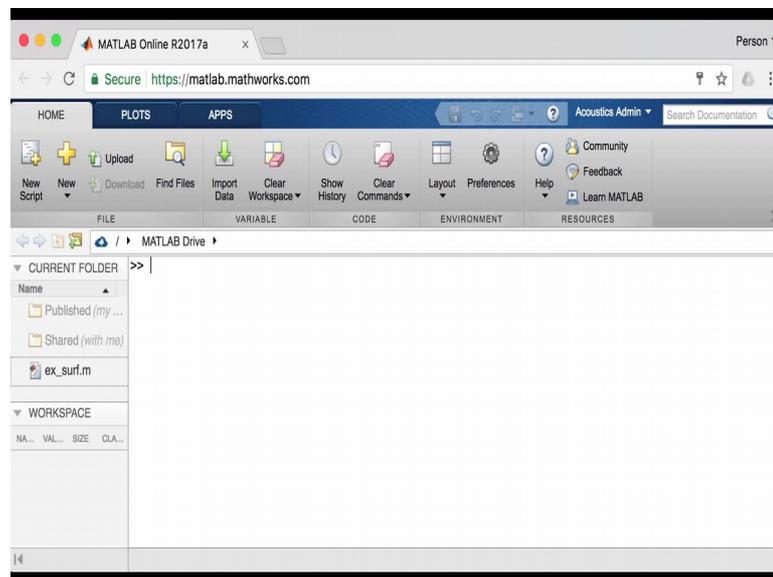


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**Lecture – 41**  
**MATLAB Tutorial - 3**

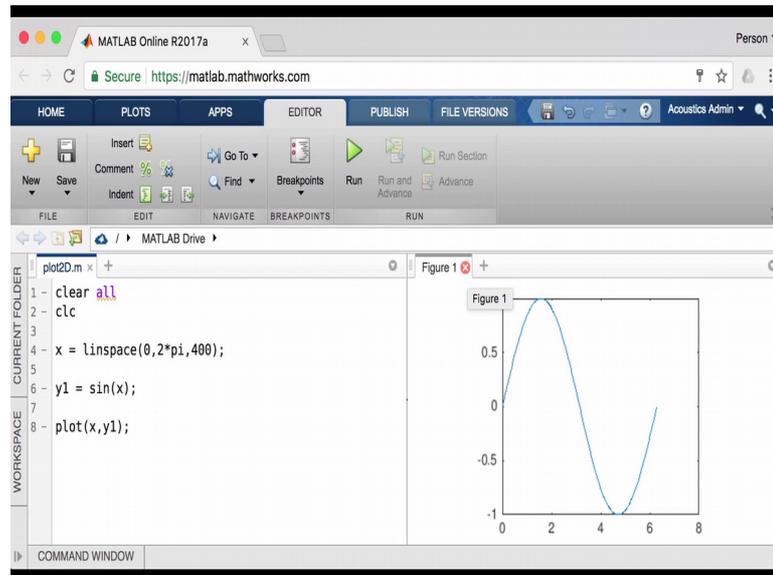
Welcome to the third tutorial.

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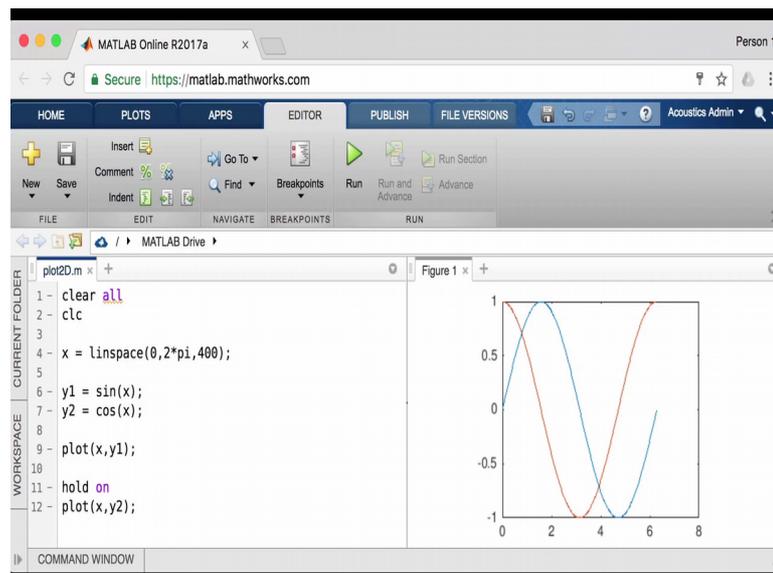
In this tutorial we will see the graphics package of MATLAB. It is often said that a picture is worth a 1000 words or in our case it is better than a huge matrix of numbers, but the picture needs to be illustrated properly. Out of many options that MATLAB provides for graphing the simplest for 2 d plotting is the command plot. We just have to provide 2 vectors of equal length and MATLAB will plot one versus the other. The resulting plot can be and should be improved. So, that it can be easily interpreted let us say we have to plot 2 functions for example  $\cos x$  and  $\sin x$  in the same axis. So, let us write a script for that let us name our script plot 2 D.

