1 Graph and Fit Data with MS Excel™

1.1 Introduction

The saying “A picture is worth a thousand words” applies equally well to tabulated data. It is considerably easier to glance at a graph to find a pattern than to sort through several pages of numbers and try to estimate the amount of variation. To this end, when we take data, we graph it. If we can find an equation which describes the data well, we can extend our understanding by developing an empirical (found by experiment) mathematical formulation. In this lab exercise, you will be given some measured data (with uncertainty – recall the Volume of the Room lab) and you must plot it, fit a trendline, calculate an additional set of data, graph that, and fit another trendline.

- **Error**: A mistake – minimize your mistakes as much as possible.
- **Uncertainty**: How well you trust your numbers. There is a numerical range about your result that denotes the variation due to the precision of the instruments.
- **Accuracy**: How close your number is to the “true” value.
- **Precision**: The size of your uncertainty.

The ideas of accuracy and precision can be described by trying to point out a feature on a map. Accuracy tells how closely you point to that feature. Precision describes what you use to point. If you point with a pin, you are being very precise (regardless of your accuracy). If you point with a two-by-four, you are being very imprecise (regardless of your accuracy). Notice that imprecision (large uncertainty) masks accuracy. If your answer agrees with the expected result because you have large error-bars, then you may or may not be accurate. You need high precision (small error-bars) to determine if you are accurate. You need to be accurate in order to trust any theory which is based on your results.

Table 1 shows some data. The units of the measurements have been made up to reduce the influence of what you may already know. Notice that when measuring, you may be able to judge the result better than the accuracy of the instrument. If this is the case, use your best estimate, but keep an uncertainty as the precision of the instrument and consider it a cautious over-estimate.

Some comment about the data:
- The data for \( x \) were decided upon and the instrument was set to give specific \( x \) values.
- The experiment was performed by groups of three and each individual made a measurement of \( y \).
- Some of the data (as for \( x = 8 \)) vary by nearly twice the uncertainty. The true answer is probably close to 14.0 or so. In order to minimize the effect of the inherent uncertainty in any given measurement, you should take multiple readings for every measurement. An average of these measurements will sort out this variation.
- You may find (as for \( x = 14 \)) that one measurement is peculiarly different. In this case, you should take additional readings for this measurement. This is an indication that “human error” may have an effect (i.e., that the measurement is awkward to make). If multiple measurements vary by more than twice the instrument precision, then you should increase your uncertainty to account for the difficulty of the measurement. Take an average and let the uncertainty be the maximum of either the instrument precision or the data variation about the average. Some additional measurements have been made and are included in Table 2.

We are now ready to use Excel. But first, some notation:
- There is an index. Most indexed topics are boldfaced.
- We will use square brackets to indicate individual keys or buttons for you to press.
Table 1: Measured Data in Specific Units. The second line is the uncertainty in the measurement.

<table>
<thead>
<tr>
<th>x (draps)</th>
<th>y (cooms)</th>
<th>y (cooms)</th>
<th>y (cooms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>±0.75</td>
<td>±1.0</td>
<td>±1.0</td>
<td>±1.0</td>
</tr>
<tr>
<td>1.0</td>
<td>6.0</td>
<td>5.5</td>
<td>5.5</td>
</tr>
<tr>
<td>3.0</td>
<td>8.5</td>
<td>7.5</td>
<td>8.75</td>
</tr>
<tr>
<td>4.0</td>
<td>9.0</td>
<td>9.0</td>
<td>9.25</td>
</tr>
<tr>
<td>6.0</td>
<td>11.5</td>
<td>12.0</td>
<td>11.75</td>
</tr>
<tr>
<td>8.0</td>
<td>14.5</td>
<td>13.0</td>
<td>14.25</td>
</tr>
<tr>
<td>11.0</td>
<td>16.75</td>
<td>17.5</td>
<td>16.75</td>
</tr>
<tr>
<td>14.0</td>
<td>23.0</td>
<td>20.0</td>
<td>21.25</td>
</tr>
<tr>
<td>16.0</td>
<td>22.25</td>
<td>24.75</td>
<td>24.5</td>
</tr>
<tr>
<td>19.0</td>
<td>25.5</td>
<td>27.0</td>
<td>29.0</td>
</tr>
<tr>
<td>22.0</td>
<td>32.0</td>
<td>31.75</td>
<td>32.75</td>
</tr>
<tr>
<td>26.0</td>
<td>35.25</td>
<td>35.5</td>
<td>36.75</td>
</tr>
</tbody>
</table>

Table 2: Additional Measured Data. The values for $x = 3$ and 8 were taken for verification. For $x = 14$ and 19, the numbers had a surprising variation when compared to the uncertainty. For $x = 16$ and 26, the data were a little more spread, but not so much as some others.

<table>
<thead>
<tr>
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<th>y (cooms)</th>
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<tbody>
<tr>
<td>±0.75</td>
<td>±1.0</td>
<td>±1.0</td>
<td>±1.0</td>
</tr>
<tr>
<td>3.0</td>
<td>7.75</td>
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<td>8.0</td>
<td>14.0</td>
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<tr>
<td>14.0</td>
<td>20.75</td>
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<td>22.25</td>
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<td>16.0</td>
<td>24.0</td>
<td>25.25</td>
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<tr>
<td>19.0</td>
<td>28.0</td>
<td>28.0</td>
<td>25.5</td>
</tr>
<tr>
<td>26.0</td>
<td>34.0</td>
<td>33.25</td>
<td></td>
</tr>
</tbody>
</table>

For example, pressing \[\text{Enter}\] on your keyboard is different than typing \text{enter} on your keyboard: \[\text{c]\text{u}\text{t}\text{e}\text{r}\]. Further, if we say

“\text{type} \ [d]\text{a}[v][c]”

we mean that you should not press \[\text{Enter}\] afterwards. If we say

“\text{type} \ [d]\text{a}[v][c][\text{Enter}]”

or if we say

“\text{enter} \ [d]\text{a}[v]\text{e}”

we mean that you should press \[\text{Enter}\] afterwards.

- When we say “\text{click} such-and-such” we mean for you to use the mouse to point to a location on the screen and press the left-most button on the mouse one time. (A single click will usually \text{select} something which can then be used.)

- When we say “\text{double-click} such-and-such” we mean for you to use the mouse to point to a location on the screen and press the left-most button on the mouse two times in rapid succession. (A double-click will usually produce an action by the computer beyond simply selection.)

