

*L1: Introduction and Room Width**Analysis Using excel: Excel Basics*Introduction

An important objective of this laboratory course is to familiarize you with the use of the computer to process experimental data. We will use Excel, the most widely used spreadsheet program. Because all spreadsheet programs are basically the same, mastering Excel will enable you to quickly learn other versions of Excel, Quattro Pro, or other spreadsheet programs. Moreover, there are many practical, non-science uses for spreadsheets, so learning this skill will help you at home or in almost any occupation. If you are already familiar with spreadsheets, you will have an opportunity to enhance your skills and to help your instructor pass on these skills to your classmates. If this is your first exposure to spreadsheets, you will likely find this experience one of the most rewarding aspects of the course. Past students have commented that learning spreadsheets was a most valuable aspect of the course.

Overview

The spreadsheet concept is uncomplicated; a spreadsheet consists of a two-dimensional grid system. Each cell is identified by two coordinates: the columns by letters (A, B, C...), and the rows by numbers (1,2,3,...) as shown below.

| | A | B | C | D | E |
|----------|----------|----------|----------|----------|----------|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |

Each cell has a unique identity, e.g., A1, A5, and B6. When you click on a cell, it will appear outlined with a small square box in the lower right hand corner. You can type numbers, letters, or formulas in that cell. When done, press enter and use the mouse as needed to go to another cell.

The power of spreadsheets derives from your ability to type a formula into a cell. **All formulas begin with the = sign.** If you type “=A1+A2” into cell A3, the computer will add the contents cells A1 and A2 and place the numerical result in A3. Try this. Only the numerical result will show in A3, but if you look toward the top of the screen, the formula you entered will appear in the edit box. If you want to edit this equation without totally retyping it, simply click on the equation in the edit box, make changes, and press enter when done. Operations far more complex than simple addition are possible.

Entering Experimental Data

Experimental data is most often entered in columns. Start by typing a heading or title, this should include parameter and unit, e.g. Time(s), for a column. Then, type numerical data in the cells below the heading. If you make a mistake, you can go to another cell and then return to the original cell, overwriting your original entry. You can also click on the edit box and edit the cell contents, pressing enter when done.

Entering Formulas

There are several ways to build formulas. First, click on the cell where you want the answer to appear. The most straightforward approach is to type the = sign followed by the formula you want, e.g., putting “=(A1+A2)/2” into cell A3 would produce the average of A1 and A2. You can also build this expression using these steps:

- Click on A3
- Type =(
- Click the mouse on cell A1
- Type +
- Click the mouse on A2
- Type)/2
- Press enter

You could even do the job by directly typing “=AVERAGE(A1:A2)” into A3 which takes the average of all cells between the cell locations specified before and after the colon. Note that formulas cannot contain any spaces. A common mistake is to accidentally place a space before the = sign where it is hard to detect.

Copying Formulas

Consider that you have in put the data below and want to calculate the area for each pair of width and length measurements.

| | A | B | C | D | E |
|----------|----------|----------|----------|----------|----------|
| 1 | Width | Length | Area | | |
| 2 | 2.5 | 2.0 | | | |
| 3 | 3.0 | 2.1 | | | |
| 4 | 3.3 | 2.7 | | | |
| 5 | 4.4 | 3.1 | | | |
| 6 | | | | | |

Click on cell C2, enter the formula: =A2*B2, press enter. The number 5.0 will appear in C2. To copy this down into cells C3, C4, and C5:

- *Click on C2 again*
- *Move the cursor over the small square on the lower right hand corner of the cell until the cursor becomes a cross*

Press down on the mouse button; drag it down to cell C5 before releasing the button.

The spreadsheet will now look like this.

| | A | B | C | D | E |
|----------|----------|----------|----------|----------|----------|
| 1 | Width | Length | Area | | |
| 2 | 2.5 | 2.0 | 5.0 | | |
| 3 | 3.0 | 2.1 | 6.3 | | |
| 4 | 3.3 | 2.7 | 8.91 | | |
| 5 | 4.4 | 3.1 | 13.64 | | |
| 6 | | | | | |

Click on cell C5 and look at the equation in the edit box. You will notice it is “=A5*B5” so the computer has adjusted the formula. This beats typing the formula 3 more times. You can also use the copy, cut, and paste commands under the edit menu for text, numbers, or formulas as you do with word processors. You should become proficient in both these methods.

