

ON EXCEL & MAPLE

This is a brief introduction to Excel (microsoft's spreadsheet) and Maple (a symbolic manipulation program). Excel enables us to present and manipulate large quantities of data including graphing, simple algebra, and simple fitting capabilities. Maple can be used to simplify algebra and calculus calculations and for plotting and numerical solutions to differential equations. Excel has the advantage that it is widely available, however, Maple can be used for analytical solutions.

While most of the basics have not changed, this introduction refers to the 2004 version of Excel. Maple is available on campus through the citrix server.

EXCEL

The basics

Cells and Addresses:

Start the Excel program by double clicking on the Excel application or on any Excel document. In front of you will appear a grid of rectangular areas called **cells** in a document labeled **Worksheet**. At the top of every column is a letter; at the left of every row is a number. The letter and number, taken together, comprise the **address** of a cell.

Cell Contents--text, numbers, and formulas

The many cells in your spreadsheet can contain a variety of different kinds of information, depending on how you are using the program. A cell can a **number**, **text** or a **formula**. If you are using a spreadsheet for data analysis, it is very important to add text cells to label to your columns or rows of data so you can keep track of what you are doing. Try typing numbers and letters into various cells and note the line at the top of the page where the typing appears. Also note that Excel treats numbers and letters differently.

Type “=2+2” into a cell, hit return, then select that cell with the mouse. Note what appears in the cell and what appears in the line at the top of the page when that cell is selected with the mouse. Anything starting with an “=” sign is interpreted by Excel as a formula. Excel also provides a number of built in functions such as “sin()”, “cos()” etc. which you can use by putting a number or expression in the parenthesis as an argument to the function. For instance, “=sin(3)” will show up as 0.14 in the cell, but clicking on the cell will reveal that the cell really contains the formula sin(3). By the way if you want to type in π try “pi()”

Excel uses the standard computer expression rules and precedence. The operators “+”, “-“, “*” and “/”, and “^” refer to addition, subtraction, multiplication, division, and raising to a power. You must explicitly use the “*” for multiplication as in “=3*sin(3)”. Standard precedence means that the computer first computes powers, then multiplication and division, then addition and subtraction. Each type if operation is evaluated left to right. Type the formula 4+2*2^3 and make sure that you understand the answer.

Relative vs. Absolute Addresses.


Excel uses two different kinds of addresses: **relative** and **absolute**:

A **relative** reference is like giving someone directions that explain where to go, based on where the person starts--"Go up 2 blocks and over 1." A relative reference tells Excel how to find another cell, starting from the cell that contains a formula. "A4" is a relative reference. If you type a formula in C4, which refers to A4, you are telling the computer to use the number 2 columns to the left in the calculation. If you copy this reference to another cell, it still points to the number 2 columns to the left which won't be A4 anymore. Try it.

An **absolute** reference tells Excel how to find a cell based on its exact location in the spreadsheet. To make a reference absolute, dollar signs are added before the column and row labels: "\$A\$4".

Absolute vs. Relative reference: Put a number in cell B3. In cell B4 put the formula " =B3+1". Copy B4, then use the mouse to select the cells B4:B9. Paste the formula from B4 into all of these cells. This is relative addressing. Now change your formula to " =\$B\$3 +1" and paste that into B4:B9. This is absolute addressing.

Help

There are two types of help in Excel, and both are very easy to use. The first is indexed help under the "Help" menu. Simply start typing and a list appears of all the possible help topics that relate to the letters that you have typed so far. Slowly type in "exponentiation" to find out how to use the exp() function. Most of the help you will need will be looking up the syntax for functions. There is an  function insert button which gives you menus of functions with brief descriptions of each. Try this with the exp() function as well.

Numerical Calculations

Graphing

A spreadsheet program is useful for graphical analysis of data. Experimental data can be read into the program from file or you can create your own data to graph. In this case we will graph the function $x=Ae^{-bx}\sin(\omega t)$.


a) Create and label a column of about 50 numbers to be the range of times from 0 to 10 seconds. You may want to vary this time scale later, so designate a cell at the left side of the page to be "dt" and use absolute addressing to use this step size for your time column.

b) Create new labeled constant cells on the left for the angular frequency ω and for amplitude A. Next to the column of times create a column of giving " $Ae^{-bx}\sin(\omega t)$ ".

	t	Ae(-bx)sin(wt)	
dt=	0.05	0	0
A=	1	0.05	0.456043679
w=	10	0.1	0.761394433
b=	1	0.15	0.858551891

0.2 0.744469767

Follow the steps below to make a graph of the data in one column plotted against another column. Note that Excel always assigns the first column of values "x" and the columns to the right as "y's". You can change this later if you need to.