- When we say “\text{right-click} such-and-such” we mean for you to use the mouse to point to a location on the screen and press the right-most button on the mouse one time. (A right-click will usually produce an appropriate menu from which you can select an action to be performed.)

1.2 Navigating Excel

1. Log into the computer and open a new document in Excel: Open Excel by using the mouse to click the [Start] button. This will pull up a menu. Click [Programs]. On some computers you will then see [Microsoft Excel] or [Excel] as an option – click it. On other computers you will need to find [Microsoft], click this, and then click [Excel] on the new menu that comes up. It may take a few moments for Excel to open.
2. You should get an empty spreadsheet (a white page with grayish horizontal and vertical lines). If not, click [File]-[New...]. If a window pops up, double-click [Workbook].

- Notice that when you click [File] (go ahead and do it), the [New...] item has a picture (an icon) of a blank sheet of paper. (If you clicked [File], then please press [Esc] on your keyboard – this will generally “Escape” back to where you were.)

- Notice also that the same blank paper icon (image) is in the list of icons (images) across the top of the page. These are shortcuts so that you don’t have to click [File] and [New...] (because it is so much trouble to click two items!!)

3. In this blank spreadsheet, each little box is called a cell. They are denoted by their column (A, B, C...) and their row (1, 2, 3...). The cell A1 should have a darker box than the others. Notice that your keyboard (probably) has two sets of arrows, one set is shared with the number pad on the right subsection of the keyboard. Notice also that your keyboard has three lights on it – one is [Num Lock] (or “number lock” or “1 lock”), another is [Caps Lock] (or “Shift Lock” or “A lock”), and the third is [Scroll Lock]. If [Num Lock] is on, then the number pad will enter numbers when you type. If [Num Lock] is off then the number pad should move the highlighted box around from cell to cell. Play with this and watch the pattern. You can toggle the [Num Lock] light by pressing the [Num Lock] key on your keyboard.

- Please press [Num Lock] several times. This toggles the [Num Lock] light.

- Please press [Caps Lock] several times. This toggles the [Caps Lock] light. (Try typing with this light on and then with this light off.)

4. You can also select the cell of interest either by pointing to a cell with the mouse (point to cell C3 now) and then clicking once (with the left-most mouse button) or by using the arrow keys on the keyboard.

5. At the bottom of the screen you should see three “Tabs” that say [Sheet1], [Sheet2], and [Sheet3]. Select cell A1 and type a word (perhaps your name). Press [Enter]. You will be moved to cell A2 when you hit [Enter]. Move the mouse to the bottom of the screen and click [Sheet2]. Notice that your name is gone (It was on [Sheet1]). Now select cell B3 and type a word (perhaps your major). Press [Ctrl]-[Enter], by which we mean hold the control key [Ctrl] and at the same time, press the [Enter] key. (The [Ctrl] button only works when pressed simultaneously with another key.) You will not be moved to cell B4 when you press [Ctrl]-[Enter].

Switch back and forth between [Sheet1] and [Sheet2] by clicking on the tabs at the bottom of the screen.

6. Go to [Sheet2], select cell B3 (where you entered your major) either by clicking with the mouse or by moving with the arrow keys, when that cell is highlighted (has a dark box around it) press the [Del] or [Delete] key. Whatever you typed here has now been deleted.

Go to [Sheet1], select cell A2 (where you entered you name earlier). Rather than deleting the contents of this cell, we will leave your name here and type something else (perhaps your parent’s name). When you press [Enter], the new word will be in the cell and the old information is lost forever (as far as the computer is concerned).

1.3 Formatting

1. Go to cell A1, enter [6]/[7]. (Remember to press [Enter]). Notice that Excel changes this to [07-Jun]. It has interpreted your entry as a date: June 7th. When you pressed [Enter] you should have been moved to cell A2. If not, go to cell A2. Enter [‘]/[6]/[7]. Notice that Excel leaves this as [6/7]. The prefix [‘] tells Excel that what follows is
and should be accepted as is. When you pressed [Enter] you should have been moved to cell A3. If not, go to cell A3, now. Enter [=][6][/][7]. Notice that Excel changes this to [0.857142857]. (You probably only see [0.857143].) The prefix [=] tells Excel that what follows is a mathematical formula and should be evaluated as such; Six divided by seven is the number you see. You will be using the prefix [=] most of the time as you enter a number or formula into Excel.

2. Select cell A1. There are three ways to select a group of cells. Try each. After you have tried one, select a cell away from the group you have highlighted (like C4 or something).

(a) Keyboard Method: Select cell A1. Press and hold [Shift]. Use the arrow keys to move to cell A2 and then to cell A3. You should see all three cells (A1, A2, and A3) surrounded by a dark border; A1 should be white and the rest are dark.

(b) Mouse Method: Select cell A1. Hold the left-most mouse button down. While you are pressing the left-mouse-button move the mouse towards you slowly. Every time you get to a new cell, it turns dark and becomes part of the selected region.

(c) Keyboard and Mouse Method: Select cell A1. Press and hold [Shift]. While holding [Shift], move the mouse to a different cell (like B5) and click the left-mouse-button. Keep holding [Shift], click cell F8, click cell A10, click cell B4.

Now that you know how to select a group of cells, select the group of cells from step 1. (It should be A1, A2, and A3.) Delete the information by pressing [Del] while the cells are highlighted. Unselect the group of cells by selecting some other single cell.

3. Excel remembers formats: Go to cell A1. Enter [1]. (You should now be in cell A2.) Enter [1] in cell A2. These are different because the previous step set the “date-format” for cell A1 but not for cell A2. Go to cell A1 and type [=][1][Enter]. This is not enough to change the format. With cell A1 selected, there are three ways to get the window which will change the format.

(a) Select the cell (or cells) to be changed. Right-click the cell (point to the cell with the mouse and press the right-most mouse button). Choose [Format Cells . . .] from the menu.

(b) Select the cell (or cells) to be changed. Select [Format] from the menu at the top of the screen. Select [Cells . . .] from the new menu which appears when you chose [Format]. (Notice that this choice has Ctrl-1 next to it.)

(c) Select the cell (or cells) to be changed. Press [Ctrl]-[1].

Now, in the new window, the [Number] tab should have a dashed line around it. This is the tab we want, but click each of the other tabs so you can see what they do. (You should be able to select [Number], [Alignment], [Font], [Border], [Patterns], and [Protection].) Then click the [Number] tab again. Notice that the category [Custom] is highlighted (in blue). Select (click on) the category [Number] and notice that the Sample has two decimal places. In the Decimal places option, click on the down-arrow and change the 2 to 1; you can click it again to change it to 0. Click the up- and the down-arrows, but end with it set to 1 decimal place. Notice that the sample changes as you do so. Click [OK] at the bottom of this window. You should now have a 1.0 in cell A1.

