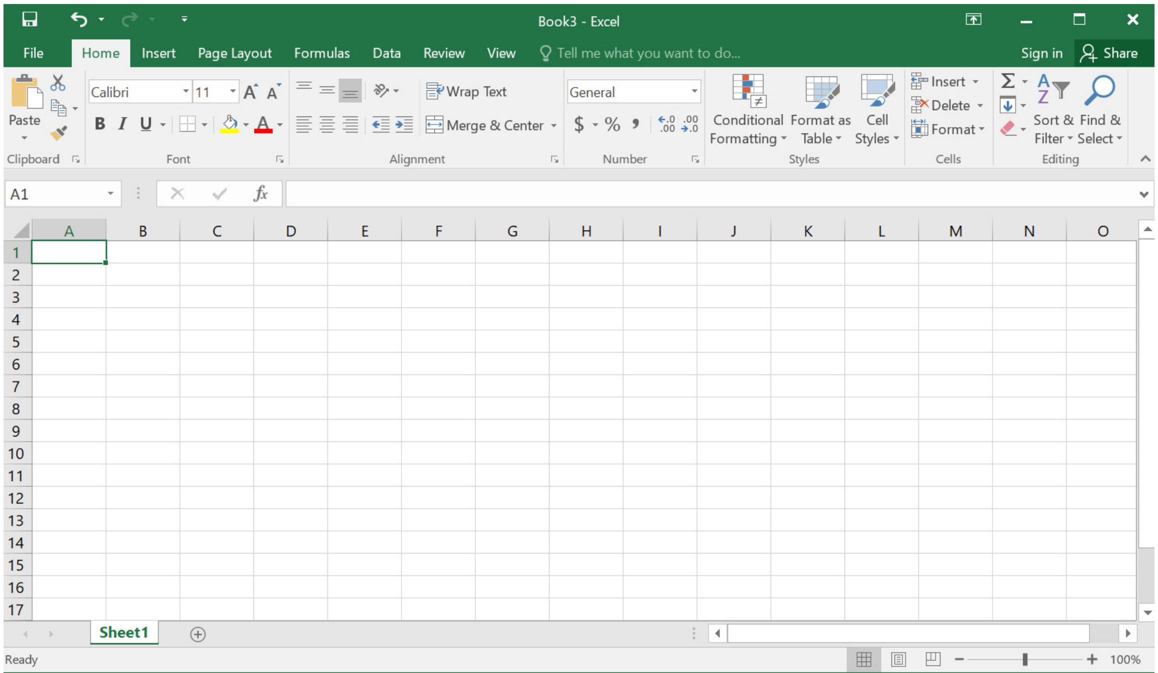

Figure C.1: A new blank workbook in Excel.

Saving your work

In lab, we will be saving our files to the netspace. Ask your TA or instructor if you are not sure what the netspace is or how to access it.

- There will be times in lab when you will be given an Excel spreadsheet that already contains data, but will be set as a "Read-Only" file so that no one can overwrite what is already in the file. In this case, you will need to use "Save As" in order to save and edit your own copy of the file.
- **Always save your work as you go – Excel can crash at any time!**

Math in Excel

Calculations and common operators

One of the main application of Excel that you are using in lab is to evaluate equations and mathematical functions. In order to have Excel calculate something in a cell, the first character that you need to type into that cell is the equals sign (=). After that, you can manipulate numbers in the way that you probably expect: add using the + symbol, subtract using the - symbol, multiply using the * symbol, and divide using the / symbol. You can raise a number to a power using the ^ symbol.

Another very useful tool of Excel is that you can reference other cells in calculations. For example, if you have a number typed in cell `B1` and you want to add five to that number and display the result in cell `C1`, you can do so by clicking on cell `C1` and typing "=`B1+5`".

Using functions

There are certain functions that we will use frequently. A function in Excel is a preset formula, much like those used in a calculator. For example, instead of taking the square root of a number by raising it to the power of 1/2, you can use the square root function, `SQRT()`. To take the square root of a number, put it in the parentheses of the function.

There are many other functions available in Excel; some useful ones follow.

- Use the `LN()` function to take the natural logarithm of a number and the `EXP()` function to raise e to a number (e being the base of the natural log).
- Some functions have no argument. The main one that we'll use is `PI()`, which Excel uses to hold many digits of π (notice the "`()`", which is required). This is more exact than typing in 3.14 when doing precise calculations.
- There are also functions that take in a range of arguments, like the `AVERAGE()` function. You can average a set of numbers by typing them into Excel, each in their own cell, and then selecting all of them as the argument for the `AVERAGE()` function. Notice that, when you drag over the selected cells, the range appears in the formula (between the parentheses of the function).