- a) Select the data that you want to graph, then click on the chart icon  at the top of the screen.
- b) A dialog box labeled ChartWizard appears. A sequence of dialog boxes will now begin. Choose an "xy scatter" plot and work your way through the dialog boxes. We will use a scatter plot without lines connecting the points for most of our work.
- c) Play around with the graphing controls to make your graph suitable for a lab report. Graphs should always have their axes labeled. You can record other parameters in the title of the graph.
- d) Play with the parameters in the function to understand how each parameter affects the graph.

Data fitting

Create a graph of the function $y=1+2*x +1*(\text{rand}()-0.5)$ from $x=0$ to 1 using about 10 points. This represents a straight line with some random "noise".

You can add x and y error bars by double-clicking on a data point and selecting the appropriate tab in the pop-up window. There are a variety of choices including "custom" which allows you to assign individual uncertainties to each data point. This is lovely because you can have Excel do the error propagation work for you.

There are several ways to fit a line to a collection of data. The simplest is to graph the data and have Excel add a trendline to the chart. "Add Trendline" is under the "Chart" menu. Make sure that you have Excel print the equation (under Add Trendline/Options) so that you know what the resultant values are. The problem with this method is that you don't know the uncertainty in your fit.

If the trendline option does not satisfy your fitting needs, you can also use the Phys 190 intro to LINEST (or use the online "HELP/Contents and Index"), an array function, and SOLVER, a general purpose fitting routine. Many data analysis programs have built in capabilities for fitting to common functions other than lines.

Maple

Maple is a symbolic manipulation program. We will use it for labs and for homework so make sure that you are confident about using it on your own. Try all of the examples below and play with the results until you understand them. Then answer the questions below.

The basics

Symbolic Logic:

Unlike Excel, most Maple manipulations are exact. If you type “=sqrt(3)” in Excel it will display 1.732050808. This is really just an approximation to the square root of 3 which is good enough in most cases. Excel uses 1.732050808 in all of its calculations. If you type “sqrt(3);” into Maple it will print “ $\sqrt{3}$ ”. This is certainly correct (if not always helpful!). Maple can also be asked to evaluate its answers and return a decimal approximation.

Syntax:

Maple is inherently a command line program, meaning that you type command lines at a prompt, and these commands are executed immediately. You can also write functions in Maple, but most of our work will not require this. Each command is followed by a semicolon, which tells Maple to execute the command and print the results. **Don’t forget the semicolon!** If you do forget a semicolon, it will print an error message (“Warning, premature end of input”) and stop. To start it going again simply type the missing semicolon to complete the command. *Extra: Maple accepts multi-line input. Maple doesn’t enter a command until you type the semicolon no matter how many lines you have used. Spaces are not read by Maple.*

Most commands take “arguments” which are parameters for the command. These arguments can be numbers such as 1,2, variables such as x,y, functions such as $1*x + y^2$ or equations such as $1*x + y^2 = 3$. Functions and equations use standard computer syntax and precedence. Use “*” for multiplication, “/” for division, “^” or “**” to raise to a power, “{ }” for grouping etc. Maple also includes the self explanatory functions sin(), sqrt(), exp(), and ln(), and the variables pi, infinity, true, and false. Maple also has a factorial, “!”, absolute value “abs()”, and a host of other built in functions.

Assigning Variables and Functions:

To assign a variable or function use “:=” as in “a := 3”. A function can be defined similarly:
`f:=1 + 3*x^2;`

Defined this way, the function is only a function of x. A simple equal sign, “=”, is used not to assign a variable, but rather to enter an equation as a unit. For instance, you can assign the complete equation “ $y = 1 + 3x^2$ ” to the variable eqn1 using

```
eqn1:=y=1+3*x^2;
```

The function defined above is only a function of x. If you want to define a function so that the user defines the independent variable, you really want to define a mapping from x to $1 + 3*x^2$. That can be done by assigning a mapping to “f” using
`f:= x->1+3*x^2;`

Now f(1) yields 4, f(z) yields $1+3*z^2$, etc.

Help:

If you type a command that Maple doesn't understand, then it will tell you what it doesn't understand. Simply retype the line correctly. If you don't know the proper syntax for a command you can get help on the Help menu. This provides a very convenient menu driven help page. You can go directly to help on a given topic. Find help on the syntax of the exponential function in Maple using the "Help/Topic Search" feature.