4. Go to cell A2. Type [=][A][1][+][1][Enter]. This will put a 2.0 in cell A2 (one more than the value in cell A1). Now go to cell A1 and enter [5]. Notice that cell A2 automatically updates itself to the number 6 (one more than the value in cell A1). Go to cell A3 and type [=][1][1][+][3][Enter]. Notice that [1] is
a single key on the keyboard which allows
you to move around the screen. Notice that
when you hit [↑] the cell above where you
started (A2) has a dashed box around it.
When you hit [↑] the second time, the cell
two above where you started (A1) has the
dashed box around it. When you then type
[+], the dashed box disappears and you find
“=A1+” in your cell. After you hit enter,
you should have an 8 in cell A3 (three more
than the value in cell A1). Now go up to
cell A1 and enter [8]. Notice that cells A2
and A3 change appropriately.

5. With these formulae in the cells (as described
in the previous step), select cell A2. No-
tice that the dark box around cell A2 has a
funny lower right corner. When you place
the mouse over this, the larger white plus-
sign (that was the mouse indicator) becomes
a smaller black plus-sign. While the mouse
is this smaller, black plus-sign press and
hold the left mouse button. (You are now
“grabbing” the corner.) Notice what it says
at the bottom of the screen: “Drag out-
side selection to extend series or fill; drag
inside to clear.” To see what this means,
while pressing the left-mouse-button, move
the mouse into the cell A2. When cell A2
turns grey, let go of the mouse button. You
have erased the formula in that cell!

Press [Ctrl]-[z]. This will “undo” your
last command, which in this case was
to delete the formula. So the formula
should be back. Whenever you make
a mistake, press [Ctrl]-[z] to undo it.
You can press [Ctrl]-[z] several times
to undo several steps.

If you press [Ctrl]-[z] too many times,
[Ctrl]-[y] will Redo what has just been
undone by a [Ctrl]-[z].

For now, press [Ctrl]-[z] several times
and then press [Ctrl]-[y] several times.
Now press [Ctrl]-[y] until nothing changes (no more to redo). Finally
press [Ctrl]-[z] one time so that there
is a formula in cell A2. Or enter
[=][A][1][+][1] in cell A2.

Now, select cell A2 and press and hold (grab)
the lower right hand corner. With the but-
ton pressed, slowly move the mouse towards
you on the desk (down the screen) and no-
tice that as you go to each new cell, it turns
black (becomes selected). When you get to
cell A8 or so, stop moving the mouse and
let go of the button. You have copied the
formula! Notice that while cell A2 said
[=A1+1], cell A3 now says [=A2+1] and
cell A4 says [=A3+1]. Go up to cell A1
and enter [1]. All of the cells get updated!

6. Now select cells A1 and A2. (Select cell
A1, press and hold the left-mouse-button,
move to cell A2, release the mouse button.)
Grab the lower right corner of cell A2 and
move the mouse to cell B2 (drag it); re-
lease the button. Cell B1 should say [2]
(one more than A1), but it isn’t a formula.
Excel assumes you want to begin number-
ing the columns and automatically adds one
to any number copied into an adjacent cell
(1). Notice however that cell B2 is [=B1+1].
When you copy down, it adjusts the row
of the formula (the number); when you
copy across it adjusts the column of the
formula (the letter).

7. We want to change this formula slightly.
Rather than retype it, we will edit it.
Go to cell B2. Press [F2] (not [F][2], there
are keys at the top of the keyboard called
“function keys” which are special). The for-
formula comes up as [=B1+1]; change it to
read [=B$1+1]. Press [Enter]. Now grab
the corner and drag this down a few cells
(through B10, for example). Notice that all
of these new cells stayed as [=B$1+1]. Nor-
ormally by dragging this formula down, you
would change the row numbers. The “$”
protects the formula against change
when being copied. Go to cell B1 and enter
[18]. All of the cells will change to [19] (one
more than cell B1).

8. Now select cells B1 and B2. Grab the lower
right corner of cell B2 and move the mouse
to cell C2 (drag it); release the button. Cell
C1 should say [19] (one more than B1); re-
call that Excel automatically adds one to any numbered copied into an adjacent cell (!). Notice however that cell C2 is \[=C$1+1\]. You copied across and it adjusted the column of the formula (the letter). The $ of C$1 only protects the 1. You can protect the column only ($C1), the row only (C$1), both row and column (C$1), or neither (C1). Go to cell C2, press [F2] and use the arrow keys to move to the part of the formula that says C$1. Press [F4]. Press [F4] again. and again. and again. and again. [F4] will cycle through these choices of protection.

You are now ready to enter and manipulate data!!!

1.4 Entering Data

When you enter data into Excel, it is a good idea to format the cells appropriately as you enter the data so that you can use this table in your report. It is also easier to read when you look back later.

1. If the spreadsheet you have open from above has some previous unimportant work in it, you should empty it. Click the grey column header A. This will select the entire column (it will turn black). Press [Del] or [Delete]. This will delete the contents of column A. Since we want to empty the entire page, notice that there is a grey square just left of the column header A and just above the row header 1. Press that square. The entire page should turn black except for one cell where you were before you pressed the grey square. Press [Del] or [Delete]. This will delete the contents of the entire page.

2. Go to cell A1; enter “x (draps)”. The column header should say the variable and parenthetically the unit. When you press [Enter], you will be moved to cell A2. Enter the data for x from Table 1. Do not enter the uncertainty yet.

3. Uncertainty: A number with its uncertainty is usually written \[x = 1.0 \pm 0.75 \text{ draps}\]. We will enter the data, the ±, and the uncertainty each in its own column.

(a) Plus/Minus: Go to cell B2 (next to your first data point). Type \[\pm\] and then [Ctrl]-[Enter]. (See the Index to remind yourself of the function of [\] and [Ctrl]-[Enter].) You should still be in cell B2. Type [Ctrl]-[u] to underline the contents of this cell. You can also select the cell and click on the U at the top of the page next to the B (boldface) and the I (italics).

(b) Copy: Use the lower right corner (Recall item 5 under formatting) to copy this cell down next to each of the values in column A (i.e., down through B12).

