Appendix B:

Introduction to Spreadsheets and EXCEL 2010

I - Spreadsheets

A spreadsheet is a computer program that turns your computer display into a smart piece of paper. It removes much of the grunt work associated with repetitive calculations and lets you easily see the results of your work. We have chosen to use spreadsheets in the physics labs because they reduce the amount of time needed to look at and understand data. Traditionally accountants have used spreadsheets to do bookkeeping and budgets, but they make outstanding tools for scientists as well. With a spreadsheet, you can enter raw data, manipulate it and plot it all with a few simple commands.

One key aspect that makes a spreadsheet so powerful is that whenever you change a number or formula in your spreadsheet, everything else in the spreadsheet that depends on that number or formula gets automatically recalculated, including plots. So if you make a mistake and have to re-measure a quantity or change a formula that you have entered into your spreadsheet, all numbers connected to it are automatically updated. Another key aspect that makes a spreadsheet so powerful is that everything you do in a spreadsheet is saved and displayed in an intuitive graphical interface (the spreadsheet). With everything displayed in front of you, it is easier to understand your data and spot problems.

Yet another reason spreadsheets are extremely useful for data analysis is because of their ability to plot data. Rather than having to draw a graph by hand, you can just select the numbers you want to plot and the spreadsheet will do the work. Even better, if you change the numbers or formulas, the graph changes automatically. Still another advantage of a spreadsheet is that it can easily handle the **statistical analysis** of data sets with hundreds, thousands, or even tens of thousands of points, something that you would never want to try doing on a calculator. Some examples of functions that are particularly useful in analyzing data are the **average**, the **standard deviation** and a least square fit of a straight line (known as a linear regression) to find the **slope** and the **intercept**.

Think about the many advantages of using EXCEL and then put your calculator away for the rest of the semester - do not use a calculator in any of the labs because it is very poorly suited to the job of recording, plotting and analyzing real data. Needless to say, EXCEL does have some significant limitations and it will not be appropriate for every data set you encounter in the future. In particular, data sets with more than a few thousand points, or that require symbolic manipulation, or that involve extensive signal analysis, sophisticated physical modeling, or image processing, are best handled using more sophisticated general purpose software (such as MatLab or Mathematica) or special purpose software.

A spreadsheet consists of a collection of **cells** arranged in a table. The cells are labeled by their column and row location (see Table 0.1 below). For example cell B3 is in the second column, the third cell down. A cell can contain **text**, a **number**, a **formula**, or a **logical value** (true/false). If you click on a cell, type in some text and hit enter, the spreadsheet will display the text in the cell (see cell A1 or cell C1 below in Table 0.1). You can also enter numbers like 15 (see cell A2). We can also put in formulas (see cells A2 and A3). Cell B1 contains a simple **formula** that is, of course, equal to 6. In Excel, all formulas begin with an equals sign. If you type this formula into cell B1 and then hit enter, you will see that the spreadsheet now displays the number 6 instead of the formula =3*2 (see Table 0.2). The formula in cell B2 shows a

Table 0.1- This shows what to put in various cells in the spreadsheet

	A	B	C	D	E	F	G
1	text	=3*2	mass				
2	15	=2*A2					
3	=A2+1	=2*A3					
4							

Table 0.2- This shows what the spreadsheet displays

	A	B	C	D	E	F	G
1	text	6	mass				
2	15	30					
3	16	32					
4							
5							

different example. It says =2*A2. What this means is twice the value of the cell A2. Since A2 is currently 15, B2 displays the value 30 (see Table 0.2). If the number 15 in cell A2 is changed to 20, then the spreadsheet will immediately recalculate everything and cell B2 would get changed to 40. This way of setting up formulas, with parameters being displayed in other cells, is very useful because it makes it easier to find and correct mistakes.

So if a cell has a formula in it, and EXCEL displays this as a number, what do you do if you want to see the formula and not the number? If you want to check a formula or change a formula, you need to see it. The best way to get EXCEL to **display a formula** in a cell, rather than the result produced by the formula, is to double-click on the cell. When you double-click on a cell, EXCEL not only shows you the formula in the cell but also **highlights any cells that the formula is using**. This simple feature turns out to be especially powerful for helping you find mistakes in a formula.

