**Machinery Fault Diagnosis and Signal Processing**
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Lecture – 21
Introduction to MATLAB

Well in this week we are going to spend most of our time on practicing signal processing. And to do that I have a software MATLAB know, this MATLAB is very popular amongst students in the institutes and the universities, and we are going to use MATLAB for certain basic signal processing and we will see that you know in the future and of students or practitioners use certain softwares which are already developed for doing the signal analysis.

And of course, I had told you during the data acquisition that there are some commercial software like lobby etcetera which are used for data occasion, and control of the hardware devices. But now in MATLAB what we have when we have the numbers already acquired and stored in the memory of a computer how we can do certain analysis. Excel, Microsoft excel is one another example wherein we work on the stored data, but in this class I am going to introduce you to MATLAB where every number is actually treated as a matrix.

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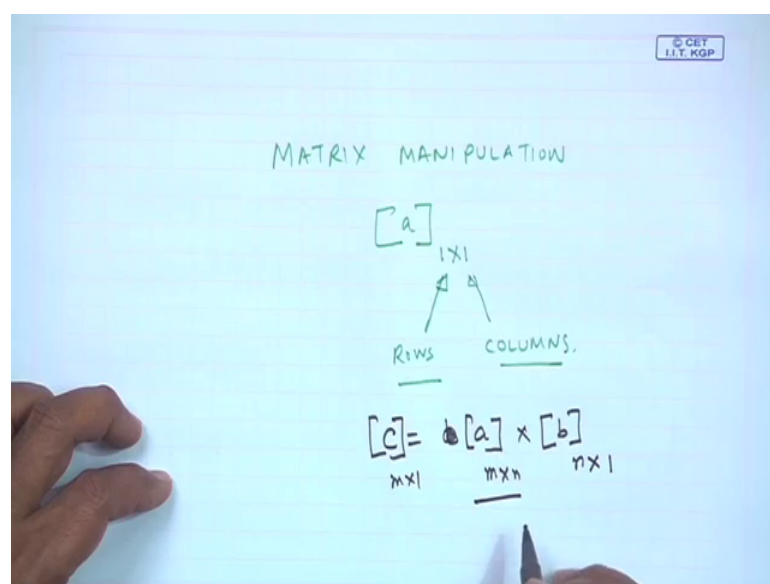
And so, basically this is all matrix manipulation and even suppose I have one character this is 1 by 1, this is number of rows and this is number of columns. So, certain rows and columns are to be used, and then I can have matrix of many row and columns and so on. And I can treat these numbers accordingly.

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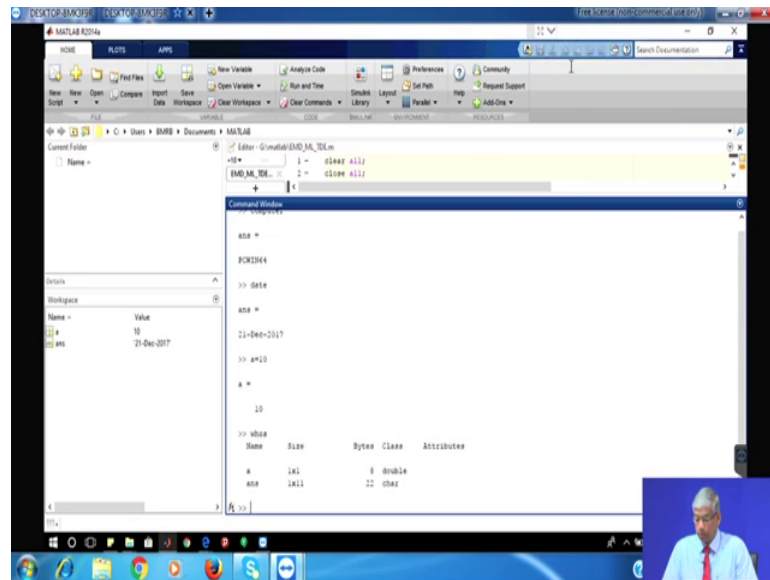
Now to invoke MATLAB what we do is or not come here to the software where in I have already opened up MATLAB you will see few windows, and actually well be working on this command window wherein we will be doing some.

For example once MATLAB is there you can try certain command like computer. It is this means this is an windows 64 bit system PC windows 64. So, commands like date 21 December 2017 is today's date, I could do a quit and then I can come out I will not do quit right now and so on. So for example, if I give a variable a is equal to 10 it means that a is equal to 10.

So, if I go to the memory of the MATLAB I can see do a command whose, and you see a is a 1 by 1 matrix with which requires 8 bits of data, and then a double class and so on. So, because it is a 64 bit machine each data equals to 8 bit and so on, because 8 times 8 is 64.

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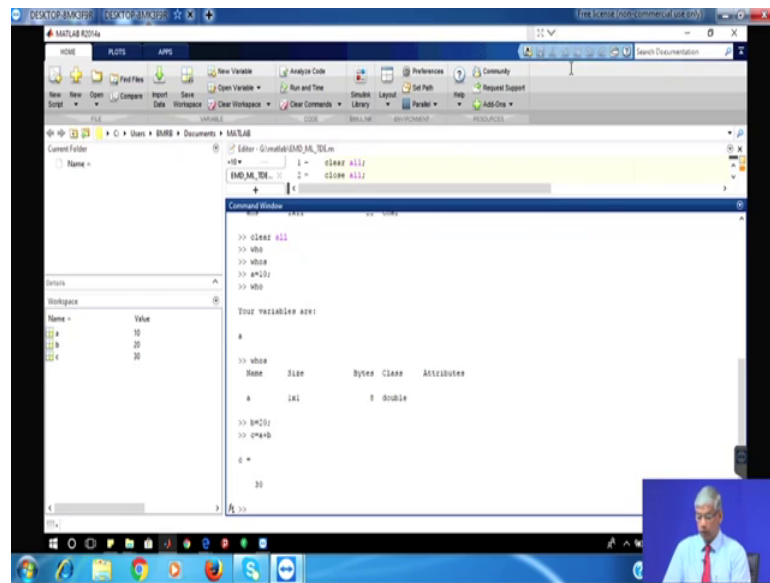
So, I can clear everything in the memory so, clear all and if I do who it shows nothing if I do whose. So, is nothing now again if I type a is equal to 10 yes, and then and do a who it will tell me that the variable currently stored in the memory of the system is a it does not tell me anything of regarding their dimensions. If I do a whose it tell me that it is a 1 by 1 matrix.

