Before Starting:

- Plan on experimenting, and make extensive use of the Help menu. You can learn all sorts of cool things just by doing "topic searches". **Give Maple a chance!**
- In the beginning, using Maple's palettes and contextual (shortcut) menus is easy and helpful, so the *Getting Started* section focuses mainly on those.
- You may eventually decide it's easier to enter some expressions using the keyboard. Some are mentioned in *Getting Started* section; included in the on-line version of this is the section *Further Exploring Maple*, which contains additional tips and some of the most relevant commands for Multivariable Calculus.
- Always check Maple's output to make sure it's interpreted what you entered as meant it to.

What You'll See:

- There are two interfaces for Maple, *Worksheet* and *Document*. *Document* mode is probably easiest to learn with (although I don't use it). Go to **File - New - Document Mode.**
- There are also two types of input – *Math* and *Text*. *Math* is the default; click the *Text* button if you want to enter text.

Getting Started

- The many palettes on the left are handy templates for Maple's syntax, especially the **Expression** and **Common Symbols** palettes. Open a palette by clicking on the triangle next to its name.
- The templates will allow you to enter all the operations ($+$, $-$, $\times$, $\div$) as well as square roots, exponents, sines and cosines, logarithms, functions, derivatives, integrals, and summations. Enter specific values or variables by tabbing from one entry to the next.
- Some expressions you may find easier to enter using the keyboard :
  - $+$, $-$, $*$, / for addition, subtraction, multiplication, and division.
    Don't omit the $*$ when typing in something like $5x$ or $5x\cos(x)$. Sometimes, Maple knows what you mean, but other times it won't – and it won't give you an error, it will just ignore part of what you type (treating it as a long variable).
  - `^` for exponents
  - *Pi* for π.
    Maple is case-sensitive! `pi` is **not** the same as `Pi` ! In Maple, `pi` represents the Greek letter, while `Pi` is the number.
  - `exp(x)` for e^x; In Maple, `e` is a variable not a number.
  - `sqrt(x)` for $\sqrt{x}$.
- Contextual, or shortcut, menus are accessed by right-clicking (control-clicking, on a Mac) on an item you've entered. Different options will appear in the pop-up menu, depending on the context. For example, if you control-click on an expression like e^x, Maple will give you options to:

  Differentiate, Integrate, 2-D Plot, Evaluate at a point, Approximate, etc

  Experiment!
- Maple comes with many packages containing extra commands. In Multivariable Calculus, you may sometimes want to load the *Plots* package, or the *Student Vector Calculus* package.
  - The Vector Calculus package allows you to calculate the cross product, norm, and numerous other things.

  - The Plots package will allow you to plot 3D curves, plot implicitly defined curves or surfaces, display multiple plots that have been defined over different domains, plot polar curves, contour plots, and vector fields.
  - To load the Plots package (for instance), from the menu bar across the top of your screen, choose `Tools-Load Package - Plots`.
  - For more on these packages, see *Further Exploring Maple*, below.

- Maple prefers to deal with exact numbers, rather than approximations. Unless you tell it otherwise, it will produce results involving e, π, fractions, etc.

  For a decimal approximation,

  1. The simplest option is usually to add a decimal point: change (for example) `5` to `5.` in an expression, and Maple will return a decimal approximation of your calculation.
  2. You may also use the `evalf` command, by either.
     - enclosing the original command line with `evalf( )`.
     - In Maple, the `%` sign refers to the last result Maple calculated, so after receiving an exact answer, type in `evalf(%)`

- Over time, you will find that it is easier to enter some expressions using the keyboard rather than the palettes. A few handy ones are:

  - use the standard keys for addition, subtraction and division.
  - use `*` for multiplication.

    You may be tempted to omit the `*` when typing in something like $5x$ or $5\cos(x)$. Sometimes, Maple will be able to figure out what you mean, but in other situations, it will not. I therefore recommend that you just get in the habit of always typing in the `*`: otherwise in those situations where it turns out that Maple needs it, you may have a hard time figuring out what's gone wrong. You may not even know that something **has** gone wrong, as sometimes Maple simply treats everything as one long variable, and doesn't produce an error message.
  - use `^` for exponents
  - type *Pi* for π.