(c) Resize: Position the mouse between the column header B and the column header C. Notice that the larger white plus-sign becomes a black double arrow when you have the mouse positioned correctly. When it looks like this, double-click the mouse. This will resize column B.

(d) Enter the Uncertainty: Start in cell C2 and enter \[0.75\] (or whatever value). If you are using the same spreadsheet as previously, it will have remembered the format (one decimal place). Right-click cell C2, select menu item [Format Cells...], select [Number], select category [Number], set the number of decimal places to [2] and click [OK]. Rather than repeating this all the way down, grab the lower right corner of cell C2 and drag it down through cell C12, then let go of the mouse button. You will have copied that value all the way down. Now resize column C the same way you resized column B.

(e) Header: Notice that the “x (draps)” is only in column A. It would be nice to
have it across all three columns. Select cells A1, B1, and C1 (click on cell A1 and with the left-mouse button held down, move the mouse across B1 to C1, then let go). Right click someplace in the selected area and select [Format Cells...]. Select [Alignment], click on the square next to [Merge cells] (it should place a check mark in the box). Before you click [OK], under the [Horizontal], click the down-arrow and select [Center]. Press [OK] at the bottom of the window. “x (draps)” should be centered over the data column.

4. Ignore column D for now. Go to cell E2. Enter the data from the second column of Table 1.

Go to cell F2. Enter the data from the third column of Table 1.

Go to cell G2. Enter the data from the last column of Table 1.

Go to cell H2. Enter the data from the second column of Table 1. Notice that the data in this table are for specific x values. Please put them in the appropriate rows.

Go to cell I2. Enter the data from the third column of Table 1 in the appropriate rows.

Go to cell J2. Enter the data from the last column of Table 1 in the appropriate rows. Do not put a column header over these cells. We will be using cell E1 later.

5. Skip column K for now. In cell L1, enter “y (cooms)”. Center it across cells L1, M1, and N1. (Recall item 3e.)

6. In cell L2, type [=][a][v][e][r][a][g][e][()]. Do not hit [Enter]. With this part typed, point the mouse to cell E2, hold the left-mouse-button and move the mouse through F2, G2, H2, I2, and J2, then let go of the mouse button and type [)][(). The formula should read “=average(E2:J2)”. Excel is smart enough to ignore empty cells when it averages. If you want a cell to be counted as zero, then you must enter zero explicitly. The value in L2 should be 5.6666667 according to the data given to you. (If you calculated 6.1875 then you did not line the data up in the correct rows. Look at Table 1 more closely.) If you enter a [0] in cell J2, then the value of L2 will change to 4.25 – do this and then press [Ctrl]-[z] to undo it. Rather than repeating this all the way down, grab the lower right corner of cell L2 and drag it down through cell L12, then let go of the mouse button. You will have (conveniently) copied that formula all the way down.

7. In cell K1 enter [s][p][r][e][a][d]. In cell K2, type [=][m][a][x][()]. Before you press [Enter], select the cells E2:J2 (as before), then type [)][(][m][i][n][()], select cells E2:J2 again, and type [)][(][Enter]. The formula should read “=max(E2:J2)-min(E2:J2)”. Again Excel is smart enough to ignore the empty cells. This formula tells the computer how much variation is in your data points. Use the lower right corner of cell K2 to copy this formula down through cells K2:K12.

8. The Uncertainty: (Recall item 3d.)

(a) Plus/Minus: Enter a ± in cell M2, which should be the cell next to your first averaged value. (Step 3a: ['] [+] [Ctrl]-[Enter] [Ctrl]-[u].)

(b) Copy: Use the lower right corner to copy this cell down next to each of the values in column L (i.e., down through M12). (Step 3b)

(c) Resize: Resize column M. (Step 3c: Double-Click between the column headers.)

(d) Enter the Uncertainty: In cell E1, enter the y precision (1.0 in this case). In cell N2, enter “=max(E$1,K2)”. The dollar-sign is very important! See Step 8 of Formatting for how the $ protects a cell.

ii. The comma in (E$1,K2) indicates a list of specific cells. The colon was for a range of cells. The set of cells “(A1:A5)” is identical to “(A1,A2,A3,A4,A5)”.
Rather than repeating this all the way down, grab the lower right corner of cell N2 and drag it down through cell N12, then let go of the mouse button. You will have copied that formula all the way down. Now resize column N.

9. **Format the entire page** of data: At this point, the table looks very sloppy. Select the entire page by pressing the grey square just left of the column A header and just above the row 1 header. Right-click somewhere in the selected region, select [Format Cells…], select tab [Number], select category [Number], set the number of decimal places to [2], click [OK] at the bottom of that window, click the mouse anywhere on the page.

1.5 Creating a Graph

Now that your data are in the spreadsheet, you can verify and replace any measurement and everything which was calculated from that number will get updated automatically. With your data in the spreadsheet, this subsection will explain how to create a graph. You will be using a feature called the “Chart Wizard.” You can access it, when we tell you to, by clicking the blue, yellow, and red icon that sort-of looks like a column-chart on the upper right corner of the icon tray.

To find the Chart Wizard: Somewhere on top, you should have a question mark that, when clicked, gives you the (annoying) Office Assistant. To the left of that is a “100%”, which is the zoom. To the left of that is an icon for drawing. Next is a globe-like icon for a map. To the left of that is the Chart Wizard. That is what you will click eventually.

If your data were lined up in columns (which isn’t the case), then you could highlight your data; Excel can usually figure out columnated data. However, **Excel expects the data** for the horizontal \(x\) axis to be in the first column and the vertical \(y\) data to be to the right of that. Our data are not aligned like that this time. However, we will be taking advantage of some of the assumptions that are built into Excel.

1. Highlight/select the data which are to be plotted on the vertical axis. This should be located in the range L2:L12. (See Step 2 of Formatting.)

2. Click the Chart Wizard icon. You will get a new window called: Step 1 of 4 - Chart Type.

   (a) On the [Standard Types] tab, select [XY (Scatter)]. The correct chart subtype should already be selected, but to be safe, click to image that has no lines. (These are **not** best-fit lines; they do not provide information about the data. They only serve to guide the eye of the viewer. We will be creating a true trendline later.)

   You will be able to access this window (Chart Type) again after you create the graph.

3. Click [Next >]. You will get a new window called: Step 2 of 4 - Chart Source Data.

   (a) You should see a picture of your graph, but notice that the \(x\)-axis runs from 0 to 12. Excel has the correct \(y\) values, because you highlighted them, but since you did not tell it what the \(x\) values were, Excel **assumed** it should use 1, 2, 3, 4, 5… etc. Our \(x\) values are not sequential, so we must explain this to Excel. Click the tab [Series]. There should be one series defined. (It is currently called “Series1”.)