Another really convenient feature of spreadsheets is the ability to replicate formulas. As an example, suppose that you wanted to extend the above spreadsheet so that the numbers go from 15 and 16 all the way to 25. Of course you could type 17, 18, … into cells A4, A5 *etc.*, but this is unnecessary. Instead, you can use the **copy** and **paste** tools to replicate the formula in cell A3 to the cells A4 to A12. Cell A3 has the formula =A2+1 in it. Now what you would like in cell A4 is not exactly the same formula as A3, but you would like it to say A3+1 (not A2+1). This way it will become 17. When you tell the spreadsheet to copy and paste a formula, the formula is automatically changed in just this way. For example, if you copy the formula A3 and paste it into cells A4 through A12, the formulas will become =A3+1, =A4+1, =A5+1 *etc.* all the way to A11+1. If you were to copy the formula in B2 and paste it into C2, it would change in a similar manner. It would change from =2*A2 to =2* B2, and in your example the value would

become 2*(2*15) or 60. The most important thing to realize is that you rarely have to type a formula more than once, even if it is used frequently. Also if you have a row of formulas and you want to change it, you can make the change once and copy it to all the other cells.

Sometimes you will want to copy a formula, or move it from one place to another, without having it change. There are a several ways to do this in Excel. The simplest way is to use **cut** and **paste** instead of copy and paste. For another way, see the discussion of the $ symbol below.

II - Using EXCEL 2010

1 - Getting Started

The best way to learn how to use EXCEL is to just go ahead and start using it. Start Excel by clicking the Microsoft EXCEL icon in Windows. EXCEL will open a **notebook** and you should see a screen that looks similar to the one shown in Figure 1 below. The exact appearance of the window will change if you stretch it or click on some of the buttons, tabs or sliders.

2 - Moving around the spreadsheet

You can move from cell to cell by using your mouse, the cursor keys, or by using the PgUp and PgDn keys. You can also go directly to a specific cell by pressing the F5 key and entering the cell address. The cell addresses in EXCEL are in the form C23 or sheet1!:C23. This is cell C23 on sheet1. You can also move around on the spreadsheet without changing cells by using the vertical and horizontal scroll bars (see Figure 1).

EXCEL lets you have many **worksheets** in the same "notebook" which can all be connected to one another. Small tabs on the bottom of the page let you switch from one worksheet to another (see Figure 1). It is also possible to have more than one notebook open at the same time and the window menu at the top of the sheet lets you toggle between notebooks.

3 - Entering Information

To enter information (text, numbers, formulas) into a cell, click on the cell and type the information. When you start to type in a cell, whatever you type appears in the cell and also on the top left of the page in the **formula bar** or display line (see Figure 1). If you press enter after typing something, it will enter it on the sheet; or if you press the escape key, it will abort the entry and leave the cell unchanged. When you are entering an expression in a cell, you can edit that expression by moving the mouse to the spot you want to change (on display line). Pressing enter or moving the cursor to another cell enters the expression. If you want to change a previously entered expression, you can move to the cell and retype the whole thing or move the mouse to the display line, click the left mouse button, and then revise the expression.

4 - Entering Text

You will need to put labels on your data to make your spreadsheet understandable. To set up nice looking labels, just type words into a cell. For example if you type the word "text" in cell A1, it will be displayed. If the text is longer than the cell width (which is adjustable) the whole text will show up if there are empty cells to the right of the cell with the text in it. If the string is long and the cell to the right occupied, the string will show up cut off - but it is all still there. You can adjust the size of columns or rows in the spreadsheet by clicking on the borders that separate the column or row designators at the top or left of the spreadsheet.