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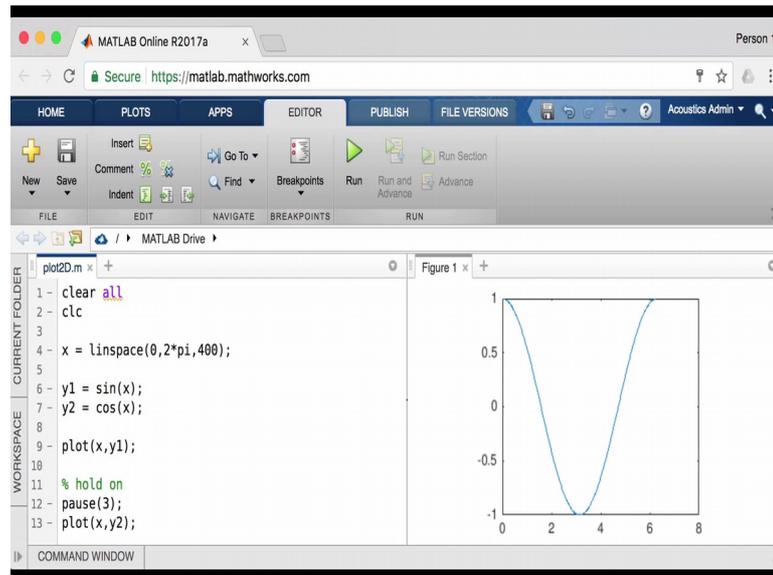
We now will define our domain for the independent coordinate  $x$  to be  $\text{linspace}(0, 2\pi, 400)$  then 400 division, and let our  $\sin x$  and  $y = 1$ . Now to plot  $\sin x$  will just write  $\text{plot}(x, y1)$  let us save the file and run. So, as you can see here MATLAB is plotted  $\sin x$  up to  $2\pi$ . Now if we want to plot  $\cos x$  in the same axis we need to use `hold on` on this `hold on` command will tell MATLAB to retain the previous plot while plotting a new graph in the same axis.

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Let us try it y 2 is for cos x and we will use hold on plot x comma y 2, again same and let us plot it. As you can see MATLAB has plotted the 2 figures in the same axis if you miss this hold on MATLAB will replace the previous figure with the latest one, we will then pause our script for three seconds to see what is happening, let us save the program and run.

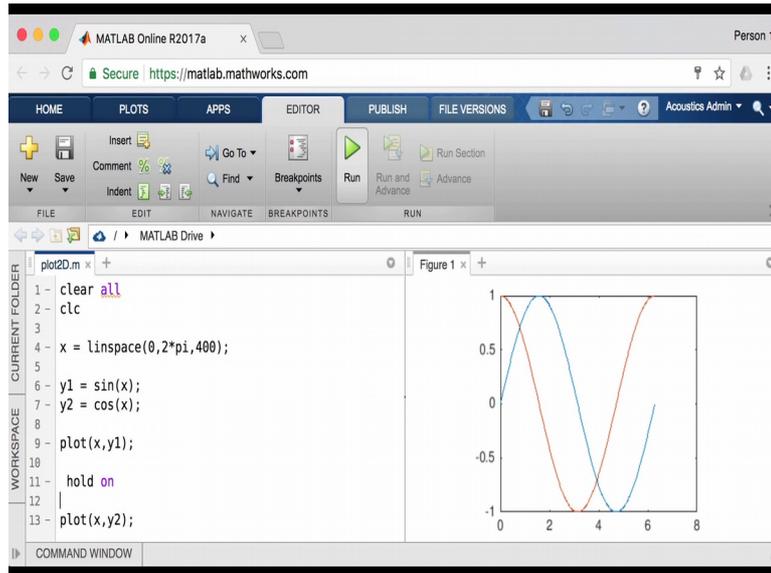
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As you can see here MATLAB first plots y 1 then replaces y 1 with y 2 as we miss the hold on.