   Next to [Name:], [X Values:], and [Y Values:], there is a white space and a white, red, and blue icon. The icon will (conveniently) allow you to select cell-ranges from the spreadsheet.

   i. “=Sheet1!$L$2:$L$12” should be in the [Y Values:] slot. This is fine.

   ii. Click once in the white space next to [Name:]. Click the [Name:] icon.
The window gets small (like a window shade being rolled up), but there is still a white space and a new icon on the right (which looks like a white bar with a red arrow pointing down as in “pull the window shade down”). Click cell L1. Notice first that since we merged L1 with M1 and N1, all three are surrounded by a blinking dashed box. Notice second that when you did that, the white space filled with “=Sheet1!$L$1”. Now click the icon on the right (the white bar with a red arrow). Notice now that the window is large, the series name has been replaced with the value of cell L1. If we change L1, it will automatically change this value as well.

iii. Click once in the white space next to [X Values:]. Click the [X Values:] icon. The window gets small (again), but there is still a white space and an icon on the right. Click cell A2. Notice that when you did that, the white space filled with “=Sheet1!$A$2”. Now select the range A2:A12 (the x data). Notice that when you did that, the white space filled with “=Sheet1!$A$2:$A$12”. Now click the icon on the right (the white bar with a red arrow).

You will be able to access this window (Chart Source Data) again after you create the graph.

4. Click [Next >]. You will get a new window called: Step 3 of 4 - Chart Options.

(a) Notice that you have been started on the [Titles] tab. Enter the title of the graph. (If you title the graph by one axis versus another, always use the vertical axis versus the horizontal axis: y vs x.) Notice that the image is updated when you enter this information. Press [Tab] to go to the [Value (X) Axis] heading. Enter the variable and, in parentheses, the unit: x (draps). Press [Tab] again to go to the [Value (Y) Axis] heading. Enter the variable and, in parentheses, the unit: y (cooms).

(b) We will not do anything with the [Axes] tab.

(c) Click the [Gridlines] tab. By clicking the white boxes, you can toggle the major and minor gridlines for the x and y axes. Turn them all on and off to see what they do. Some professors line no gridlines, others like just y-major, others like x-major. Ask your professor which is preferred.

Minor gridlines are useful if you are measuring something from the graph. We will not be doing this. If you have minor gridlines turned on, then it is difficult to make adjustments later. If you must use minor gridlines, you can do this after you have created and formatted the graph.

(d) Click the [Legend] tab. If there is more than one set of data, you will need the [Show Legend] box checked. It should by default, be checked now. Since we only have one set of y data, please uncheck it by clicking the box next to [Show Legend].

(e) We will not be using the [Data Labels] tab.

You will be able to access this window (Chart Options) again after you create the graph.

5. Click [Next >]. You will get a new window called: Step 4 of 4 - Chart Location.

As the pictures should indicate, the [As new sheet] creates the graph in a new sheet which is accessible from the tabs at the bottom of the page. (This is in addition to the [Sheet1], [Sheet2], and [Sheet3] which are currently there.)

(a) Select [As new sheet] by clicking on the white space next to it and typing in a
name for the graph which will appear on the tab next to [Sheet1]. The value defaults to [Chart1]; we suggest using something more descriptive such as “y vs x”.

(b) If the “radio button” (white dot) to the left of [As new sheet] does not get a black dot in it, then click on the white dot there.

You will be able to access this window (Chart Location) again after you create the graph.

6. Notice that you cannot click [Next >]. Click [Finish]. You should be looking at your graph as a full window view in its own page. You can get back to the data page by clicking the [Sheet1] tab at the bottom. You can get back to the graph by clicking the [Chart1] or [y vs x] tab at the bottom (depending on what you named this tab earlier).

7. Click on the graph background in a spot away from the data points and away from the gridlines. (Be aware that it is difficult to click on the background through minor gridlines.) You should see a light, hashed box appear around the graphed area. The help box that might appear next to the mouse pointer will say [Plot Area]. Notice that if you right-click on the plot area (away from the data and the gridlines) you get a menu which allows you to go back to the previous four menus: Chart Type, Source Data, Chart Options, and Location.

8. Notice that the screen background (behind the graph “paper”) is a light grey, the “paper” is white, and the graph background is a medium grey. The grey can make the graph hard to read and it wastes ink. Click on the graph background in a spot away from the data points and away from the gridlines. You should see a light, hashed box appear around the graphed area. Go up to the icon menu at the top of the page and look for the icon that looks like a paint can being poured out with a yellow line under it. This is the [Fill Color (Yellow)]. Yellow is the current color. Click the small down-arrow just right of the paint can icon. A color palette should come up. Click on [No Fill] to **make the plot area background white**.

9. Notice that the **axis labels are formatted** (like the data columns) to two decimal places. In this case we do not need (nor want) two decimals. There are several format modifications we want to be able to make. Right-click on one of the axes. Select [Format Axis...] to get a new window.

(a) Select the [Number] tab. Change the [Decimal Places:] to 0 (zero). Notice that this turns off the [Linked to Source] button which would maintain the format on the graph of the source data in [Sheet1].

(b) Select the [Scale] tab. We will not be doing anything with this at this time, but you may want to be able to change the scale at some point in the future. This is where you do so.

(c) Select the [Patterns] tab. Different professors like different formats. For practice, set the [Major tick mark type] to [Cross], the [Minor tick mark type] to [Outside], and the [Tick mark labels] to [Low]. The major gridlines may hide the changes to the major tick marks. The minor gridlines may hide the changes to the minor tick marks. Setting the labels to [Low] will only have an effect if the other axis data range includes negative numbers.

10. Repeat with other axis.

11. We will now add the **error-bars** to the graph.

(a) When the mouse points to a data point, a small help box will tell you the Series Name and the values of that data point: (x-value, y-value). Right-click any data point and select [Format Data Series. . .].