So, similarly I can store up different values so, b is equal to 10 or 20. So, if I do c is equal to a plus b it just adds up and does a 30.

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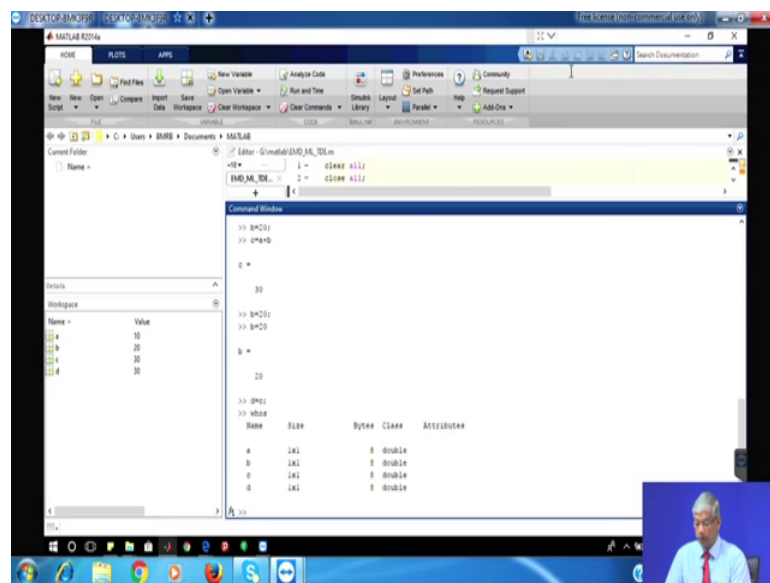
Now that is always a command I am giving b is equal to say 20. if I put a semicolon it will not prompt me the value of b and then this 20 is already stored into the variable name b, but if I beat the b is equal to 20 and do not give any semicolon it will prompt me the value of b. So, it is up to an user how you want to do it. So, we just saw how easily 2 numbers are up where c is equal to a plus b I can say d is equal to c.
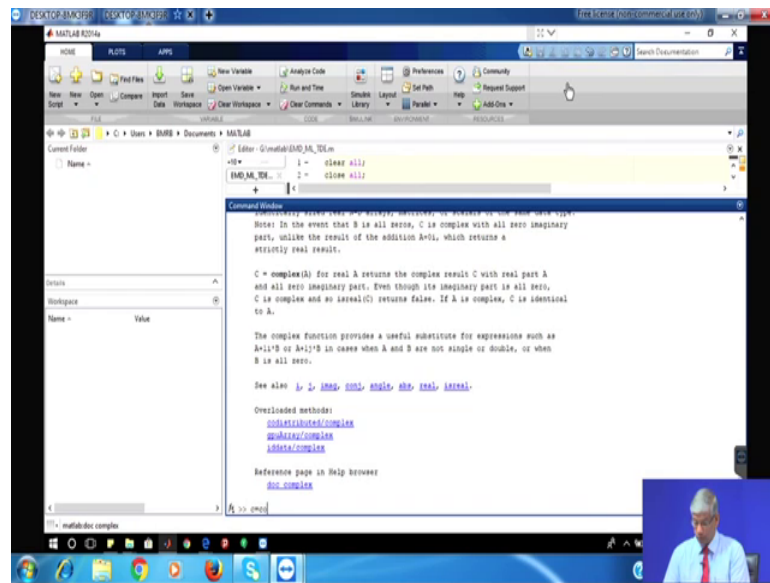
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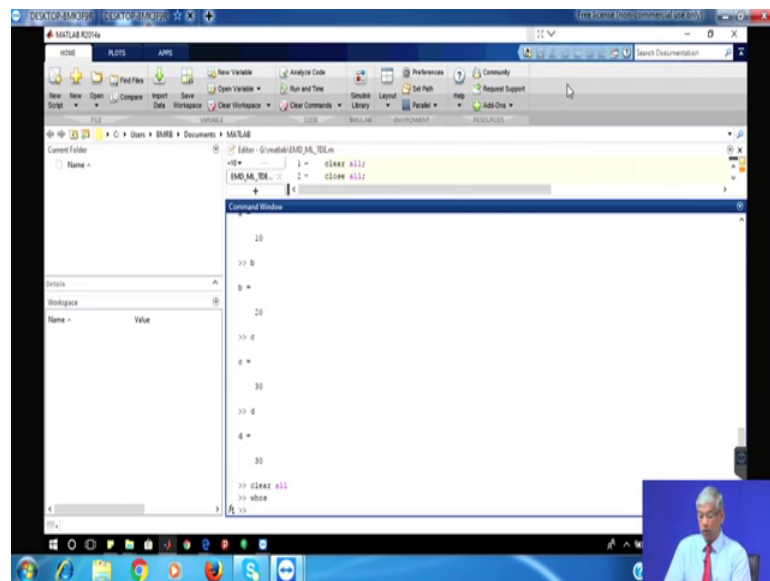
So, then if I do a whose I should be getting a b c d is that a b c d, if I want to know the value of a is 10 b is 20 c is 30 d is equal to c 30, and I can clear everything from the memory here all do whose. So, nothing is there so, always a good practice to clear everything in the memory once you do a fresh set of computation ok.
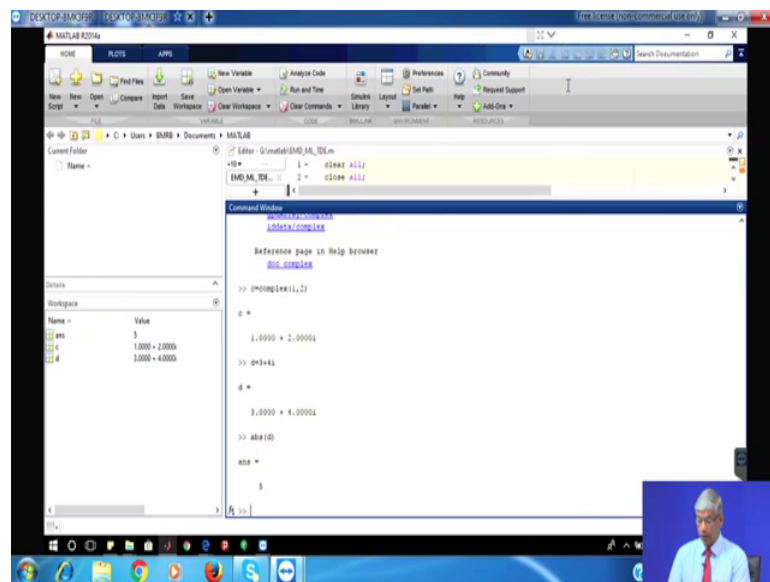
Now, let me show you some of the things, if I want to treat a number as a complex number I can say I have clear everything. So, I will give a fresh number a is equal to complex 1 comma 2. So, I can always do a help lets ok.