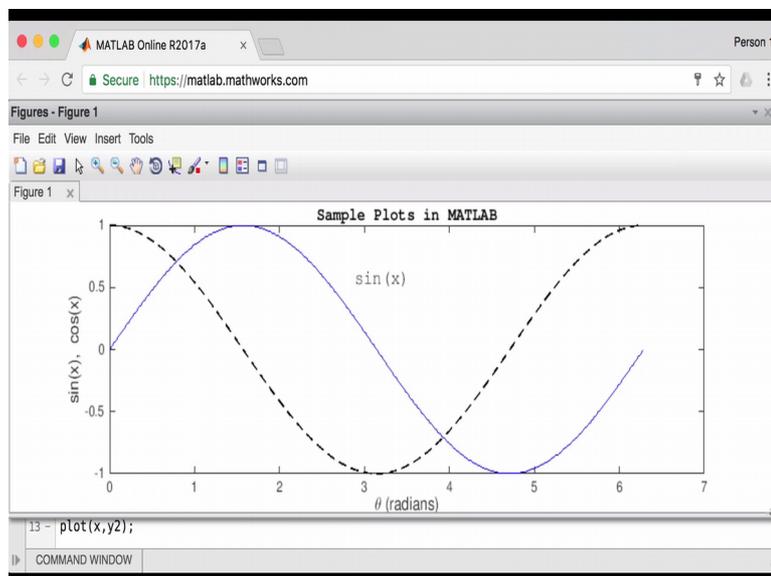
So, when plotting 2 or more graphs in the same axis we should use hold on let us run our code again.

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As you can see these plots look 2 planes. So, let us improve our plots first we will see how to edit the plots using figure editor. Let us do it in stages first we will label the axis give title to our plot indicate which is cos and which is sin. So, for that let us maximize the figure and go to edit plot double click on axis.

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And now we have to mention x level our x axis represents data in radian. So, let us display theta Greek symbol theta instead of writing theta the units are radian, and then y axis is sin x and cos x, we can insert title from here also title for our plot is sample plots in MATLAB.

Now, to indicate which curve is sin and which is cos we can use legend, will go to insert and insert legend. So, it will give me an identifier to indicate which data represents cos and which data represents sin. So, here we double click it and the blue line represents sin and other line represents cos. So, this is what the plot will look like after we improve it in the first stage. In the next stage we will change the appearance of the graph so as to differentiate the 2 graphs easily; here both the graphs are represented by continuous lines.

So, let us change the line style of one of them to dash. So, let us again go to the figure editor, here you can see line which represents the line style, here we will select dash and then as you can see the appearance of cosine has changed from continuous to dash and so is the entry updated in the legend. Now let us add finishing touches to the graph so that it can be presented in a nice way and can be easily read. For that we can increase the line width let us say as you can see here the line width is 0.5.

So, let us make it 1.1, let us make it 1.2, let us change the colour from red to black and let us change this colour to blue, let us increase the font size of these axis. So, that it can be easily read. So, we can do that here select the y label, let change the font to monospaced and we can increase the font size, similarly with x axis and title. As you can see we have improved the appearance of the plot and now we can save them. Before saving let us improve the resolution of the plots. So, there we do that by going to file export setup will go to rendering to resolution let us set it to 3500 and we applied to figure and ok.