Order of operations and scientific notation

As you continue to use Excel throughout this course, the calculations that you do in Excel will become more complicated than just typing in one or two functions per cell. It will then be very important for you to type equations with the correct mathematical order of operations into Excel. In addition to recalling order of operations rules from math classes you have taken, using parentheses in Excel will be useful. Sometimes how you write a calculation can make a huge difference. Make sure to use parentheses if you need to to get the result you wanted. For example, "$= 1/3*4$" and "$= 1/(3*4)$" will each give different answers; make sure your calculation is clear. However, for clarity do not use too many parentheses, e.g. `=(((4*3)*7)+6)` could be simplified to `=(4*3*7)+6` or `=4*3*7+6` .

Scientific notation is a way of writing very large or very small numbers in a format that is easy to read. For example, instead of writing out the speed of light as $300,000,000$ m/s, you can write 3×10^8 m/s. Using scientific notation in Excel will make it easier for you to use correct order of operations. The way to write the speed of light in scientific notation in Excel is `3E8`. To be able to work with numbers and also to keep track of units, you would write `m/s` in the cell to the right of the cell containing `3E8`.

Utilizing cell referencing

When manipulating equations in Excel, it is extremely helpful to use cell references in an efficient way. This will streamline calculations and allow you to work with data quickly. Suppose that you want to make a list of the numbers $1-20$ (as the x-axis data of a graph, for example). You could type all of these out by hand, but it would be easier and faster to type in an equation using cell referencing. Follow the steps provided to create a list of numbers from $1-20$ using cell referencing.

- In a blank cell in your Excel workbook, type the number one.
- In the cell below that, type an equation that will reference the first cell (with "1" in it) and output the number two. For example, if 1 is in cell `A1`, type "=`A1`+1".
- Now that you have an equation that will reference cells and produce the numbers you want, you can copy that cell in order to calculate the rest of the list. Hover over the bottom right corner of the cell with the equation you just made – your cursor should change to look like a plus sign. Click and drag down to get your list of numbers. Notice that Excel increases the cell number that you've referenced for each new line: if you referenced cell `A1` in your first equation cell, the next cell will reference cell `A2`.

Now suppose that you are working with a more complicated equation, like the one below.

$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{-(x-a)^2}{2\sigma^2}} = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{-1.0*(x-a)^2}{2\sigma^2}} \tag{C.1}$$

Making a mistake while working with such a detailed equation happens often — you may forget to square a number, use parentheses, or mistype a constant. In Eq.(C.1) we rewrote $-(x-a)$ to $-1.0*(x-a)$ because Excel does not know how to calculate $-(\ldots)$, so remember to type `-1.0*(...)` when you use Excel.

An efficient way to work with equations in Excel and clarify your work in order to minimize mistakes is to use something called absolute cell referencing. An example of the notation for this in Excel is `$G$1`, and it tells Excel to lock any reference to that cell.

Absolute cell referencing is useful for defining constants. In the example equation above, we could set up cells for each of the constants. A nice way to do this is to type "sigma=" in one cell and the number you want to enter in the cell to the right. The cells with words are just for you to keep track of what values you are using for each of your variables. The actual numbers are what you will need to calculate a value for $f(x)$, so you will need to reference those cells in your equation.

To use the constants that we defined, you could type "f(x)=" in another cell (for labeling purposes), and in the cell next to it calculate the equation. Use absolute referencing for all of your constants (in other words, absolute cell reference the cell with the value for σ anywhere you see that variable in the equation). Now that you have an equation, you can define a list of input values, x, and utilize cell referencing and the list of numbers to find $f(x)$.

You can now easily change any of the input parameters and quickly get out a new value for $f(x)$ without having to type the entire equation again.

Note that once you change a value in one of your constant cells, the equation will automatically update. It is a good idea to always use absolute referencing for constants in Excel so that those numbers can be easily edited, and so that the references won't change if you copy the equation over multiple cells. This will also make your Excel equations less cluttered and easier to read and edit.

Analyzing data in Excel

Now that you know how to manipulate data, the next step is to analyze that data.

Note: Remember when recording data to label the columns. This is hugely important for both you and others to easily follow your work. If you create an Excel spreadsheet to analyze data from lab and don't label your work, the TAs and instructors will have a hard time helping you if something goes wrong. It will also be harder for you to follow your own work if you open the file later in the semester (for example, while studying for exams).