(b) In the new window, the following tabs exist:
Data Labels Leave this off.
Series Order This allows you to favor one set of data over another. The most favored will be placed on top when data points overlap.
Options Do not use this.
Patterns Change style, size, and color of the data and of any connecting line (not of the trendline)
Axis Allows you to create a secondary axis (on the “wrong” side)
X-Error bars See below
Y-Error bars See below

(c) Select the [X Error Bars] tab. In some cases (like for our x data) you can use the fixed error bars, but we won’t. In other cases, you can use the fixed-percentage error bars, but we won’t. Please use the custom error bars. Click the “spreadsheet” icon to the right of the white space which is to the right of [Custom:]-[+]. The window should get small as before. Click on the page-tab [Sheet1] (or wherever your data is) to find your data page. Notice that the x-errorbars are in the range C2:C12. Highlight this set of data so that the value “=Sheet1!$C$2:$C$12” is entered in the blank. Click the icon to the right of the white space (the white bar with a red down-arrow) to go back to the [X Error Bar] window. Notice that it has automatically darkened the [Plus] option for which side to place the error bar. Repeat with the [Custom:]-[−] using the same set of data (“=Sheet1!$C$2:$C$12”). This should automatically bump you up from the [Plus] square to the [Both] square.

(d) Repeat with the [Y Error Bars] tab using the range N2:N12 (which should have your y-error data), highlighting the set of data so that the value “=Sheet1!$N$2:$N$12” is in the blank.

(e) Click [OK] and notice that your graphed data now has error bars. A reasonable trendline ought to pass within all of the errorbars. If it does not, then you should review that data point. Look for typos and miscalculations in that point specifically.

12. We are now ready to add a trendline. This line will average out the bumps in the data (due to minor imprecisions in the measurements).

(a) When the mouse points to a data point, a small help box will tell you the Series Name and the values of that data point: (x-value, y-value). Right-click any data point and select [Add Trendline…]. (It is possible to create more than one trendline for a single set of data.) If your data points are exactly along the trendline, then once you have created a trendline, it will be difficult to point to the data because they lie underneath the trendline.

(b) On the [Type] tab, we will select the formula which we expect the data to follow. If we have made a poor choice, then the “R-squared” value will not be close to one. This is an indication that we should start over with a new trendline formula. For now, your data should be pretty obviously linear. Make sure that the [Linear] option is blackened (selected).

(c) On the [Options] tab, we can format the trendline.

i. The [Trendline Name] option is asking for what will be displayed in the Legend. Since we have not made use of the legend, this will not affect our graph.
ii. The [Forecast] option allows you to extend the trendline. This might be used if you are interested in where it crosses the axis, although this can also be calculated from the equation of the trendline.
iii. The [Set intercept] forces the trendline through a specific point. Generally this is frowned upon unless
your theory restricts the value. (Do not use this.)

iv. Click the box next to [Display equation on chart] to display the equation of the trendline. This tells you what the pattern that the data are trying to follow. It “averages out” the bumps which are probably due to imprecise measurements.

v. Click the box next to [Display R-squared value on chart]. This will show you how well the data agrees with this pattern. If \( R^2 = 1 \), then your data fits this trend exactly. If your \( R^2 \) value is less than (rough estimate) 0.98, then you should review your measurement technique. If your \( R^2 \) value is less than 0.94, then you may want to consider a different trendline formula.

(d) Click [OK]. You will see the graph with the line, the equation, and the R-squared value. By pointing to the equation, holding the left-mouse button down, and moving the mouse, you can move the equation to a location which is easy to read. Let go of the mouse button when you have decided on a location.

(e) You can edit your trendline either by double-clicking on it or by right-clicking on it and selecting [Format trendline...]. Notice that if you do this, you have three tabs: [Type] and [Options] as before, as well as [Patterns]. [Patterns] allows you to change the style, color, and width (weight) of the trendline.

13. Evaluate your data. The trendline should pass through at least the corner of the implied box made by the error bars. Most of our data are accurate (according to the trendline), except perhaps \( x = 11 \) and 22; and even those are reasonable (i.e., within uncertainty). The imprecise data have large error bars. The description of the graph is that “the data are consistent with a linear relationship.” We can therefore expect an equation of the form

\[
y = mx + b
\]

where, for our data, \( m = 1.2097 \) and \( b = 4.3964 \). (In fact, we generated the data using a random variation from \( y = 1.2x + 4.6 \); but you wouldn’t know that in the lab.)

(a) Notice that data point \( x = 22 \) just barely extends its error-bars to touch the trendline. The “just barely” is fairly irrelevant. However, if you find a data point for which the error bars do not reach the trendline, then you should question either that data point or the assumption used to pick the form of the trendline. Remeasure that point several times to verify consistency. You may have written the number down incorrectly or misread the instrument.

i. If you find that you did make a mistake, try to figure out what the mistake was. Mention in your procedure section that the reader should be careful to not make this or that mistake.

ii. If you find that you did not make a mistake; that the discrepancy is real, then check the error bars. Are you underestimating your uncertainty? If yes, then adjust them. If not, then you have shown the data to be inconsistent and should propose an improved measurement technique to verify this apparent anomaly.

*** If you find that you did not make a mistake and that it cannot be explained by uncertainty, this is exciting news! It is what experimenters look for, but when found, you have to show that you are actually seeing an anomaly and not a mistake!

(b) Since there are measurement uncertainties in the data, the fitted trendline will not be the exact theoretical equation. Looking at our trendline, we would
assume the theory to be

\[ y = 1.2x + 4.4 \]

(Notice that this does not quite agree with the equation which actually generated the data.) So, we need to consider the \textbf{uncertainty in the slope and the intercept}.

i. Using the tabs at the bottom of the screen, go to your data page [Sheet1].

ii. The \( x \)-data are in A2:A12. The \( y \) data are in L2:L12. Go to cell K14. Enter \[ \text{Slo}[\text{p}][\text{e}] = \].

iii. In cell K15, enter \[ \text{Int}[\text{er}][\text{c}][\text{e}][\text{p}] = \]

iv. In cell L14, enter the formula:

\[ \text{=index(index(linest(L2:L12,A2:A12,true,true),1),1)} \]

The Excel function \text{[LINEST]} will generate the data relevant to a linear trendline. (It only works for linear trendlines.) The first “1” means “give the value, not the uncertainty.” The second “1” means “give the slope, not the intercept.” Rather than typing L2:L12, you can use the mouse to select that range. Similarly for A2:A12. But it must be \( y \)-values and then \( x \)-values. The value in L14 should be the same as the slope on the graph (but it may be rounded to a different number of decimals).

v. In cell L15, enter the formula:

\[ \text{=index(index(linest(L2:L12,A2:A12,true,true),2),1)} \]