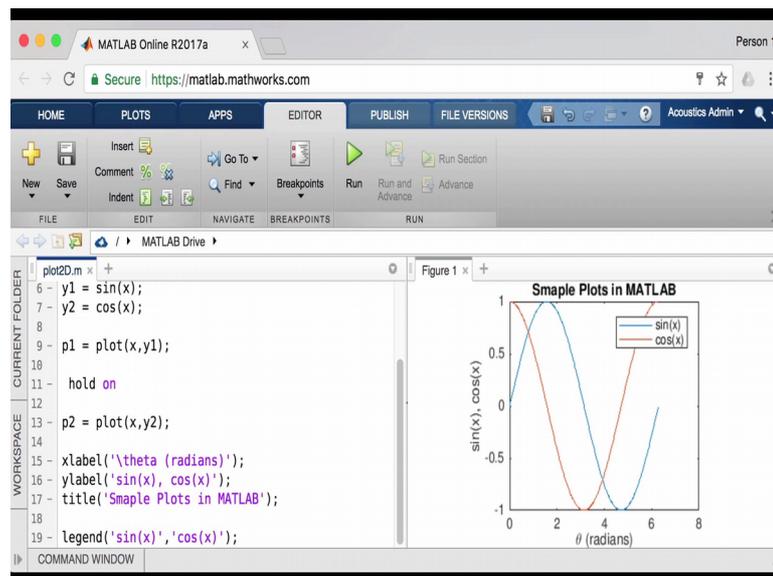
Now, we can save our figure, sample plot one and save. As you can see that plot figure has appeared in the current folder. So, if we want to edit that plot further we can just open this fig file and continue editing. So, let us do it we can double click on it to open and suppose I want to mention the identifier sin and cos near the curves and not in legend. So, first let us hide the legend then we go to insert text box, let us say we will enter sin first sin x let us edit it.

So, we go to text box we select the lines as none, alinement center we will change the font and the font size similarly we can do it for cos x. Every time we run a MATLAB script using plot, MATLAB will give us a plane figure and we will have to go through the entire process each and every time. There is a way by which we can edit the plot

directly from the script, we can do that using handles. When we want to edit a particular line in figure we should be able to tell MATLAB to edit that particular line and not any other. So, how do we do this? We will use something called handle, creates a reference for that particular object we can access the properties of that object using its handle.

So, how do we use it? Let us editor previous plots using handles. So, even will serve as the handle to the plot y 1, let us see what p 1 stores let us combine this save and run these are all the properties of y 1 that we can access through p 1 let us plot y 2 and edit our plots step by step from the script p 2 will store handles to plot y 2. So, now we will label our x axis y axis and give our figure a title. To label x axis we write x label theta bracket radian y label its sin x and cos x for title we say sample plots in MATLAB then we can even add legend from here legend sin x since we are plotting sin x first then cos x and let us do it.

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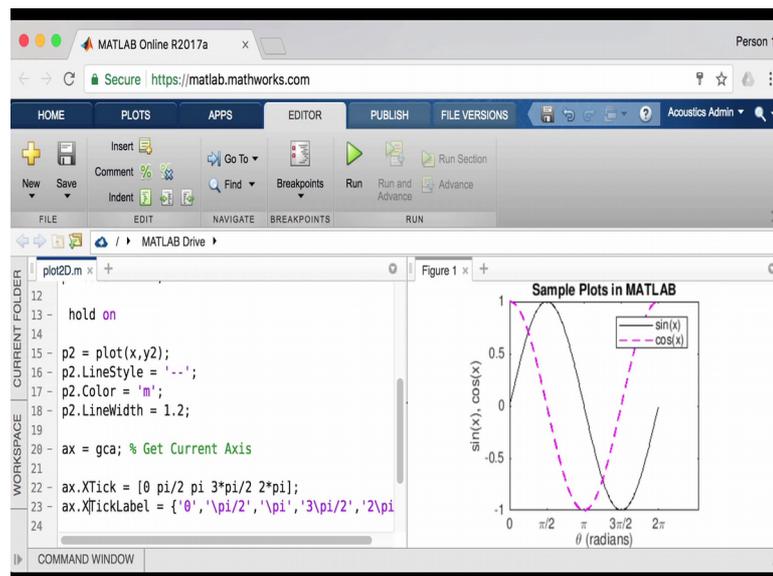


So, as you can see it here our plot has a legend which we can move around, it has a title and it is a typo it has x label it has y label let us correct. Now we will go to the next step where we change the appearance of the 2 graphs. So, to change line width of p 1 the syntax is p 1 dot line width let us set it 1.2 let us change the colour also. So, p 1 dot colour let us make it black, the shortcut for black is k in MATLAB, let us make p 2 a dash line line style dash let us change colour of p 2 to magenta m and now line width p 2 dot line width is 1.2. So, let us run it.