Once you've taken and labeled your data, you can begin analyzing it. One way that you will do this in lab is to plot and fit a line to the data. Excel calls this a "trendline."

- To plot data in Excel, highlight the data first. Then, find the "Insert" tab, followed by the "Charts" section. This will give you multiple options for types of graphs to make. The one we will use most often is the Scatter plot.
- Make sure that the graph looks accurate and that Excel has plotted the correct quantities on the appropriate axes. Typically, Excel will assume the first column you select contains your horizontal data and that the second column contains your vertical data. If you need to edit the plot, right-click on the graph, choose "Select Data" from the menu, and edit the data series.
- Now, explore the `Chart Elements` menu by clicking first on our graph and then on the + icon on the right side of the graph. This will give you options for

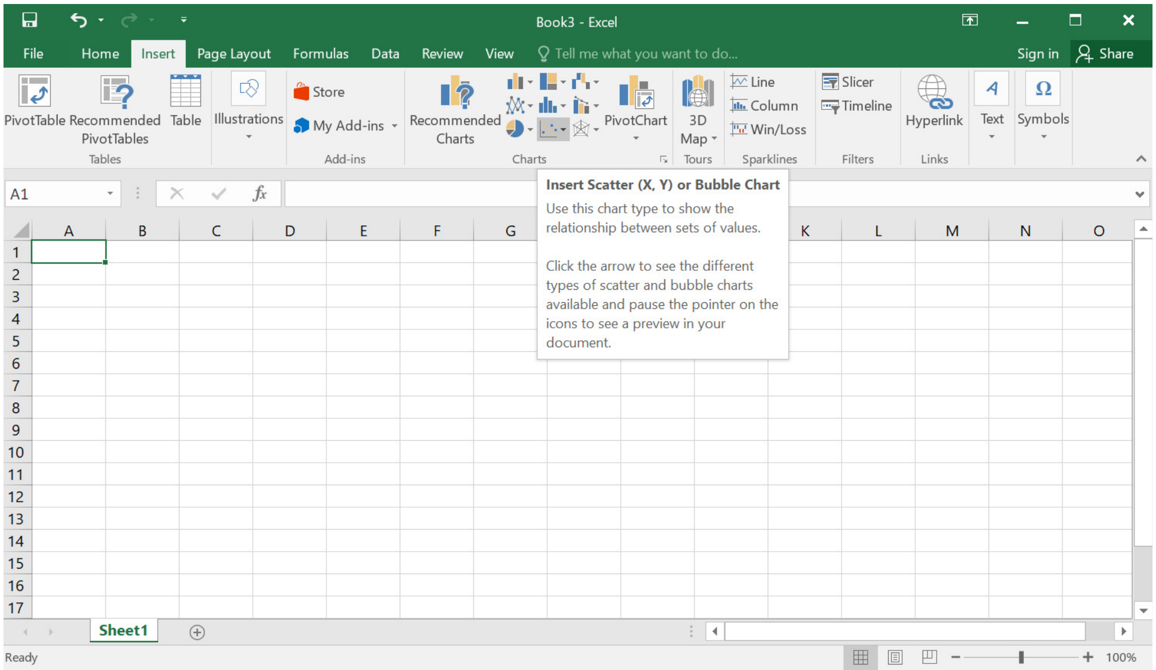

Figure C.2: Inserting a Scatter plot in Excel.

additions to the plot. You should add axes titles to your graph so that others can understand what you have plotted here, as well as for your own records. Once you have done this, find the `Trendline` option in the menu and click on the arrow to the right of it to select `More Options`. From this menu, you can add a linear trendline to your plot and display the resulting trendline equation on the plot.

Trigonometric functions in Excel

Excel has built-in trigonometric functions: `SIN(x)` takes the sine of x and `COS(y)` takes the cosine of y where in Excel you would replace x with a cell reference, e.g. `SIN(B5)`. However, Excel requires that the argument for trigonometric functions be in radians only. It will often be the case that you will make measurements with a protractor in degrees and then need to convert to radians in order to analyze your data in Excel. You can convert degrees into radians using the Excel function `RADIANS()`, where the argument of the function is the number in degrees, e.g. `=SIN(RADIANS(B5))` .