    Maple is case-sensitive! `pi` is **not** the same as `Pi` ! Whichever one you type, you will see the Greek letter, but whether it is representing a number or is acting as a variable will depend on what you type: `pi` represents the Greek letter, while `Pi` is the number.
  - enter `exp(x)` for e^x; Maple has allowed the letter `e` to represent a variable, so (similarly to the situation with π) if you enter `e^x` and hit enter, you'll see something that *looks* right, but Maple won't know you intend `e` to represent the irrational number.
  - enter `sqrt(x)` for $\sqrt{x}$.

Further Exploring Maple:

On the course website is a link to some Maple tutorials; although developed for an older version of Maple, you still might find them helpful.

On the next several pages are many of the commands we'll use, roughly organized by type.

If you're already familiar with Maple, and just want the commands specific to Multivariable Calculus, those are on the last two pages.

Command	Description
CONSTANTS:	
`Pi`	The constant π
`exp(1)`	The constant e
`sqrt(5)`	$\sqrt{5}$
`cos(Pi/4)`	$\cos(\pi/4)$
COMMON FUNCTIONS:	
`exp(x)`	The natural exponential e^x. For example, to get e^2, you would enter `exp(2)`.
`sqrt(45+sin(x))`	The expression $\sqrt{45+\sin(x)}$.
THE BASICS OF DEFINING FUNCTIONS AND ASSIGNING VALUES:	
`w := x^2 + 3*x`	Assigns w to be the *expression* x^2+3x. From that point on, whenever you use w, Maple will substitute x^2+3x.
`w:='w'`	Unassigns w. Now, w is just w.
`f := x -> x^3 + sin(x)`	Defines a *function* of one variable $f(x)=x^3+\sin(x)$.
`L:=[ [1,10], [2,5], [4,2]]`	Defines a list of points
`A:=matrix[ [2,3], [4,5] ]`	Defines a 2 x 2 matrix with top row consisting of 2 and 3, second row consisting of 4 and 5
`restart`	Clears all definitions and reinitializes Maple.
VARIOUS USEFUL COMMANDS:	
`value(3*sqrt(Pi))`	Returns the *exact* value (not a decimal approximation). `value( )` can be combined with other expressions like `Diff( )` to find a value.
`evalf(3*sqrt(Pi) )`	Returns a decimal approximation of $3\sqrt{\pi}$ using 10 significant digits. evalf stands for "evaluate to floating point".
`evalf(3*sqrt(Pi), 20)`	Returns a decimal approximation using 20 significant digits.
`%`	The output from the last executed statement.
`simplify( sin(x)^2 + cos(x)^2 )`	Simplifies the expression. In this case, the result is 1.
`solve(x^2+3*x+1)`	Solves the equation $x^2+3x+1=0$.
`solve(t*x^2+3*x*t+1, t)`	Solves the equation $tx^2+3xt+1=0$ for t.
THE BASICS OF GRAPHING:	
`plot(sin(x)+Pi/2, x=-2..Pi, color=blue)`	Generates a plot of $y=\sin(x)+\pi/2$ from $x=-2$ to $x=\pi$ in blue. You can leave out the color if you want.
`plot( [x^2, cos(x)], x=0..2*Pi, color=[blue,red])`	Plots the two functions $y=x^2$ and $y=\cos(x)$ on the same set of axes. The color is useful for distinguishing the plots.
`plot(L, x=0..5)`	If you have defined L to a list of points (see above) whose x coordinates are all between 0 and 5, this command will plot these points and draw lines connecting them.