So, as you see we have again improved the appearance, the continuous line represent sin and the dotted line represents the cos. Now we would like to have our x axis in terms of multiple of pi instead of integers. So, let us see how to do it? Let us close the figure for that we will get the handles to the current axis by gca, gca will give me get current axis. Now gax has handles to gca, now we want our x labels to appear at the following positions. So, x dot x tick we want 0 then we want pi by 2, then we want pi now let us save and run the code and let us see how our x axis looks.

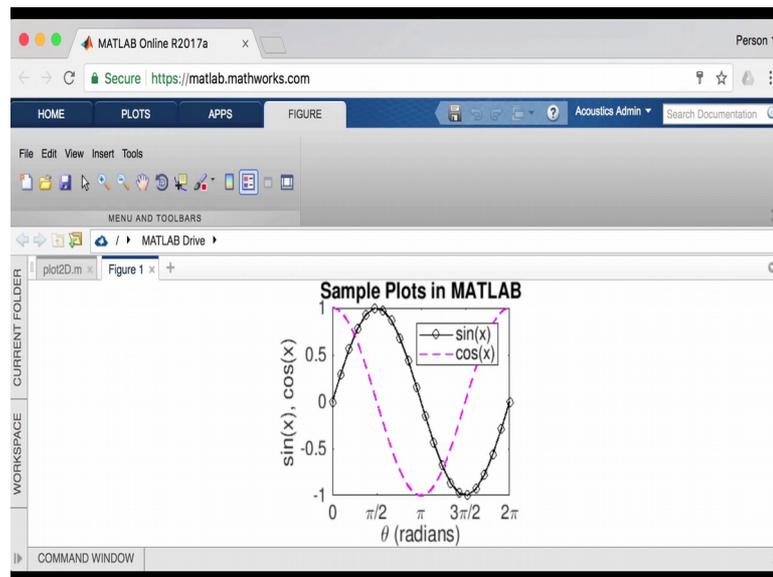
As you can see MATLAB has printed that fraction values of pi, pi by 2 and all instead of that we want MATLAB to show Greek symbol pi and its multiples. To tell MATLAB that we have to create something called a cell array we will say x tick label to be we have to enclose to curly bracket and we have to give the input as strings. So, 0 then pi by 2 then pi saving the program and let us run missed the x here. So, save the program and run it.

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So, as you can see MATLAB has replaced the fraction values by the symbol pi, we can improve it further by increasing the font size let us say x dot font size equal to 12 or let us say 14. So, as you can see MATLAB has made these changes, we can eliminate this wide space by setting the limit to x axis to set limit to access. We say axis parentheses we have to give the limits as a vector and the syntax is x minimum which is 0, then x maximum and which is 2 pi then y minimum which is minus 1 and y maximum which is 1. So, we will again run the code and see.

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So, now it looks better; one more thing which we can do is we can remove this legend and put identifiers close to the curve as we did previously, for that we will use a function called `gtext`. So, let us comment our legend and so, `g(1)` means the handle tool `gtext` `sin(x)` and `g(2)` is `gtext` `cos(x)`. Let us set the property `fontSize` to be 13 same with `g(2)`, let us save the program and run it. So, what `g(2)` will do is that, it will give me a cursor with which I can place the texts wherever I like. So, first is `fontSize`. So, let us put this text here next it will ask for `cos(x)` let us put it here.