The “2” means “give the uncertainty, not the value.” The “1” means “give the slope, not the intercept.” The value in N14 should be the uncertainty in the slope of the graph. This may be easier to do by going to cell L14 and typing the following on the keyboard:

\[ \text{[F2]} \text{[Shift]-[Home]} \text{[Ctrl]-[c]} \text{[Esc]} \text{[→]} \text{[→]} \text{[Ctrl]-[v]} \]

and then

\[ \text{[F2]} \text{[←]} \text{[←]} \text{[←]} \text{[←]} \text{[Backspace]} \text{[2]} \text{[Enter]} \]

vi. To paste the \( \pm \) into the two cells, go to cell M12; type \[ \text{[Shift]-[l]} \text{[Ctrl]-[v]} \].

vii. In cell N14, enter the formula:

\[ \text{=index(index(linest(L2:L12,A2:A12,true,true),2),2)} \]

The “2” means “give the uncertainty, not the value.” The “2” means “give the intercept, not the slope.” This may be easier to do by going to cell L15 and typing the following on the keyboard:

\[ \text{[F2]} \text{[Shift]-[Home]} \text{[Ctrl]-[c]} \text{[Esc]} \text{[→]} \text{[→]} \text{[Ctrl]-[v]} \]

and then

\[ \text{[F2]} \text{[←]} \text{[←]} \text{[←]} \text{[←]} \text{[Backspace]} \text{[2]} \text{[Enter]} \]

viii. In cell N15, enter the formula:

\[ \text{=index(index(linest(L2:L12,A2:A12,true,true),2),2)} \]

The first “2” means “give the uncertainty, not the value.” The second “2” means “give the intercept, not the slope.” This may be easier to do by going to cell L15 and typing the following on the keyboard:

\[ \text{[F2]} \text{[Shift]-[Home]} \text{[Ctrl]-[c]} \text{[Esc]} \text{[→]} \text{[→]} \text{[Ctrl]-[v]} \]

and then

\[ \text{[F2]} \text{[←]} \text{[←]} \text{[←]} \text{[←]} \text{[Backspace]} \text{[2]} \text{[Enter]} \]

The value in N15 should be the uncertainty in the intercept of the graph.
c) The values that we get (to two decimal places) are: (please notice the units!!!)

Slope = $1.21 \pm 0.02$ cooms/draps
Intercept = $4.40 \pm 0.31$ cooms

So, the slope is quite consistent with the 1.2 theoretical value and the intercept is reasonably consistent with the theoretical value. The slope only has a 1.6%-uncertainty and the intercept has a 7%-uncertainty.

14. Report your results: The data are consistent with (meaning that the error-bars overlap with) a line with slope $1.21 \pm 0.02$ cooms/draps and intercept $4.4 \pm 0.3$ cooms. Notice that since the uncertainty is in the first decimal, we should not report the second (as it is insignificant). These number can also be reported as $1.21(2)$ cooms/draps and $4.4(3)$ cooms. Be aware that the notation (2) implies that it is an uncertainty in the last decimal place listed (the second decimal place) and the (3) implies the same about the 4.4 (the uncertainty is in the first decimal place).

1.6 Calculated Data

The true point of using a spreadsheet in a scientific class is so that you don’t have to repeat a calculation for each point in a data set. You can type it in one time and then copy-and-paste it all the way down. This is specifically why computers were invented (to compute), and is specifically what they are good at: tedious repetition. If you find using a computer tedious or repetitious, then you are probably not using the computer correctly; let the computer do the repetitive part.

Now that you have been introduced the next two subsections reinforce your ability and show you how to create calculated data.

1. Create the set of calculated data.

(a) Go to your data sheet [Sheet1] by clicking the appropriate tab at the bottom of the page.
(b) We are going to put the calculated data in columns O, P, and Q. In order to use the same format as was used for y, select the range L1:N12. (point to L1, press and hold the left-mouse button, move the mouse to N12, let go). Type [Ctrl]-[c] (to copy that range). Go to cell O1. Type [Ctrl]-[v] (to paste the data). Notice that O1:Q1 is merged, that the $\pm$ has been copied, and that the two-decimal format has been copied as well. (yay!)

(c) But these are not the numbers that we want, so we will have to get rid of them. Select O2:O12 (you can do this quickly with the keyboard by pointing to O2 and typing [Shift]-[End]-[1] and press [Del] or [Delete] to delete that data. Select Q2:Q12 (point to Q2 and type [Shift]-[End]-[1] and press [Del] or [Delete] to delete that data. Go to O1 and enter “z (coom-draps)”.
(d) Resize column P. (Step 1.4.3c.)
(e) We will assume that $z$ can be calculated according to

$$z = y(x + 2)$$

Go to O2 and type [=], click cell L2, type [*][(), click cell A2, type [+][2][)]][Enter]. The value should be 17.00 and the formula should read: “=L2*(A2+2)”.

(f) Copy that all the way down through O12. (Step 1.3.5: Click cell O2, point to the unique lower-right corner, so that the mouse becomes a black +, press and while holding the left mouse-button and move the mouse to O12, let go.)

(g) Since the calculated uncertainty for $z$ is

$$\frac{\Delta z}{z} = \frac{\Delta y}{y} + \frac{\Delta x}{x + 2}$$

or

$$\Delta z = z[\Delta y/y + \Delta x/(x + 2)]$$

Go to cell Q2 and enter the formula “=O2\*(N2/L2+C2/(A2+2))” by doing the following: type [=], click cell O2, type [*][(), click cell N2, type [/], click
cell L2, type [+], click cell C2, type [/][[, click cell A2, type [+][2][)]][][Enter].

(h) Copy that all the way down through Q12. (Step 1.3.5.)

2. Create a graph of $z$ versus $x$.

(a) Rather than recreate the entire graph step-by-step, which would be tedious, we will copy and modify the old graph! Right-click on the old graph tab (which should either be [Chart1] or [y vs x]). Select [Move or Copy...]. Click (This is an important step!!!) to check the box by [Create a copy]. Press [Enter] or click [OK]. Double click the [Chart1 (2)] or [y vs x (2)] tab that you have just created. When it turns black, type [z][ ][v][s][ ][x][Enter].

(b) Right-click a data point on the new graph and select [Source Data...]. Select the [Series] tab. Click the funny spreadsheet box to the far right of [Y Values]. It should produce a dashed line around the $y$ data. Highlight the $z$ data O2:O12 instead and press [Enter]. Now press [Enter] or click [OK]. Notice that the trend of your data is no longer linear, so we will have to fix the trendline.