If you would next like the sum of the 4 areas to appear in cell C6, you could type “=C2+C3+C4+C5” or “=SUM(C2:C5)”. You could even use these steps:

- Type =SUM(
- Highlight the cells from C2 to C5
- Press enter

You would get the following.

| | A | B | C | D | E |
|---|-------|--------|-------|---|---|
| 1 | Width | Length | Area | | |
| 2 | 2.5 | 2.0 | 5.0 | | |
| 3 | 3.0 | 2.1 | 6.3 | | |
| 4 | 3.3 | 2.7 | 8.91 | | |
| 5 | 4.4 | 3.1 | 13.64 | | |
| 6 | | | 33.85 | | |

Consider now that you have gathered some radius measurements for circles and wish to calculate areas. Note that you have placed a value for π in B1.

| | A | B | C | D | E |
|---|--------|------|---|---|---|
| 1 | Pi= | 3.14 | | | |
| 2 | Radius | Area | | | |
| 3 | 2.1 | | | | |
| 4 | 2.7 | | | | |
| 5 | 2.2 | | | | |
| 6 | 1.9 | | | | |

Since $A = \pi r^2$, you would type “=B1*A3^2” in B3. However, if you copied this down as before, you would have “=B4*A7^2” in B6. Clearly, B4 does not contain π . To copy this down correctly, you need to prevent B1 from changing as follows:

- Click on B3 and go to the edit box to edit the formula
- Place the cursor on B1
- Press the F4 key on a PC. The formula will change to =\$B\$1*A3^2
- Press enter

When you copy this revised formula, B1 will never change, yielding the spreadsheet below. *If you had held the Apple key down, and pressed the T key again, it would have cycled through holding the row or column constant, finally returning to simply B1 without the \$ signs.*

| | A | B | C | D | E |
|---|--------|---------|---|---|---|
| 1 | Pi= | 3.14 | | | |
| 2 | Radius | Area | | | |
| 3 | 2.1 | 13.8474 | | | |
| 4 | 2.7 | 22.8906 | | | |
| 5 | 2.2 | 15.1976 | | | |
| 6 | 1.9 | 11.3354 | | | |

Using the Function Feature

In this course you are likely to know the syntax to get Excel to calculate sums, averages, standard deviations, slopes, and intercepts, i.e.,

$$\begin{aligned} \text{Average: } &= \text{average}(x_1:x_n) \\ \text{Standard Deviation: } &= \text{stdev}(x_1:x_n) \\ \text{Slope: } &= \text{slope}(y_1:y_n, x_1:x_n) \\ \text{Intercept: } &= \text{intercept}(y_1:y_n, x_1:x_n) \end{aligned}$$

However, if you forget these or want to perform some other operation, you can select Function under the Insert menu or press the f_x button. You will see an incredible number of selections to include, for example, all the trigonometric functions.

Slopes and Intercepts

Although the average and standard deviation functions only have one argument, the slope and intercept functions have two arguments, x and y. You are calculating the best fit straight line that fits your x and y data. This mathematical operation is called a Least Squares or Linear Regression Fit to the data. Before calculating the slope and intercept you must identify your x and y data which presumably are located in two columns of your spreadsheet as shown below. Assume that you want the slope and intercept to appear in cells B5 and B6 as indicated by the alphanumeric labels typed into A5 and A6.

| | A | B | C | D | E |
|---|------------|--------|---|---|---|
| 1 | x data | y data | | | |
| 2 | 2 | 3 | | | |
| 3 | 3 | 4 | | | |
| 4 | 4 | 6 | | | |
| 5 | Slope= | | | | |
| 6 | Intercept= | | | | |

To put the slope in B5 use these steps:

- Click on B5
- Type: =slope(
- Highlight your y data B2:B4
- Highlight your x data A2:A4
- Press enter