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So, c is equal to a plus complex a plus b. So, I can write c is equal to complex let us 1 comma 2.

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So, you see the c is a complex number with a real part a real part being equal to 1 and imaginary part equal to 2. I could write d is equal to 3 plus 4 i. So, this is a complex number. So, very easily I can write down the complex numbers. So, I can if you want to find the magnitude of the complex number I can do absolute d so, it is 5 it is the magnitude of this complex number.

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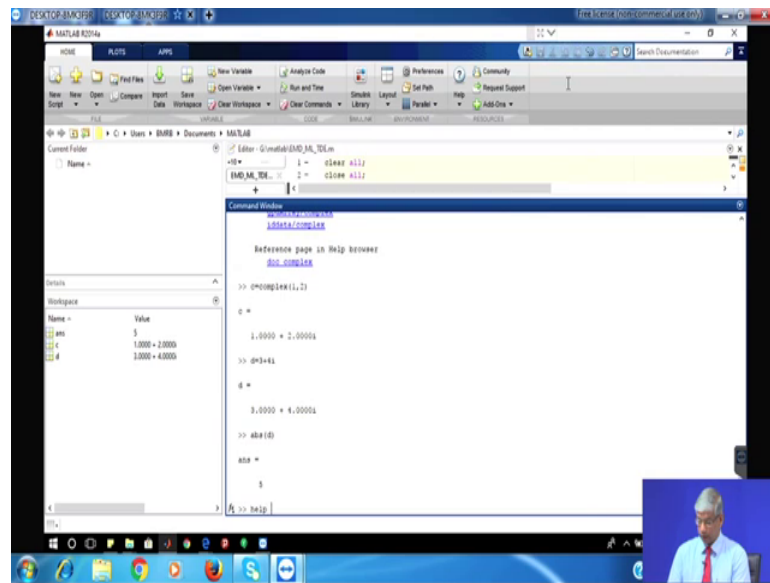
So, if I anytime I have a problem in MATLAB I can do help and that command. So, for example, I did right now help complex and then you can see a plus bi, and then I can get the imaginary real parts for example, c is equal to 5 minus 4 I it is a complex number.

I can say what is the imaginary value imagine c is minus 4 real c is 5. So, thus I can give variables as real numbers as complex numbers as the case may be, and I can do any sort of math operations all the arithmetic operations can be done.

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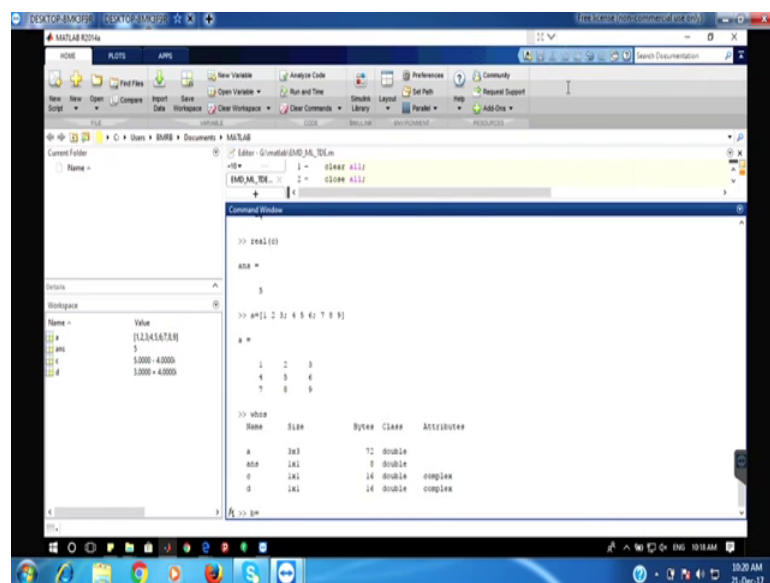
Now coming to matrix multiplication now, suppose I have a matrix a is equal to second bracket 1 2 3, and a give a colon 4 5 6 then 7 8 9. So, this is basically a 3 by 3 matrix. So, I have written the first column first row 1 2 3 with a semicolon, then I have the second row 4 5 6, and then the third row 7 8 10. So, this is a 3 by 3 matrix.