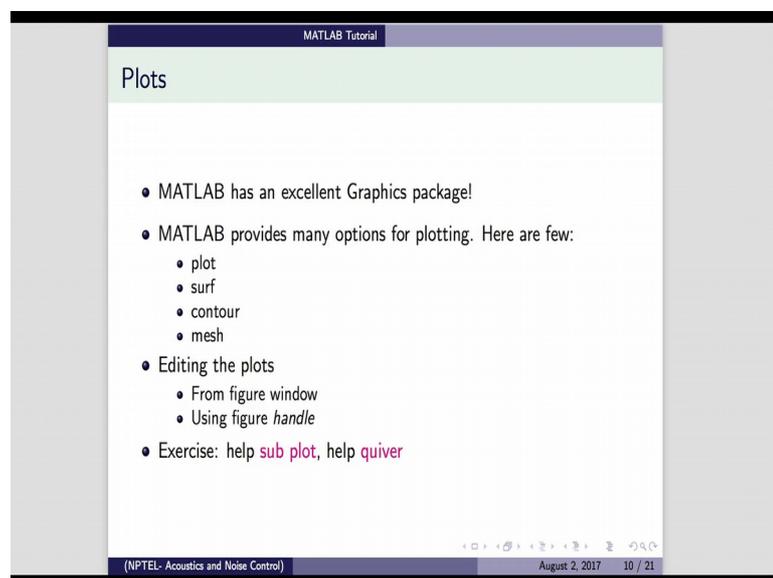
Let us add some markers on the `sin`, to display markers over the plot we write let us comment `gtext` again and uncomment legend now, to marker right `p1` dot marker hash circle. There are so many different types of markers which you can look in the MATLAB documentation; here we will use a circle. So, let us see. So, as you can see the plot is covered with circles, this is due to the fact that our vector is of size `1 x 400`, but we do not want these many markers.

We want certain gap between 2 markers; let us say they appear after every 19 elements in `x`. So, we will define a vector `gap` and it starts from 1 with increment of 19 up to the length of vector `x`. Now we do not want to plot the entire `y(1)` vector, we just want to plot the selected elements in `y(1)` and that selection is governed by the vector `gap`. So, we will just plot elements in `y(1)` which corresponds to the values in `gap`, then we will say our

marker is a circle and let us change the marker to continuous and this time let us make cos as dashed line let us save the file and run.

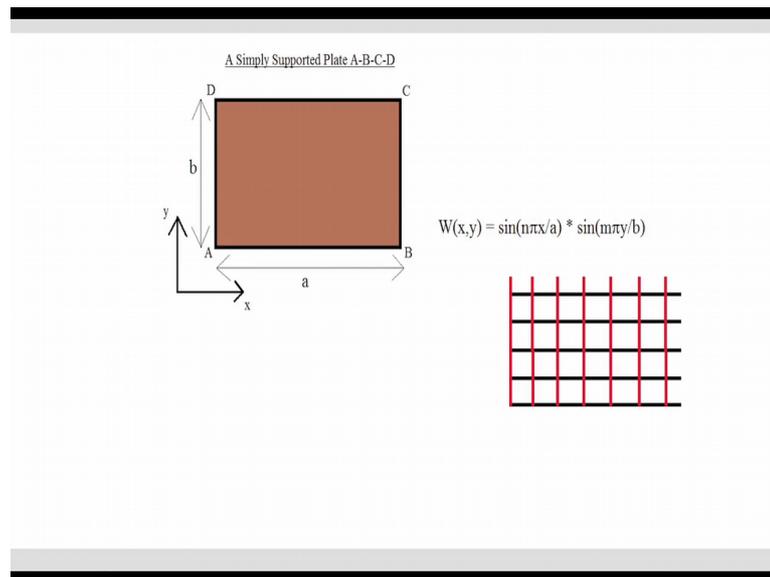
Looks pretty right figures, in MATLAB actually go a long way they represent your results in presentations reports etcetera. So, presenting a figure in a better way is as important as plotting the figure. The job does not end with plot, but we must spend some time and effort in enhancing them so that a third person can interpret and understand them easily.

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So, we just saw the 2 D plotting option available in MATLAB. So, we will now see surface plot, for that we will take example of plotting the mode shape of plates let us first see the geometry of the plate.