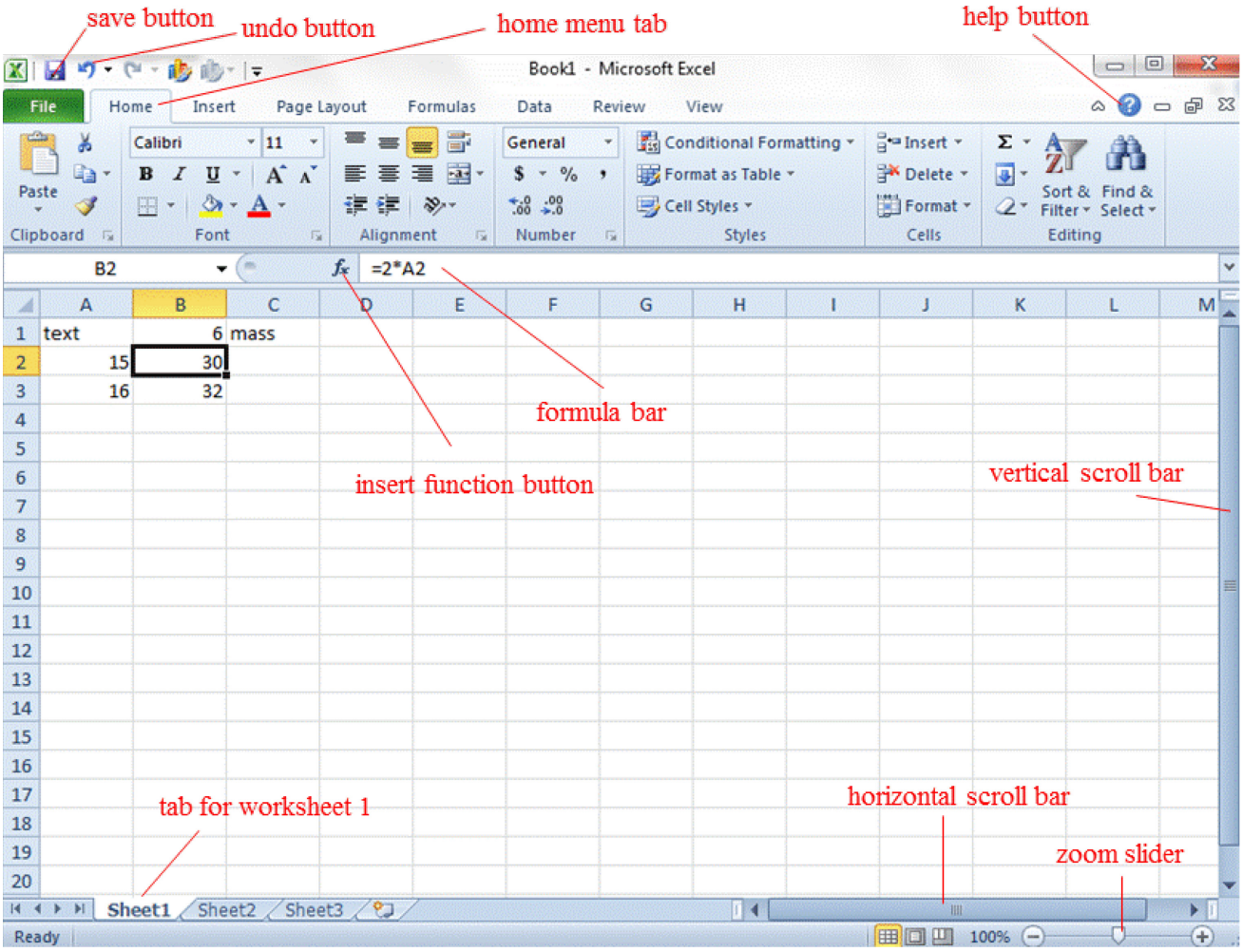

Figure 1. Layout of an Excel 2010 spreadsheet, highlighting some important buttons, bars and menus. The "Home" menu tab has been selected and some text and formulas have been entered into the worksheet. Cell B2 has been selected and the contents are displayed in the formula bar.