So, I can go do whose and you see a is a 3 by 3 array of our number. So, matrix a is a 3 by 3. So, I can give b is equal to so, if I want to multiply a 2 matrix C is equal to matrix a times matrix b. So, this is m times n so this is maybe n times 1. So, C will be m times 1 so, we have already defined just let me clear it again sorry clear all its fresh.

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So, my matrix a is a matrix 1 2 3, 4 5 6, 7 8 9 and b is the matrix which is a 3 by 3 this is 2 5 6 I will do a this is 1 by 3.
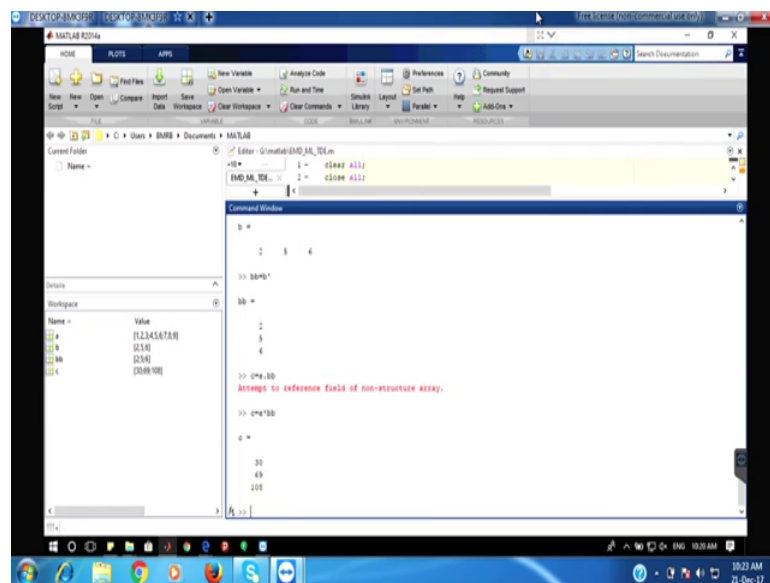
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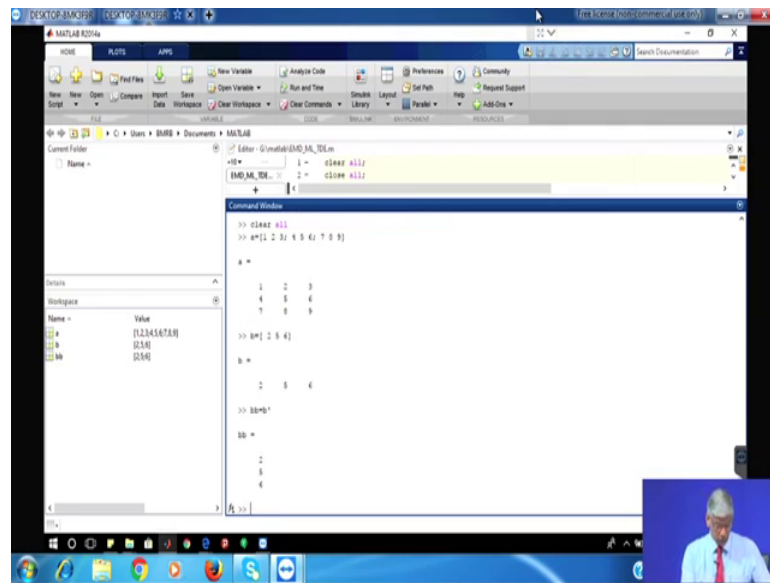
So, this will not allow if I do a matrix multiplication let me first write a is equal to one 2 3 4 5 6 7 8 9.

Now, b is equal to 2 5 6 so b is a 1 row and 3 columns. So, this multiplication like c is equal to a times we will not be correct because it did I have to make it b transpose. So, let me give it be or maybe be b is equal to b transpose.

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So, in matrix multiplication so, transpose of matrix is given by the command say b this sin here so, I got b as b transpose. So, now, I can multiply c is equal to a dot b b sorry

give the command c is equal to a star b b right, you see that this multiplied c is equal to a times b transpose where this was 3 by 3 this is 3 by 1, so this will be a 3 by 1 .

So, now these numbers where real numbers they could have been a complex numbers as well and so on. Now I can generate so, let me clear everything now see if you look in the internet, and there are many resources for understanding MATLAB and learning MATLAB, but the way I am going to tell you is certain key elements in MATLAB which are going to help us at least generate certain signals plot them.

And then do certain mathematical operations. So, all the arithmetic operations of addition subtraction multiplication divisions can also be done, multiplying with the constant ,handling complex numbers, finding out certain parameters of this number of area of numbers like mean of an vector of numbers and so on.

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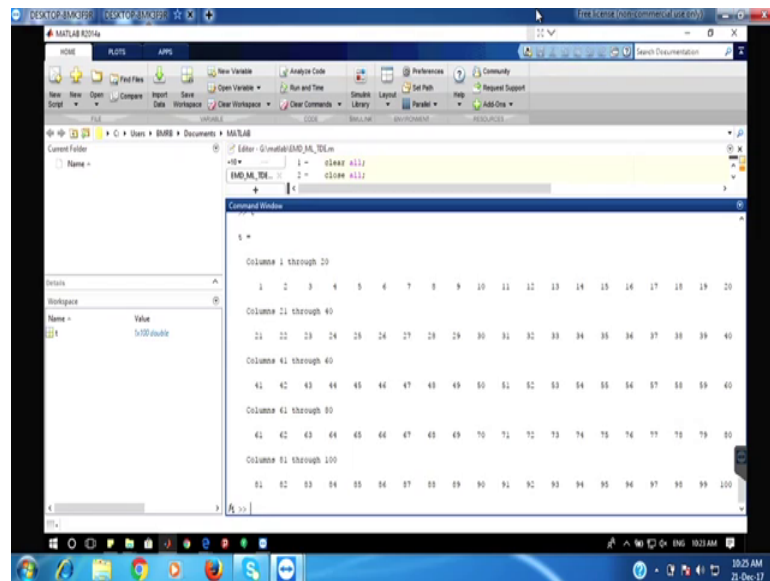
a I want to generate the time sequence t is equal to 1 colon 1. So, this means it is generating a series of number a rho vector with 100 columns where all elements from starts from 1 it increments by 1 and goes up 100. So, 1 2 3 4 and so, on if I plot t it is 1 2 3 4 all the way up to 100, this is what my t is this sometimes helps us in indexes etcetera when you order help of course.