The computer program even puts in the parenthesis for you. Put the intercept into B6 in the same way to obtain the following.

| | A | B | C | D | E |
|---|------------|----------|---|---|---|
| 1 | x data | y data | | | |
| 2 | 2 | 3 | | | |
| 3 | 3 | 4 | | | |
| 4 | 4 | 6 | | | |
| 5 | Slope= | 1.5 | | | |
| 6 | Intercept= | -.166667 | | | |

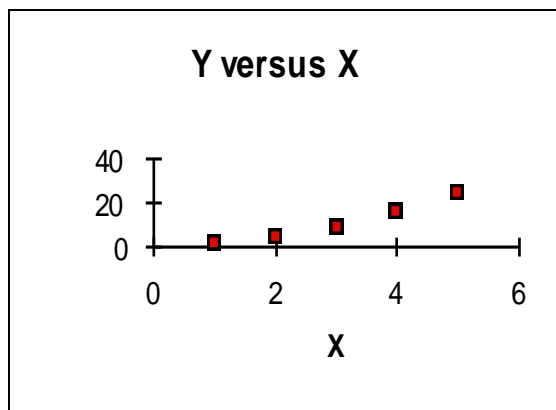
Graphing and Plotting

Plotting is one of the great features of spreadsheet programs. Before starting, plan ahead. **Make sure your column of x data is to the left of your y data.** Excel assumes this to be the case, regardless of what you tell it. Assume you want to plot the following x-y data.

| | A | B | C | D | E |
|---|--------|--------|---|---|---|
| 1 | x data | y data | | | |
| 2 | 1 | 1 | | | |
| 3 | 2 | 4 | | | |
| 4 | 3 | 9 | | | |
| 5 | 4 | 16 | | | |
| 6 | 5 | 25 | | | |

Follow these steps to produce a scatter plot--the type most used for experimental data.

- **Highlight your x and y** data simultaneously by highlighting the block of cells from A2 to B6. Note if your x and y data are separated by other columns, hold the control key down while you individually highlight the x and y data columns. *Do not include the titles on row 1*, just numerical data.
- **Press the Chart Wizard icon** on the upper right portion of the menu bar. It looks like a vertical bar chart *or* go to INSERT, then CHART.
- Double click quickly on the **xy(scatter)** plot which is usually the type you will use or single click it and press next.
- You will now see your plot with actual data points displayed. Note that if you don't like it, you can go back and change something. Confirm that the **data series are in columns**.
- Press next. You will now see your chart and be able to add a title and label the axes.
- Click the cursor in the title and label boxes, **and type in the labels you want**. The actual information you enter will appear on the plot after a moment. **Do not press enter until you are satisfied with your plot** or at least have made an entry for the title and each axes. Prematurely pressing enter will take you out of the chart wizard and makes it difficult to add titles or labels to your plot later; it is relatively easy to change a title or label as long as you put something in initially.
- Select having your object in the sheet.
- **Press finish** and your final chart will appear on your spreadsheet.
- **Resize your chart**. Note that the border of the chart will have small boxes at each corner and the middle of each side. Place the cursor on any of these boxes, press down on the mouse, and stretch the plot to the size you want.
- **Relocate your chart** by placing the cursor anywhere on the border of the chart other than on one of the small boxes. When the cursor changes to an arrow, press down on the mouse and move the plot to the selected location.
- **Click on a spreadsheet cell outside of the plot** area to exit the plot; click again on the plot to change its location or size again. Double-clicking on the plot will open the plot so you can make changes to the title, type of chart, etc. This is what you should have if you have used the above steps.