5 - Entering Numbers

Numbers are simply entered in a cell. A number like 15 can just be typed and its value is entered in the cell. If the number is negative just start it with a minus sign.

6 - Entering Formulas

Formulas always start with an equal sign. A formula can be a simple numeric expression such as =2*3, or it can include more complicated expressions involving other cells and statistical and mathematical functions. A formula like =2*B5^3 follows the rules of programming where this means 2 times the contents of cell B5 raised to the third power. Use parentheses in a natural way - for example, you can write:

=1/((1/B3)^2+(1/B4)^2)^(0.5))

The spreadsheet has numerous mathematical functions such as sine (=SIN), cosine (=COS), and square Root (=SQRT), which are almost the same as in a normal mathematical

expression. =SIN(C3) takes the sine of the contents of cell C3 (the angle must be in radians). Many other functions exist. The list of available functions can be viewed by clicking on the **function button** *fx* (see Figure 1) and choosing "all" in the "or select a category" dropdown menu.

Functions, such as sine, take normal numerical arguments. Some statistical functions take lists of cells or a range of cells. An example of this type of function is the average. The average function will compute the average of a list of numbers or the average of the numbers in a list of cells. So if you enter =AVERAGE(5,6,7,8) the value of the cell will be 6.5. This type of function is most useful when you give it a list of cells. If you wish to find the average of a column of numbers that are in cells A1 to A20, you just enter =AVERAGE(A1:A20). Most spreadsheet functions are "smart" so that if your range includes empty cells, they are not counted in the average or other statistical function (Excel distinguishes between empty cells and zero).

7 - Pointing at Cells

When you first start using a spreadsheet, you may often find yourself typing cell numbers into equations and expressions. Much of this typing is unnecessary and can lead to errors. The easiest way to put a cell number into an expression is to click on the cell, or "point" at it. For example, suppose that you have a number in Cell A3 and are writing an expression in which you want the cosine of the number in Cell A3. Simply type "=COS(" then move the mouse or cursor to cell A3 using the page up/down/left right buttons or by clicking on the cell. Then the expression you are typing will look like =COS(A3. At this point do not press enter because you have not completed the expression. Just type the closing parenthesis and then hit enter and you will have =COS(A3) .

8 - Selecting Ranges

You can also point at groups of cells. This is useful for functions such as the average or standard deviation that expect ranges as arguments. It is also useful when you want to mark a region that needs to be moved or copied. Anytime you need a range of numbers, use the mouse to move the cursor to the first cell in the range and hold down the left mouse button. Now "drag" the cursor to the last cell in the range and release the button. You should now have the range highlighted and displayed in the display line.

9 - Copying a formula

Suppose you have a column of numbers in cells D2,…D20, and you wish to evaluate the sine of each number (see Figure 2). To begin, enter the numbers into D2… to D20. Next in cell E2 enter the formula =SIN(D2). Now copy the formula to the entire range E2,...E20. To do this put the cursor on E2 and press the copy button (on the keyboard type either Ctrl-C, or move to the menu, click on edit and select copy). Now it expects a cell or range to be the object to be copied. Use the techniques described above to select the output range E2,...E20. (It is OK to copy the formula onto itself). Hit enter and your formula will be replicated over the entire range. Note that in cell E2 the formula is =sin(D2), but in cell E3 it has been updated to =sin(D3) rather than =sin(D2). This smart copying by Excel is very useful and leaves column E with the sine of the values in column D, in just the way you would want.

There is another type of copying that uses **fixed cells** in which the cell location does not change. To fix a cell location so that it does not change when you copy, put a $ in front of the cell name, *e.g.* B1. Note that there are two dollar signs in this particular example, because it is possible to fix just the column or just the row or both so that they do not change when you copy.

For example, suppose you have a column (A1,...A20) of measured accelerations, and you want a column of forces and all objects have the same mass. If the mass is in cell D1 your formula in B1 might be =A1*D1. This way when you copy the formula to B2 it will be =A2*D1. If you did not use $ signs in the second factor the formula would have become A2*D2 which would be wrong if the mass was in D1.