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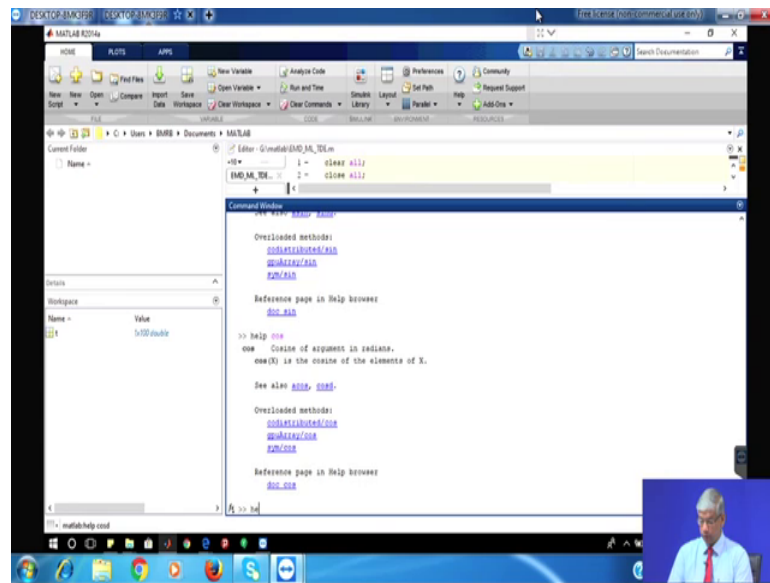
I can use the arithmetic functions like a help sin. So, it does the sin of the element of argument is in radians ok. We also have sine d etcetera so, help cosine.
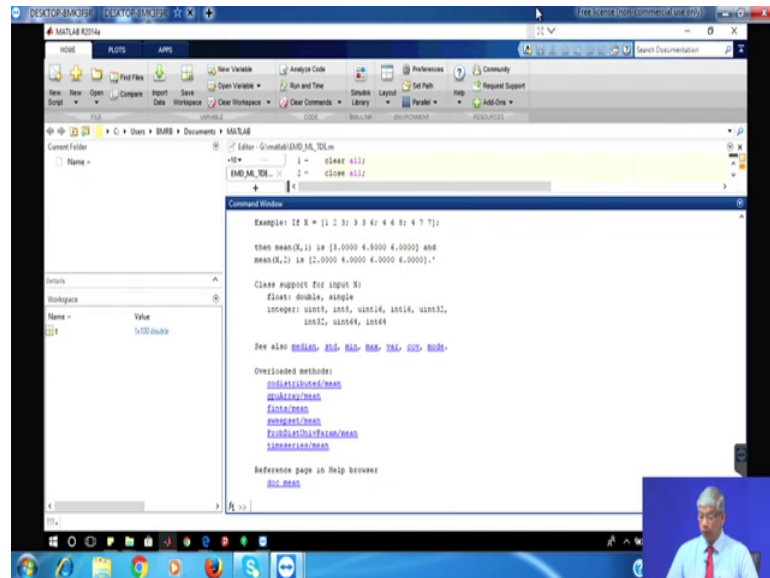
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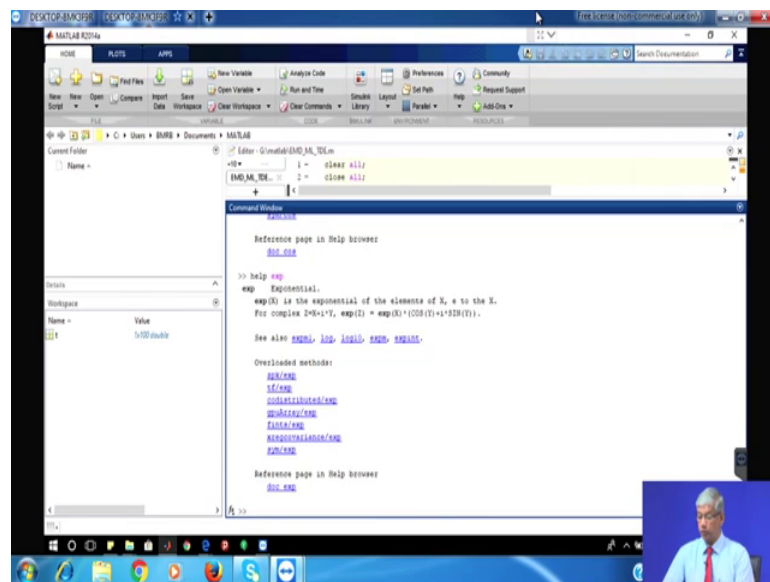
So, I can hand in trigonometric functions also help exponential it does an exponential operation. So, I can do many complex operations trigonometric expressions logarithmic expressions and so on. Now let me show you if I want to multiply or find out the mean

often array of numbers. So, I can do a help mean so, average value mean is the mean value of the elements in x if x is a vector ok.

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So, we can do media and standard deviations minimum maximum variance covariance and so on all this is possible in the software, since I can find out the Eigenvalue of a vector also for example a 3 by 3 matrix.