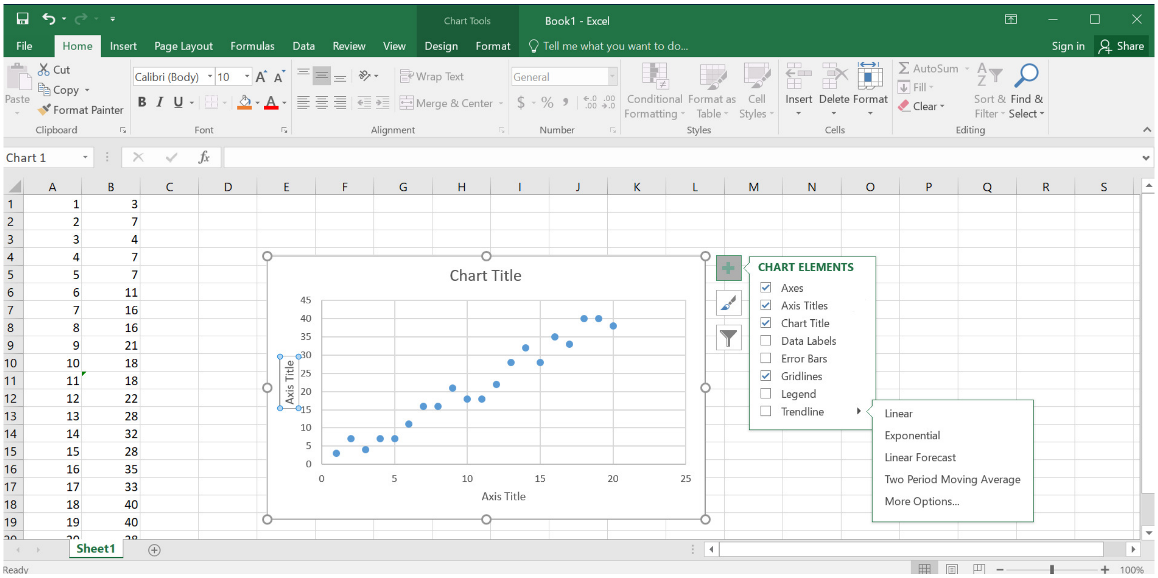

Figure C.3: Sample data plotted in a Scatter plot. The chart elements menu is shown and the trendline options are displayed.

Adding a trendline (no uncertainty)

You can add a trendline to any graph by first right-clicking once on the data in your chart to select them and then selecting `Add Trendline`. To display your equation on the graph, select `Display Equation` from the `Format Trendline` menu that appears on the right side of the screen.

If you have a linear fit and want Excel to extrapolate the fit backwards, find the `Backward` option in the `Forecast` section of the `Format Trendline` menu. You will then need to select an appropriate number of periods for Excel to use to forecast your function. Excel defines a period as the change Δx in two points on your plot. For example, if one point in your plot is $(5, 15)$ and the next is $(8, 24)$, one period will be a value of $8 - 5 = 3$. Excel will be able to forecast your trendline backwards even if your data is not evenly spaced.

Error Bars

To add error bars to a graph in Excel, click on the Chart Elements icon (+ icon to the right of the graph) and select `Error Bars`. Then click on the arrow next to `Error Bars` and select `More Options`. A menu on the right side of the screen will appear, entitled `Format Error Bars`. You can switch between horizontal and vertical error bars by selecting the arrow next to `Error Bar Options` and finding the appropriate option (e.g. `Series 1 Y Error Bars`).

Least squares fit (trendline uncertainty)

Excel uses the method of least squares to determine a straight line of the form $y = mx + b$ by minimizing the squares of the distances between each data point and the proposed line. Excel will provide the best values for m, b, and their standard deviations, Δm and Δb. You can extract the uncertainty in the intercept and slope using the Excel function `linest()`. The commands for using this function are a little complicated, so follow the instructions carefully.

a. In a part of your spreadsheet that does not contain any information, select an area measuring 2 columns $\times$ 5 rows.

b. While the area is still selected type

```
=linest(B1:B50,A1:A50,true,true)
```

where cells `A1` through `A50` contain the x-values, cells `B1` through `B50` contain the y-values, the first true is needed to calculate the intercept, and the second true is needed to calculate the errors in the slope and intercept. Note: your x-values may not be in cells `A1` through `A50` and your y-values may not be in cells `B1` through `B50`. Use the cells corresponding to your x- and y-values!

c. Do not press enter yet! Press (control, shift, enter) all at once to make the function appear in curly brackets, i.e., {`linest(....)`}, and the array function will calculate the values of the slope, intercept, and errors.

d. The top left value is the slope, the value under this is its error. The top right value is the intercept and the value under it is its error. The other cells contain other statistical information that we don't use.