Command	Description
Calculus I and II Commands:	
`Diff(x^3+sin(x), x)`	Returns the expression $\frac{d}{dx}(x^3+\sin(x))$. This allows you to check whether you've entered everything correctly.
`value(%)`	If you follow the command `Diff(x^3+sin(x),x)` immediately with the value command, it will return the derivative of $x^3+\sin(x)$ with respect to x.
`diff( x^3 + sin(x), x)`	Returns the derivative of $x^3+\sin(x)$ with respect to x, $3x^2+\cos(x)$. Once you feel comfortable both with Maple and with differentiation, you can use this command rather than the previous one.
`diff(f(x),x)`	Returns the derivative of a function you have already entered, see middle of page 2.
`diff(x^{3}+sin(x),x,x)`	Returns the second derivative of $x^3+\sin(x)$ with respect to x, $6x-\sin(x)$. You can also do second derivatives as above, where the expression is returned first, by simply capitalizing the "d" in `diff`.
`Int(x^3+sin(x),x)`	Returns the expression $\int x^3+\sin(x)\,dx$.
`value(%)`	If you follow the above command with this one, Maple will return the indefinite integral (i.e. the antiderivative) of $x^3+\sin(x)$.
`int( x^3 + sin(x), x)`	Returns the indefinite integral, or antiderivative, of $x^3+\sin(x)$, $\frac{1}{4}x^4-\cos(x)$.
`int(f(x),x)`	Returns the antiderivative (indefinite integral) of a function you've already entered (see middle of page 2).
`int(x^{3}+sin(x),x=2..5)`	Returns the definite integral of $x^3+\sin(x)$ from 2 to 5. If you capitalize the "i" in "int", it will return the expression $\int_2^5 x^3+\sin(x)\,dx$. To get the value, you would then enter `value(%)`.
`Sum( j^2, j=1..300)`	This creates the sum $\sum_{j=1}^{300} j^2$, but does not evaluate it. You'll need to use `value(%)` to get a numeric value.
`sum(j^{2}, j=1..300)`	This returns the value of the sum directly.

Command	Description
Calculus Graphing Commands:	
`Tools -Load Package-` `Student Calculus 1`	Loads the `student` package. You must load this package before you can use `RiemannSum( )`, command.

`RiemannSum(x^2, x=0..3,`
`partition=10, method=left,`
`output=sum)`
	Generates the leftsum approximation of $\int_0^3 x^2\ dx$ using 10 equal subintervals. You need to use `evalf( )` to get the decimal approximation.
	Replace "left" with "right" or "middle", and "sum" with "plot" or even "animation".

`Tools-Load Package- Plots`	Loads the `plots` package. You must load this package before you can use the `display` or `tubeplot()` command.

`plot1:=plot3d(7-x^2/9+y^2/16,`
`x=-5..5,y=-5..5):`
`plot2:=plot3d(x+y/2+3,x=-5..5,`
`y=-3..4):`
`display(plot1,plot2);`
	Allows you to display multiple plots structures (that may have been defined over different domains) on the same set of axes. Notice the colon at the end of the first two lines, to suppress the output from these commands.

`tubeplot( [x, 0, 0], x=0..4*Pi,` `radius =sin(x)+ 2)`	This will draw the surface obtained by rotating the graph of $y = \sin(x) + 2$ about the x-axis from $x = 0$ to $x = 4\pi$. For all of our plots, you should not change the `[x,0,0]` part of the command.

Multivariable Calculus Commands:	
`<1,2,3>`	The vector $< 1, 2, 3 >$.
`f := (x,y) -> 3*x^2 + 2*x*y`	Defines a function of *two* variables
`Diff(3*x^2+2*x*y,x)'`	Returns the expression $\frac{\partial}{\partial x}(3x^2 - 2xy)$ so you can check if you've entered everything correctly. To actually find what the partial derivative with respect to x *is*, you can follow up with `value(%)`.
`diff(3x^2+2*x*y,x)'`	Using the lower case d in *diff* tells Maple to actually find the partial deriviative, just as is true with derivatives of functions in one variable.
`Tools-Load Package-` `Student Vector Calculus`	Loads the commands in the Student Vector Calculus program. This allows you to find the cross product, norm, and numerous other things – if you want to see the commands, click on the link *StudentVectorCalculus* after loading the package.
`<1,2,3>.<4,5,6>`	Returns the dot product of $< 1, 2, 3 >$ and $< 4, 5, 6 >$. You can also use the commands `DotProd(<1,2,3>,<4,5,6>)` and `DotProduct(<1,2,3>,<4,5,6>)`.
`<1,2,3>&x<4,5,6>`	Returns the cross product of $< 1, 2, 3 >$ and $< 4, 5, 6 >$. You can also use `CrossProd(<1,2,3>,<4,5,6>)` or `CrossProduct(<1,2,3>,<4,5,6>)`.