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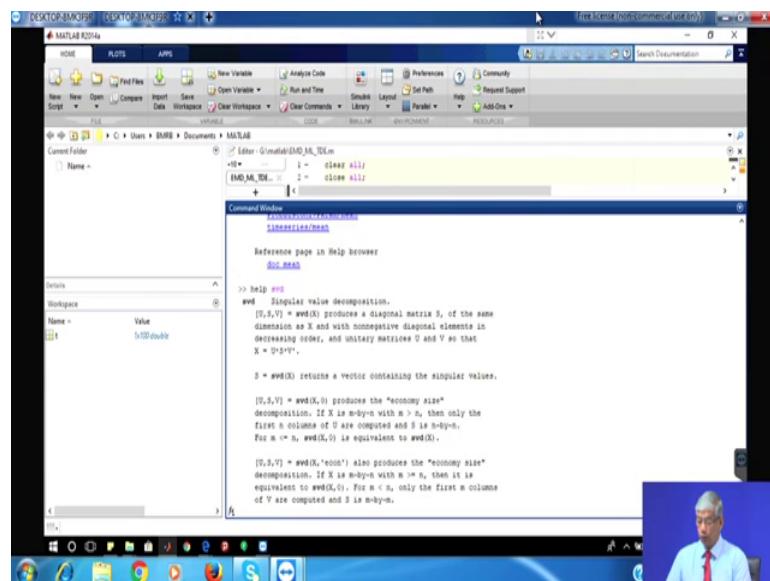
So for example, help svd is 1 command it gives the singular value, where s is contains the symbol and value I can do an eigenvalue also. I have a i g produces the column vector e containing the eigenvalues of a square matrix a.
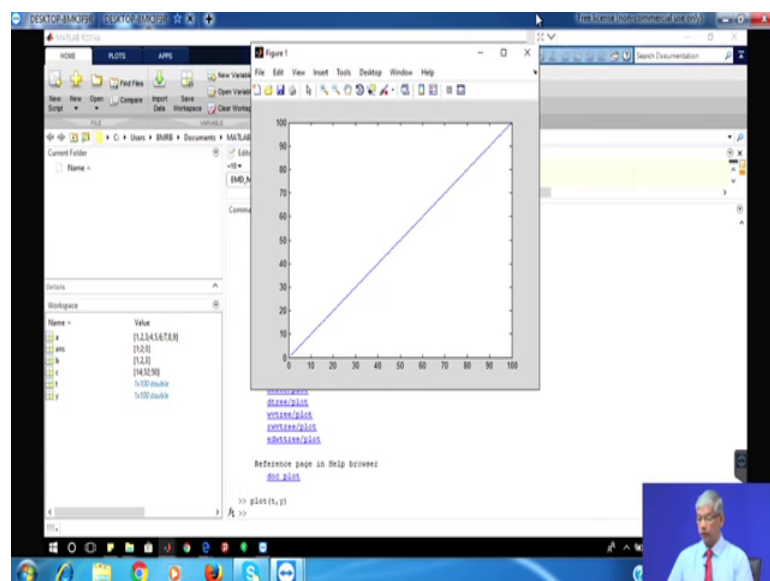
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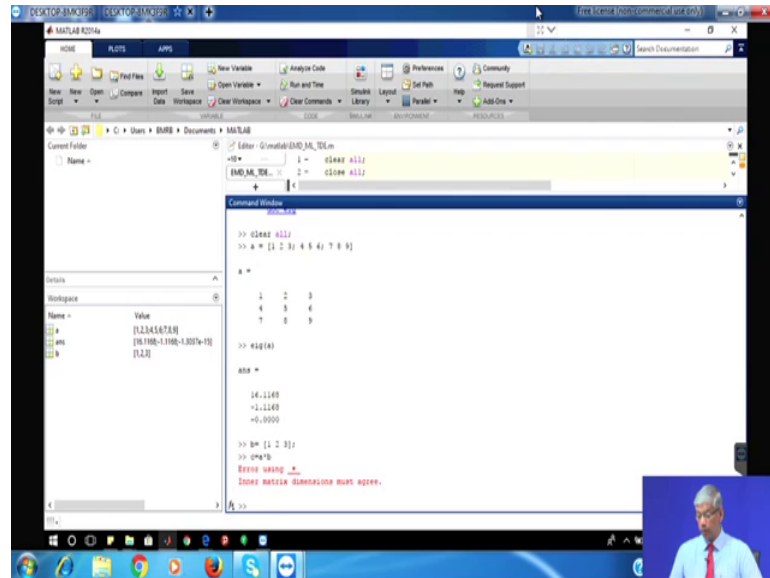
So, let me give you an square matrix clear a is equal to I can do Eigen a it is giving the eigenvalues of this matrix square matrix a right, but many times in if I go back to the my example. So, b is equal to 1 2 3, if I try to multiply c is equal to a times b it will give me an error because I am trying to multiply a 3 by 3 matrix with an 1 by 3 it will give me an error right.