Maple As A Calculator:

The simplest commands for Maple mimic what you would type into a calculator. Try typing $3+4^{1.5}$;

into Maple. (Yawn!) You can set the answer to this equal to a variable using ":= " as in $a:=3+4^{1.5}$.

Maple will combine several assignments if you wish.

$f:=x+2$;

$x:=4$;

typing f ; results in the proper result, 6.

Substitutions:

You can substitute one expression into another. For example, you can use the `subs(subs,exp)` command to replace x with $\sin(wt)$ in the expression for the potential energy of a spring:

$PE:=\text{subs}(x=\sin(wt), (1/2)*k*x^2)$;

*Extra: You can make multiple substitutions if the first argument is a list of substitutions instead of a single substitution. $\text{subs}(\{a=2, b=3, c=3\}, a*x^2+b*x+c)$*

Numerical Approximations:

You can obtain a numerical approximation to a symbolic result using the `evalf(expr)` function. The floating point evaluation is not exact, but it may be easier to interpret than an exact result.

$\text{evalf}(\sin(3))$

Plotting:

Use the `plot(func,horiz.)` function to display your results over a given range. The range is indicated by two periods separating the limits of the range.

$\text{plot}(2+2*x+5*x^2, x = -1..3)$

You can plot several functions by enclosing them in curly brackets. You can specify the vertical range as a third argument.

Systems of Equations:

To solve a system of equations, simply enter them into `solve(expr,var)` or `fsolve(expr,var)`. `solve()` solves the equations symbolically, `fsolve()` solves them numerically using floating point operations. `Solve` takes a list of equations, and a list of variables to solve for. In the simplest case, you can give it one equation to solve for one variable.

$\text{solve}(y=2*x, x)$

You can also define lists of equations and variables using curly brackets.

$\text{solve}(\{y=2*x, 2*y+1=4\}, \{x,y\})$

Maple may give the exact answer in terms of a real root of a polynomial. In such cases you may want to use `fsolve` to find a numerical approximation for the solution.

$\text{solve}(y=2*x^2-\cos(x),x)$

Derivatives:

Maple has simple commands for derivatives and partial derivatives. The `diff(func,var)` command takes the derivative of a function with respect to the given variable.

`diff(2+x^3,x)`

is the derivative of $2+x^3$ with respect to x , or $\frac{d}{dx}(2+x^3)$.

`diff(2+x^3,x,x)`

is the derivative with respect to x twice, or $\frac{d^2}{dx^2}(2+x^3)$. *Extra:* `diff(2+y*x^3,x,y)` takes two

partial derivatives, or $\frac{d}{dy} \frac{d}{dx}(2+yx^3)$. *We will learn about partial derivatives later in this course.*

Integrals:

Maple can calculate indefinite and definite integrals with the `int(func,var)` command.

`int(1+x^2, x)`

gives the indefinite integral, and

`int(1+x^2,x=0..3)`

gives a definite integral. To find a numerical value for a definite integral use the `evalf()` function.

`evalf(int(1+x^2,x=0..3))`

Differential Equations:

Maple can solve differential equations symbolically, or numerically. For a symbolic solution, use `dsolve(eqn,var)`. For example,

`dsolve(diff(f(x),x,x)=0,f(x));`

solves the equation $\frac{d^2 f}{dx^2} = 0$ which has the solution $f = ax + b$.

Numerical work is more involved. Here is one example:

> `with(plots): with(DEtools);`

> `ODE := diff(w(t), t) + .05*w(t);`

> `SOL := dsolve({ODE,w(0)=5},w(t),type = numeric);`

`SOL := proc(x_rkf45) ... end proc`

> `odeplot(SOL,[t,w(t)]);`

This plots the solution of $\frac{dw}{dt} + 0.05w = 0$ with the initial condition $w(0)=5$.

Maple Reference Card

Assignment		A:=3 f:=1 + 3*x^2 f:= x->1+3*x^2
Syntax	Enters a command	;
	Groups eqns or variables	{ , , }
	A range of values	1..4
Substitution		subs(x=a,expr) subs(s1,...,sn,expr)
Numerical approximation		evalf(expression)
Plotting		plot(function, horizontal range) plot(function, horiz. range, vert. range) plot({function list}, horz. range...)
Systems of Equations		solve(equation, variable) solve({eqn1, eqn2,...}, {var1, var2...})
Derivatives	(single derivative)	diff(function, variable)
	(partial derivative)	diff(function, var1, var2..)
Integration	(indefinite)	int(function, variable)
	(definite)	int(function, variable=a..b)
Differential Equations (symbolic)		dsolve(diff.eq., y(x))