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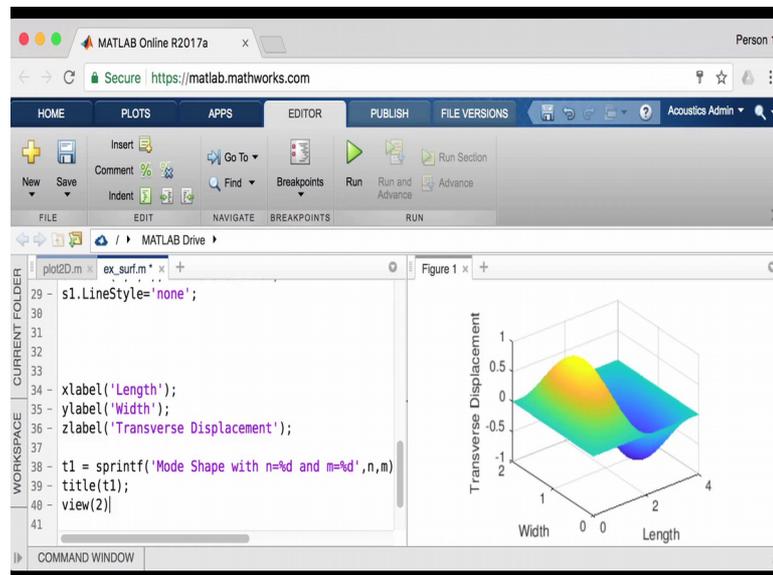
This is our plate a b c d which is simply supported on all the four sides, in the mode shape is given by multiplication of 2 sin functions one along the x direction and one along the y direction. To plot surface we will need the values of W over the area of the plate. The strategy which we will follow for this is first we will create 2 vectors along x and y we already have a file saved let us look at that. So, describe will plot mode shapes of a simply supported plate using surf. So, first we define the length of the plate and the width of the plate.

This is the length and this is the width, then we set the mode shape number m and n after that we create 2 vectors x and y as the first step in our strategy, x is discretized from 0 to a in 400 parts, similarly y is discretized from 0 to b into 400 parts. We will now create a grid or mesh over the plate using mesh grid what it does that suppose I have these 2 vectors let us say this is x and y and this is the plate. So, if I am using mesh grid it will create 2 matrices; one will contain a rows of x and other will contain columns of y.

So, that if we use array multiplication, we will get each and every point in the domain let us see an example. So, suppose have vector x which goes from 1 2 3 and y goes from 4 5 and 6. Now if I use mesh grid let us store the x matrix from capital X and column matrix in a capital Y and mesh grid x comma y. So, as you can see x contains rows of x and y contains columns, and if I do and array multiplication what I will get is each point in this matrix.

Let us get back to our editor x 1 contains the information about the mode shape in x direction, and y 1 contains the information about the mode shapes in the y direction to obtain z we use array multiplication let us set the program and let us run it.

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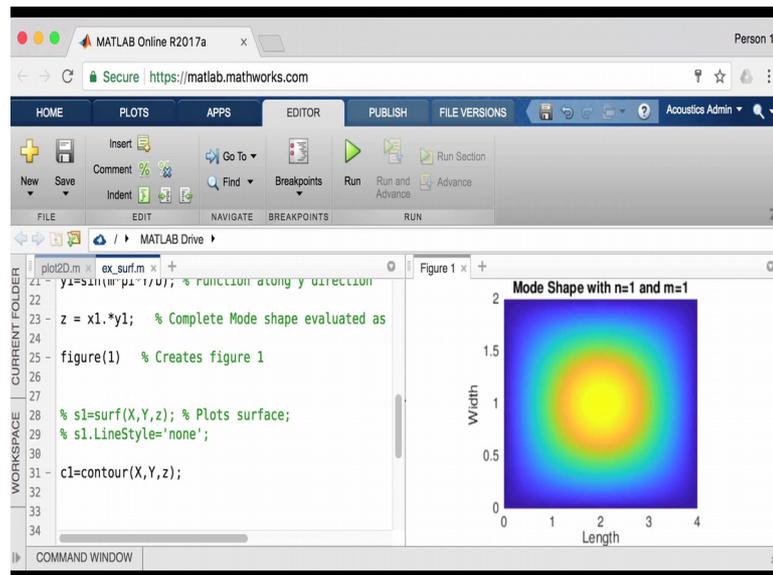
So, we got a plot, but it is completely dark, this is due to the fact that we have a very fine grade you remember our x and y are 400 and 400. So, z is of size 400 cross 400, that is why to see the actual plot we will set the line style to none. So, the handle to surface is s one dot line style, which we will set to none let us save it and run it.