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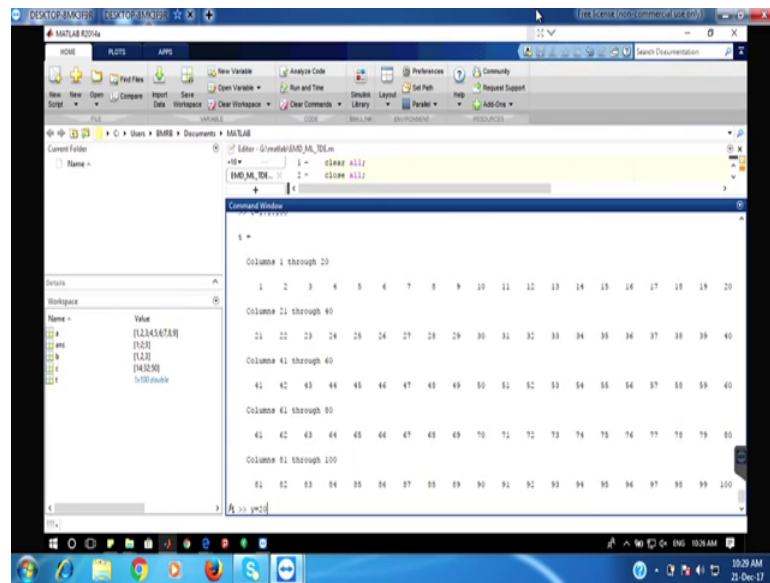
Now, so inner matrix dimensions must agree as is they so, that is why in if you have to take v transpose it will work c is equal to a star b transpose ok. So, because now the b transpose looks like this and there is no end to how much I can change and so on. Now let me generate 2 strings of vectors the t is equal to 1 colon 1 colon 100, and let me generate y is equal to 22 22 5 5 let me generate y same thing. If I plot I could do the help plot so, there are many commands on options of plots; plot x y plots, the vector y which is vector x and so on. And then you can give certain commands etcetera for example, plot x y z plus gives this dot red line with a plus at each point and so on.

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Now, I will plot plot t I should get a straight line at 45 degrees see, this is my p this is my y and I have plotted it.

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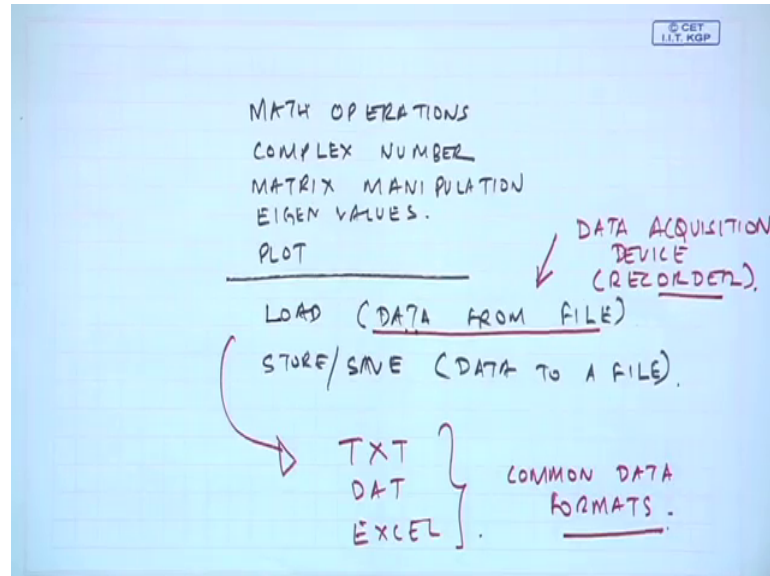
So, this is very simple plot functions I can close it, because if you go to MATLAB you can do that and another thing in MATLAB is you know I can save so, I can do math operations, I can deal with complex numbers, I can do matrix manipulations like transpose inverse etcetera. I can find out no eigenvalues, I can plot now another very important thing is I can load data from file I can store or save data to a file.

So, you see typically when I have a data acquisition device or a recorder I can have all these files in a file format. So, MATLAB very easily I can take text files take data files, I can take files out of excel so, these are some of the common data formats. And this data can be stored can be recovered, and then I can store a load from a file name for example, if I come here if I do load best what about MATLAB is there you have any problem with anything just do an help.

And I find that very convenient myself to so, you can load a file you can give the file name, file am you can give the variables so, weary limbs can be stored a mat taps or a nasty type it will take it as an ASCII file and so on. So, I can load certain text files and so on. Similarly help save file name stores all variable into a workspace. I can add so and what format you want to save and of course, I like in any software with different versions there are updates and so on.

And I here do not recommend that any particular version of the software so, whichever is available at your convenience or at your place you can use it for doing certain analysis the reason, I wanted to show you this is you know we will be using this subsequently for doing certain signal crossing. The next classes, but now let me give you some other examples as to this can be used also to do FFT. And let me plot a sine wave sector for example, let me generate the time series.