Command	Description
Multivariable Graphing Commands:	
`plot3d(x^2-cos(y), x=-5..5, y=-7..7);`	Generates a graph of the surface $z = x^2 - cos(y)$ over the domain $-5 \leq x \leq 5$ and $-7 \leq y \leq 7$.
`plot([cos(t),t^3, t=-2..2]);`	Graphs the 2D parametric curve defined by $x = \cos(t)$, $y = t^3$. (To plot a 3D parametric curve, see `spacecurve` below.) After the square brackets, you can add in `x=-3..3, y=-2..5` if you like. **Note:** placing the range for t inside the square brackets graphs the parametric curve; placing it outside the square brackets plots the two functions $\cos(t)$ and t^3 on the same axes.
`plot3d([s*t, s^2*t^3,cos(s)], s=-2..2, t=-4..4);`	Produces a graph of a parametric surface.
`Tools -Load Package-Plots`	The plots package allows you to use the commands below.
`spacecurve([sin(t),-3*cos(t),2*t], t=0..30);`	Plots a parametric curve in 3D, without any axes. Add the axes by including the `axes=normal` option. (For other options, see `plot3d[options]` in Maple help.) Maple only plots and connects 625 points, which may not be enough. For more points, try `numpoints=2000`.
`implicitplot(x^2-y^2/9=1, x=-10..10, y=-4..4);`	Returns a 2D plot of this implicitly defined curve. Notice that you must give bounds for both x and y. To change the colors, the tickmarks on the axes, or anything else, investigate `plot[options]` in Maple Help.
`implicitplot3d(x^2+y^2/9+z^2/4=1, =-2..2, y=-4..4,z=-2..2);`	Returns a 3D plot of this implicitly defined surface – without any axes. To add axes, change the color, etc, investigate `plot3d[options]` in Maple Help.

`plot1:=plot3d(7-x^2/9+y^2/16, x=-5..5,y=-5..5):`
`plot2:=plot3d(x+y/2+3,x=-5..5, y=-3..4):`
`display(plot1,plot2);`
	Allows you to display multiple plots structures (that may have been defined over different domains) on the same set of axes. Notice the colon at the end of the first two lines, to suppress the output from these commands.

`polarplot(sin(2*theta), theta=0..2*Pi);`	Generates a graph of the polar equation $r = \sin(2\theta)$, $0 \leq \theta \leq 2\pi$.
`contourplot(x^2-y^2,x=-5..5, y=-5..5);`	Returns a contour plot of the surface $z = x^2 - y^2$. Try the `filled=true` and/or `coloring=[blue,red]` options.
`densityplot(x^2-y^2,x=-5..5, y=-5..5);`	Generates a density plot of the surface $z = x^2 - y^2$. Try the options `colorstyle=HUE`, `style=PATCHNOGRID`, and `grid=[100,100]`Be careful not to make the grid too big.
`fieldplot([[x-y,2*x], x=-5..5, y=-5..5);`	Generates a graph of the vector field $f(x,y) =< x - y, 2x >$. Control how many vectors are graphed with `grid=[10,10]`. Change the color with `color=red`, and control how bold the arrows look with `fieldstrength=maximal(2)`.
`gradplot(x^2-y^2, x=-5..5, y=-5..5);`	Returns a gradient vector field.