Printing

You may print your spreadsheet using the following steps:

- **Select Print Preview** under the File menu.
- You will now see how your spreadsheet would look when printed. It is unlikely to be in an acceptable format.
- **Press Setup**
- Select the best orientation--usually **landscape**--and select **scale to fit page**. At this point, you can change headers and footers, etc.
- Press **OK** to take you back into print preview to see what your spreadsheet will look like
- Press Margins to display current settings. You can simply click and drag them around to center your chart or otherwise get it the way you want it
- Press Print to **Print or Close** to return to the spreadsheet. You can always select Print under the File menu, but only do so after you have previewed your work. You will be asked to verify the **number of copies** and the **destination printer** before printing takes place

To print just a full size chart on a page without the spreadsheet, double-click on the chart until you open it. Then go to print preview to get the page the way you want it

Saving Your Work

It is important to periodically save your work. Almost everyone working with computers has experienced a computer lockup where all is lost except what you last saved. We suggest that before inputting data you select Save As under the File and save your spreadsheet to a removable drive. Note that any files saved on the hard drive will be lost if there is a power fluctuation. Lab computers contain software, which automatically removes any student-saved files every time the computer is rebooted. Thus a power loss means data loss if the file is saved on the hard drive. Once you have saved it to a removable drive, you can use the *Save* Icon located in the upper right part of the menu bar every so often. When you are done with your spreadsheet *Save* and *Close* it from the *File Menu*. This way you have a copy on your removable drive and can go to any other computer to view, print, or change your spreadsheet.

Name: _____

Exercise: Using Excel to analyze the Room Width

1. Measure the width of the room in meters to the nearest 0.001 m four times and record the measurements in the table below. The width of the room for this exercise is defined as the distance between the two walls that have no windows. Before starting, be sure to take a minute or two with your partners to plan out how you will do it.

| | Measured Values () |
|---|---------------------|
| 1 | |
| 2 | |
| 3 | |
| 4 | |

2. Go to one of the lab computers and open Excel and create a spreadsheet using your four values, to calculate the mean and standard deviation of your data. (see Page 8)
3. Print your results. Then close your spreadsheet. Hand in your print out with the completed lab.
4. Now return to your lab bench and try the same calculation with your hand calculator. You should get the same results.

Error analysis equations – **Show your calculations here**

a. Mean $\bar{x} = \frac{\sum x_i}{n}$ Where $x_i = i^{\text{th}}$ experimental value

Spreadsheet Value: _____ Calculated Value: _____

b. Deviation $|x - \bar{x}|$ $n = \text{no. of experimental values}$

Spreadsheet Value: _____ Calculated Value: _____

c. Standard deviation

$$\sigma = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}} = \sqrt{\frac{(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + (x_3 - \bar{x})^2 + (x_4 - \bar{x})^2}{4-1}}$$

Spreadsheet Value: _____ Calculated Value: _____

d. % error $\%error = \frac{\sigma}{\bar{x}} * 100$

Spreadsheet Value: _____ Calculated Value: _____

5. Discuss with your lab partners what errors and problems you encountered and conclude how well you measured the width of the room. Please be able to say you measured it to within some number of meters, **e.g.**, within +/-0.003m. State the result of this discussion below.

Room Width Spreadsheet

| | A | B | C |
|-----------|-------------------------|-----------------|---------------|
| 1 | | Measured | |
| 2 | | Values | X-mean |
| 3 | 1 | 4.773 | -.010 |
| 4 | 2 | 4.811 | .028 |
| 5 | 3 | 4.770 | -.013 |
| 6 | 4 | 4.777 | -.006 |
| 7 | Mean = | 4.783 | |
| 8 | Standard dev = | 0.19 | |
| 9 | Percent Error = | 0.40 | |
| 10 | Mean + 2 sigma = | 4.821 | |
| 11 | Mean - 2sigma = | 4.745 | |

Room Width Spreadsheet Formulas

| | A | B | C |
|----|-----------------|------------------|---------------|
| 1 | | Measured | |
| 2 | | Values | X-mean |
| 3 | 1 | 4.773 | = B3-\$B\$7 |
| 4 | 2 | 4.811 | = B4-\$B\$7 |
| 5 | 3 | 4.77 | = B5-\$B\$7 |
| 6 | 4 | 4.777 | = B6-\$B\$7 |
| 7 | Mean = | = Average(B3:B6) | |
| 8 | Standard Dev = | = STDEV (B3:B6) | |
| 9 | Percent Error = | = B8/B7*100 | |
| 10 | Mean + 2sigma = | = B7 + 2*B8 | |
| 11 | Mean - 2sigma = | = B7 - 2*B8 | |