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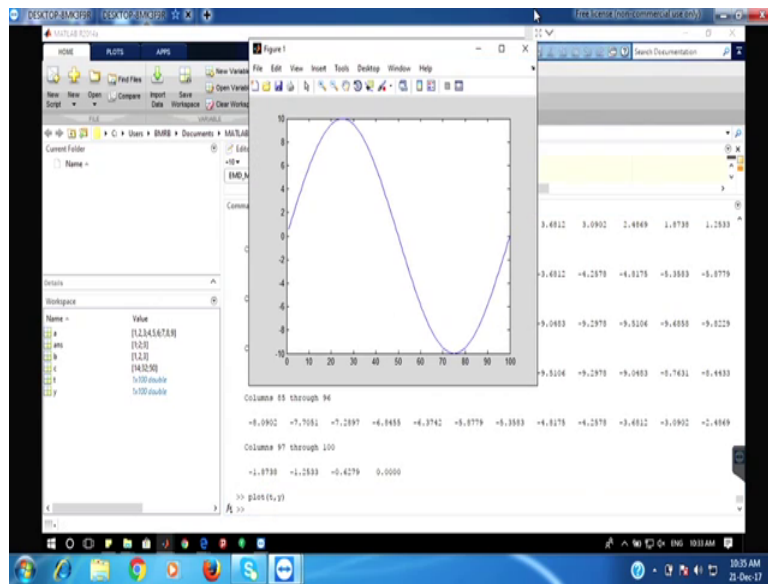
Now, let me generate x or y is equal to 10.0 star sin 2.0 star pi MATLAB understands pi has no 22 by 7, 3.141. So, I will give the frequency of the signal to pi f t so, f may be 10 hertz star t means at whatever time. So, maybe every 0.001 seconds and star t sort of generate a sine wave let me plot t verses y, you see I generated one sine wave something some takeaways from here is it know you can always in MATLAB for debugging you can always go back to your arrow key and it will get back your previous command.
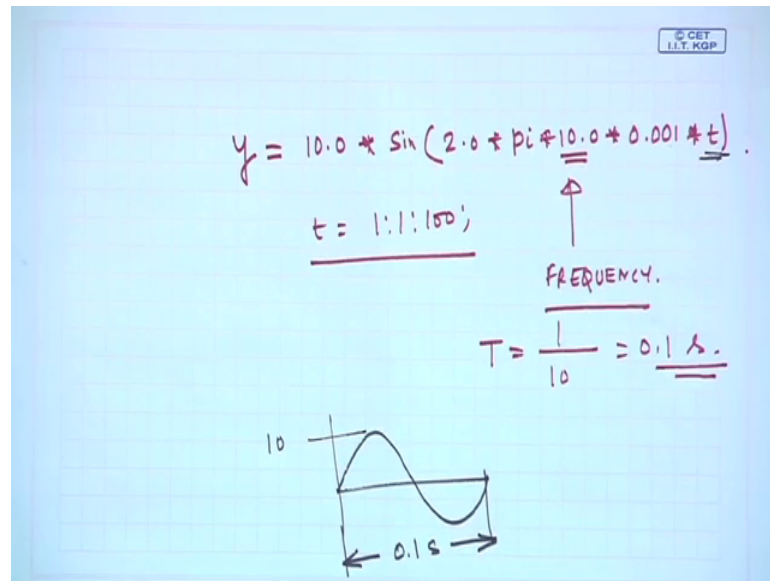
So, I have generated this y is equal to 10.0 start sin 2.0 start pi star 10.0 start 0.001 start t see my t was always 1 so, I have 100 data points and this is the frequency of the signal. So, which is that and what is the time period. So, time period is t is 1 by f 1 by 10 0.1 seconds, you see here my maximum value of t is 100. So, I am if I at t is equal to 1 this is 0.01 and t is equal to 100 this comes to 0.1 so; that means, I am having only 1 wave, and this is 0.1 second and this is my 10.

So, now if I want to make 10 waves I all I do is then, I will or if I increase the frequency I will make it 100 hertz I can plot I will I will level you see that I have got 10 waveforms.
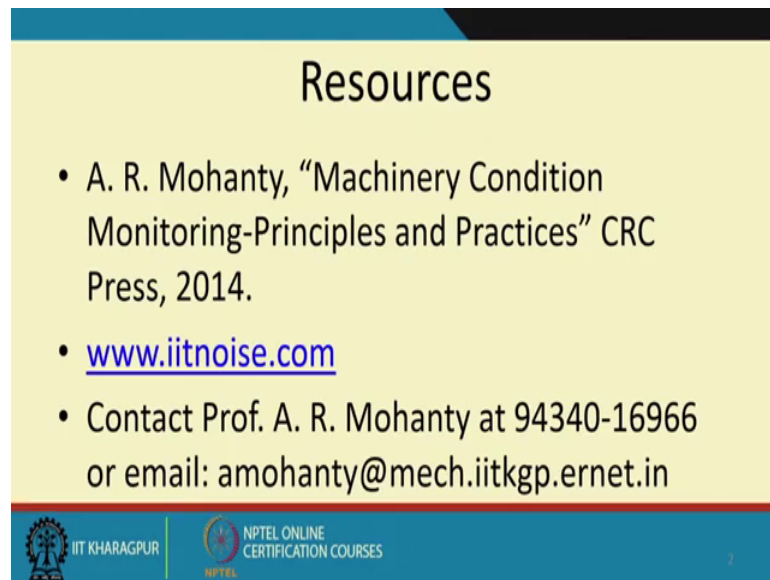
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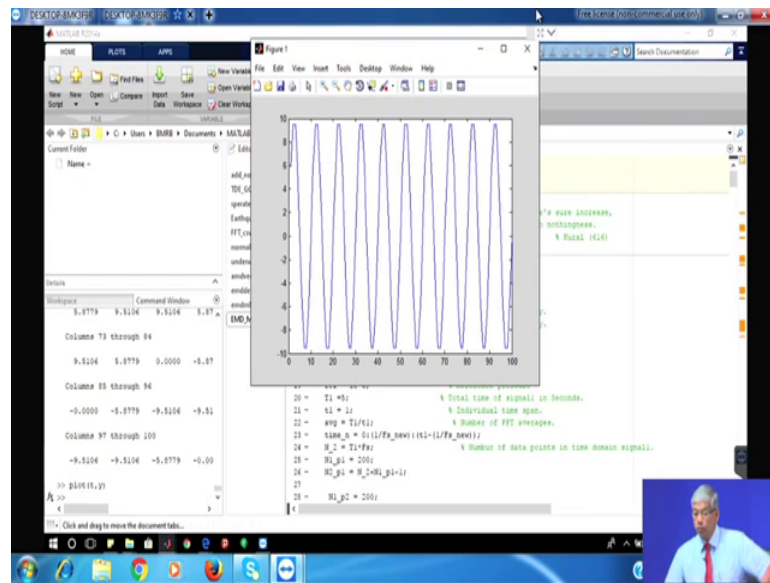
Of course I will come to this later on because my resolution was not that fine. So, that is why this clipping occurs, but nevertheless. Once I went 100 my signal become I can go back to my you original and make it back to 10 and I can again plot t and y, I got back my original sine signal.

So, in this brief exercise on MATLAB, I just told you some of the elementary commands as to how we can treat numbers find out treat them as real numbers complex numbers do certain matrix operations and do addition multiplication subtraction etcetera. And then plot files our plot expressions and then save values and so on.

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So, some of these examples you will see in my book in the appendix, which we will be discussing in the subsequent classes.

Thank you.