The first thing to remember about Maple is this: Experiment, and make copious use of the Help menu! You can learn all sorts of cool things just by doing "topic searches". **Give Maple a chance:** The way you learn it is just by diving in. By the end of the course, if you give it a chance, you can really know your way around Maple.

If you'd like to install Maple on your own computer, you can do so for the semester, as long as your computer is connected (wirelessly is fine) to the campus network and you have a sufficiently recent operating system. Instructions for installing it on either a Mac or a Windows PC are available through the course web page.

What You'll See:

- Depending on how the computer you're working on is set up, when you open Maple, it may present you with a new file in *Document Mode* or in Worksheet Mode. The computers in A102 and the computer lab (and possibly those scattered around campus that run Maple) are set to work in *Worksheet Mode*. If you install Maple on your own computer, the default interface is *Document Mode*. Experiment with the two formats, and decide which you prefer. To change from one mode to the other for just one file, go to `File - New  - Document Mode` or `File - New - Worksheet Mode`. Experiment to get a feel for what you like better.

  Once you download Maple onto your own computer (if you do), you will have some choices on how to set it up. Go to Maple 13-Preferences (mac) or Tools-Options (pc) if you'd like to change the default mode to Worksheet Mode, and also to choose whether as you type, the input gets converted straightaway to mathematical notation or looks just the same as how you type it. Change the mode by going to the interface tab; change the input display by going to the display tab.

- In either format, there are two types of input – mathematical commands and text. Unless you choose to enter text, you'll be entering mathematical commands. You can switch between them by choosing the button text or math (these buttons are located a bit above the main input window, but below the menu bar that scrolls across the entire Maple window).

- If you choose to use worksheet mode, then to execute your commands, you need to end each command with a semi-colon or a colon, then hit *return.*. A semi-colon displays the result, a colon suppresses the result.

Getting Started

- There are many palettes available on the left side of the Maple window. You can open (or close) one by clicking on the triangle next to its name. The *Expression* palette, and perhaps also the *Common Symbols* palette, will be especially useful for Calculus 2: by clicking on your choice, you can enter all the operations (addition, subtraction, multiplication, division) as well as square roots, exponents, sines and cosines, logarithms, functions, derivatives, integrals, and summations. You can then enter all your specifics by tabbing from one entry to the next.

- 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 $\sqrt{x}$.

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

  For example, suppose you want to find $\int_1^5 \frac{1}{x}\,dx$. If, using the expression palette, or typing on the keyboard, you tell it to evaluate this, it will give you `ln(5)`. This is the exact answer, but if you were evaluating this integral because you need to know volume or position, you may want an approximation.

  In this case, you have three options:

  1. In many cases, the simplest option is to add a decimal point: change (for example) `5` to `5.`, and Maple will return the approximation for you.
  2. You may also use the `evalf` command, in one of two ways.
     - Go back to your original command line and enclose your command with `evalf( )`.
     - In Maple, the `%` sign refers to the last result Maple calculated, So you can simply type in `evalf(%)`

- 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 to options to:

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

  Experiment!

- There are also packages you can load to access more commands: we will particularly be using the *Plots* package. To load this (or any other) package, from the menu bar across the top of your screen choose

  `Tools-Load Package - Plots`.

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.

Calculus Graphing Commands:

Command	Description
`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.
`with(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.