So, as you can see here according to the displacement of each point MATLAB has colored the plot, we can add our usual information regarding x label y label and z label. So, x is the length y is the width and z direction represents the transfers displacement, and let us change our n to 2 and let us see what happens. So, as you can see we get a figure in which along the x axis we have a behaviour like  $\sin 2 \pi x$  by a, and along y axis along the width where m is 1 we have a behaviour similar to  $\sin 5 x$  by a. So, now, if you want to print our title and title should show what is the value of n and what is the value of m. So, for that we will use this new function s print f. S print f will create a string which we can use as a title.

Similar to print f if you remember where we use the format specification percent d for integers, here also we will use percent d and percent d to input the values of n and m at particular locations in the string. So, currently our n is 2 and m is 1. So, we create a

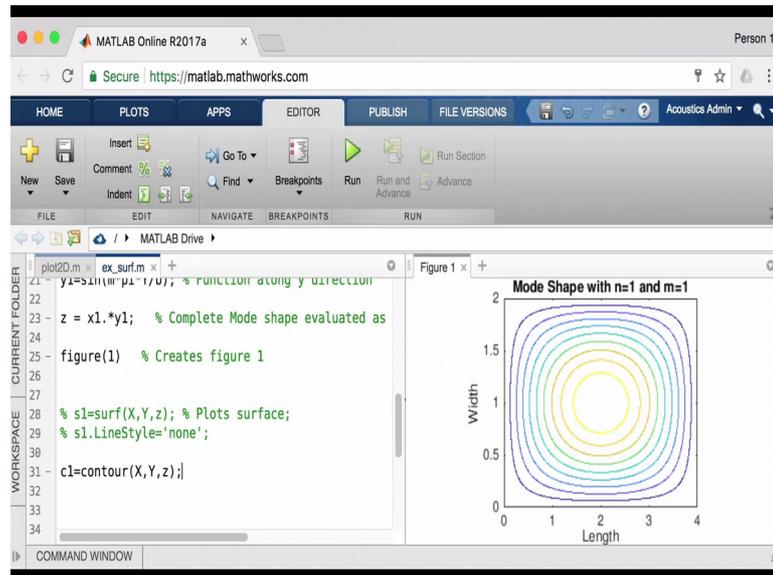
string and store it in t 1 then we tell MATLAB to use this t 1 as the title. If you see this figure it is an alpha matrix u. Suppose I want to look it from the top view for that we have to use the command view 2 view 2 will tell MATLAB to display the surface plot in a top view. So, let us see how it looks like.

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In this way it is much more clear that a long length side I have behaviour like  $\sin 2\pi$  and n is 2 and along width behaviour is like  $\sin \pi x$  by b and n is 1. We can change m to 2 and let us run it again, in this case you can see MATLAB has plotted the figure and title with necessary changes. Now we will move on to contour plot. So, what it does is it plots locus of points which are at the same value of z that is they have same height from the base. If we look at our one mode shape, we can observe that certain points can be connected by a curve and those points are at the same transverse displacement. So, in order to see it in forms of lines, we will replace surf with a contour. So, c 1 will be the handle contour x comma y comma z and let us set the figure, let us save the file close the figure and let us run it.

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So, as you can see MATLAB is given me a locus of points which are at the same distance from the base or which have the same transfers displacement. Now if we want to view the surface plot and contour plot side by side in the same window, but in different axis we can use subplot. So, let us see how to use it, let us uncomment surf to tell MATLAB we are using subplot we begin with writing subplot. Now this n and m this first 2 numbers indicate the size of the matrix. So, in this case we have 2 figures and we can either place them side by side in one line or vertically one below the other.

So, either we will we can have a matrix of size 1 cross 2, that is 1 row and 2 columns or 2 rows and 1 columns. So, let us place them side by side for that we will tell MATLAB the size is 1 row 2 column, and the first figure will be the surf and the next figure again we had mentioned subplot. The next figure in that 1 by 2 matrix will be contour you can adjust the size of the figure for better viewing we have seen 2 d plotting option plot we have seen three d plotting option or surface plotting option surf contour we have seen how to edit the plots from the figure window using figure editor.

Then we have edited the same figure using handles from the script then we also have seen how to use subplot there are 2 more interesting plotting options one is quiver, other one is stem I would request you to search for quiver plots and stem plots in MATLAB help here we are concluded tutorial for plots, in the next tutorial you will see about loops vectorization and finally, animation.

Thank you.