(c) Right-click any data point and select [Format Data Series...]. Select [Y Error Bars] tab. On the [Custom:] option, click on the spreadsheet button to the far right of [+]$. It should give a dashed line around the $y$ uncertainty. Select the $z$ uncertainty Q2:Q12. Press [Enter]. On the [Custom:] option, click on the spreadsheet button to the far right of [-]. It should give a dashed line around the $y$ uncertainty. Select the $z$ uncertainty Q2:Q12. Press [Enter].

3. Fix the trendline: double-click the trendline, select the [Type] tab, select the [polynomial] window, verify that the number 2 is selected nearby (so that it is a quadratic), press [Enter] or click [OK].

4. Fix the titles on the graph by right-clicking the background and selecting [Chart Options]. Change these by clicking the appropriate title and typing in the new name. Press [Enter] or click [OK] when finished.

1.7 Printing Data Sheet

There are a couple of options for this and it will depend on exactly how your data-set is laid out. You can even highlight and move your data around without changing any of the calculated values! With this data-set, we would like to have it all on one page, with the essential data listed first and the measured $y$ values listed later. But first we will look at a few options that may be appropriate in later labs.

1. Go to your data sheet.

2. Highlight from A1 through Q15 (all of your data). Click [File] at the top of the page. Click [Print Preview] on the [File] Menu which you just pulled up. Notice that the data does not fit on a single page. This is ugly.

(a) Select [Setup]. On the [Page] tab of the new window, click [Landscape]. Click [OK]. Now, the data will fit, but it is horizontal. Sometimes this will be nice, but not here.

(b) Select [Setup]. On the [Page] tab of the new window, click [Portrait]. Click [Fit to:] so that it reads “Fit to: [1] page(s) wide by [1] tall.” Click [OK]. Now, the data will fit and it is vertical, but it is a bit small, and we have a large mostly-empty page. This will also be a good format for some data, but not for this data set.

(c) Click [Close].

3. You should be back at your data page. Notice the column headers A through Q. Click the column header E. Notice that the column turns black. Now, Press and hold the mouse button on the column header E, then with the button still held, move across to column J. Columns E, F, G, H, I, and J
should all be black. Right-click in this black-

ened region. Select [Hide]. (These columns
are still there.) Now, click [File] at the top
of the page. Click [Print Preview] on the
[File] Menu which you just pulled up.

(a) Notice that the data all fits nicely (al-
though there is still a good bit of room
on the page). Unfortunately, we would
also like to include the data which are
hidden.

(b) Click [Close] again.

4. Highlight column headers D and K (which
should currently be adjacent). Right-click
in the blackened area and select [Unhide].
All of your data should be back.

(a) Highlight the data in cells E1 through
K12. Point to the black edge of the
highlighted region (the mouse should
become a white arrow when you are
in the right place). Press and hold the
left-mouse-button while moving the
mouse around. Place the upper left
corner in cell A17 and then let go of the
mouse button. Notice that the data in
column B doesn’t fit and is displayed
as ##. Highlight the data in cells
B17:G28. Move it all over one column.
Resize column C (Click between the C
and D column headers).

(b) Highlight cells K1:Q15. Move them
so that the upper left corner is in cell
D1. Move F17:H28 one column to the
right. Highlight I17:I28. Move this
set of cells to the right by one column.
Resize columns F and I (where the ±
are).

(c) (Niceties) You might also wish to re-
size columns G and J, but it is not ne-
necessary. You might also want to add a
comment in cell C17: Measured y val-
ues, average-value listed above.

(d) (Niceties) It would be very helpful if
you could also change the title of every
graph and data sheet you create to in-
clude your name and the name of your
partners.

(e) Now, click [File] at the top of the page.
Click [Print Preview] on the [File] Menu
which you just pulled up.

(f) Click [Print. . .] at the top of the page.

(g) The [Print What] option should be set
to [Active Sheet(s)]. Click [OK].

5. Smile happily.

6. Turn in your data sheet and your graphs,
please. (If you feel up to it, figure out how
to import your data sheet and graphs into
a Microsoft Word document!)
Table 3: Some Key Combinations

<table>
<thead>
<tr>
<th>Key Combination</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enter</td>
<td>Enter information in a cell and move down one row</td>
</tr>
<tr>
<td>Ctrl-Enter</td>
<td>Enter information in a cell and remain in current cell</td>
</tr>
<tr>
<td>Ctrl-1</td>
<td>Open menu to format selected cells</td>
</tr>
<tr>
<td>Ctrl-2</td>
<td>[Ctrl][-b] selected cell/text</td>
</tr>
<tr>
<td>Ctrl-3</td>
<td>[Ctrl][-i] selected cell/text</td>
</tr>
<tr>
<td>Ctrl-4</td>
<td>[Ctrl][-u] selected cell/text</td>
</tr>
<tr>
<td>Ctrl-5</td>
<td>Toggle ICON MENU at top of screen</td>
</tr>
<tr>
<td>Ctrl-6</td>
<td>Works for when you are using an OUTLINE</td>
</tr>
<tr>
<td>Ctrl-7</td>
<td>Hide selected rows</td>
</tr>
<tr>
<td>Ctrl-8</td>
<td>Open a new blank excell document</td>
</tr>
<tr>
<td>Ctrl-9</td>
<td>Save document with given name</td>
</tr>
<tr>
<td>Ctrl-n</td>
<td>Redo latest Undo, feature is recursive</td>
</tr>
<tr>
<td>Ctrl-s</td>
<td>Undo latest revision, feature is recursive</td>
</tr>
<tr>
<td>Ctrl-y</td>
<td>Get Help</td>
</tr>
<tr>
<td>Ctrl-z</td>
<td>Edit the contents of a cell</td>
</tr>
<tr>
<td>F1</td>
<td>Cycles through these choices of protection for a formula</td>
</tr>
<tr>
<td>F2</td>
<td>Goto a specified cell</td>
</tr>
<tr>
<td>F3</td>
<td>Spell Check Document</td>
</tr>
<tr>
<td>F4</td>
<td>Create a blank Chart</td>
</tr>
<tr>
<td>F5</td>
<td>Save document with option to change the name</td>
</tr>
</tbody>
</table>

Table 4: Some Excel Functions. In each case, RANGE has either the format (E3,E4,E5,E6,E7,E8) or (E3:E8).

- `=average(RANGE)` Average a column or row of numbers
- `=max(RANGE)` Find the maximum of a set of numbers
- `=min(RANGE)` Find the minimum of a set of numbers
- `=linest(RANGE,RANGE,TRUE,TRUE)` Find the statistics associated with the best fit line