Biomathematics

Prof. Dr. Ranjith Padinhateeri

Department of Biotechnology

Indian Institute of Technology, Bombay

Lecture No. #39

Learning mathematics with the help of a computer

Hello, welcome to this lecture on biomathematics. In this lecture, we will basically discuss some kind of questions, miscellaneous questions that arise, that typically students ask which will help to see this course in kind of something that complimentary to what many things that we learnt or something that we missed out or something that, one should some students would want to know. So, this kind of things like some miscellaneous things put together is this lecture, this lecture basically formed by putting to where this this kind of miscellaneous things.

So, that will be like two, three, four things which are not completely unrelated, but when different questions, we will discuss. So, we will go through these questions and or various things so, and we will discuss those things. So, let us see, what are the questions that, these are some questions that, some students typically ask. So, this is, we will we will see this.

So, the question, the title of the lecture is questions and discussion. So, we will see, what are the questions are. So, the first questions is related to the first part of the course, where we did lot of plotting functions, and we learn how to plot functions then the question is the following.

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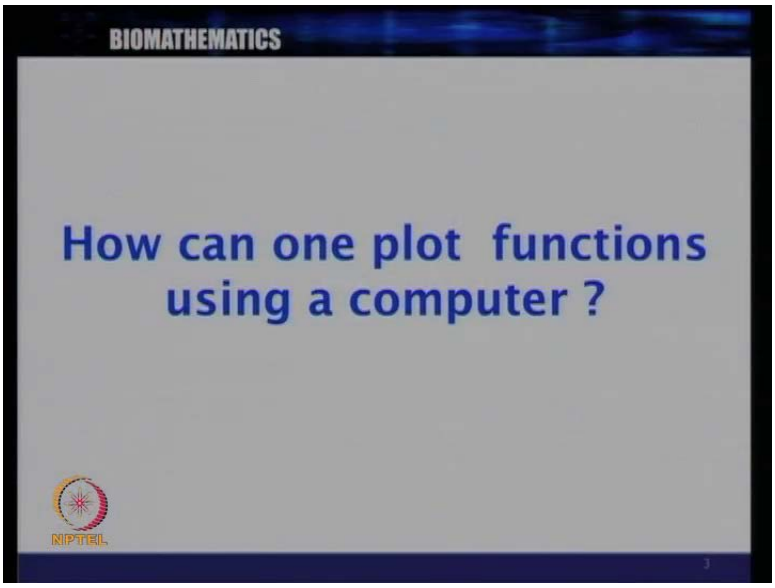

How can one plot functions using a computer? So, we learnt, how to plot functions using, so we learn using various mathematic techniques, how do we find minima, maxima and then how do we plot functions, we know how to take values and plot functions. But this all, you one should know, but in day today use, it is much easier, if you could plot it using a computer, and really use it for let us say research purpose or some other purpose.

So, (( )) quickly see, how would a function will look like. So, we will briefly discuss, how do we plot some functions using a computer. So, do this, we will discuss a software. So, there are many software available to do this plotting using a computer and I will discuss one of them and you can, there are many other things you can learn, any of this and you can do the same thing using many other things.

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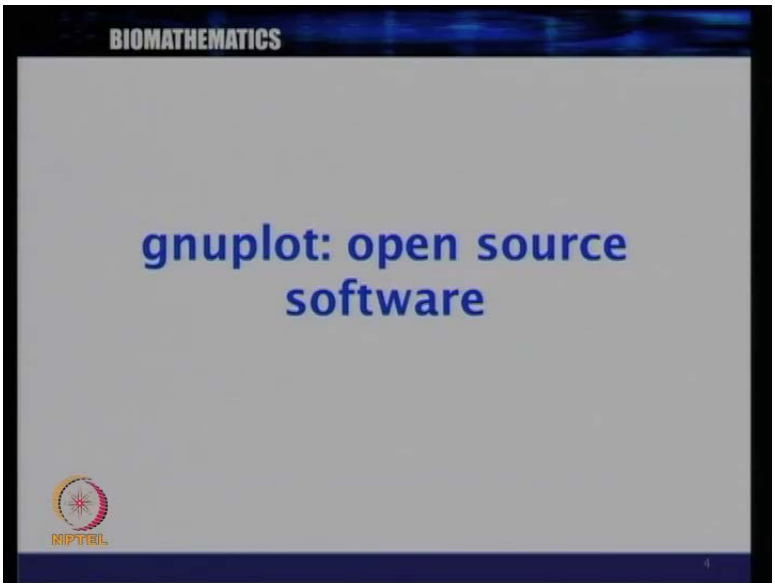

So, what I will be discussing is something called g n u plot. So, the software name is g n u plot, it is an open source software which means that, it is available for you to download from the web for free, anybody can download and use it.

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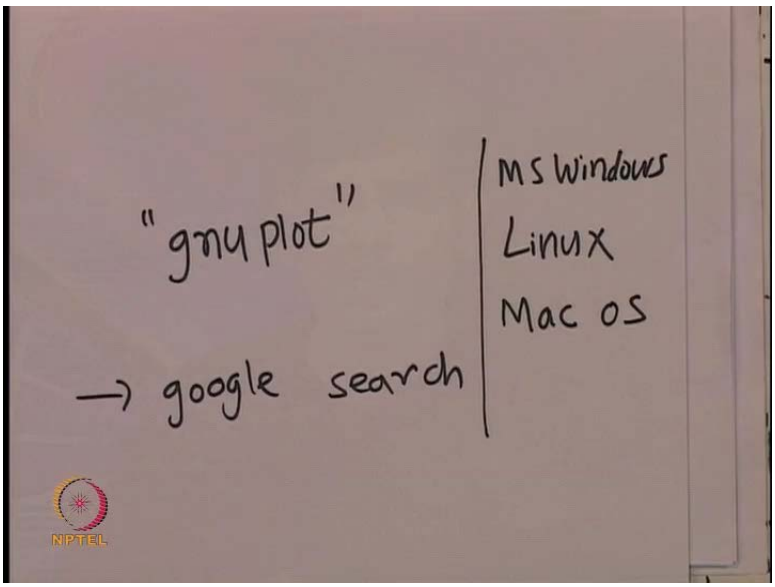

So, let let me write it here, it is called g n u plot and if you Google search for g n u plot, the first website that you will get, so, Google search (no audio from 03:26 to 03:31). The first web site, you will be getting is this from their, you can download this software and download and then you can install this software and once you install, you can use a

software, it is very simple and you can plot almost any function that you want. So, first, what I will be giving this a demonstration of how to do various things using these functions.

So, we will see, how do we plot simple function like x, x square, sin x, log x, exponential x, all the functions that we learnt, how can we do this, which can also do many other things like, this can also do for example, simple fitting, how do we fit a linear function, how do we fit something quadratic. For example, if you have or if you have some function, which is some f of x, how do we fit that, we will see that in this lecture. So, the first part of this lecture will be a demonstration and demo of, how do we use this software called g n u plot.

So, you can so, you can this is available. So, this g n u plot is available for windows, if you are using windows, Microsoft windows, it is available for the x (( )), if you are using Microsoft windows, it is available, if you are going to use some kind of Unix or Linux, it is available available for g n u Linux, it is also available for Mackintosh Mac O S. So, it is available property which all popular operating systems. So, this is what we will be using, we will be demonstrating today.

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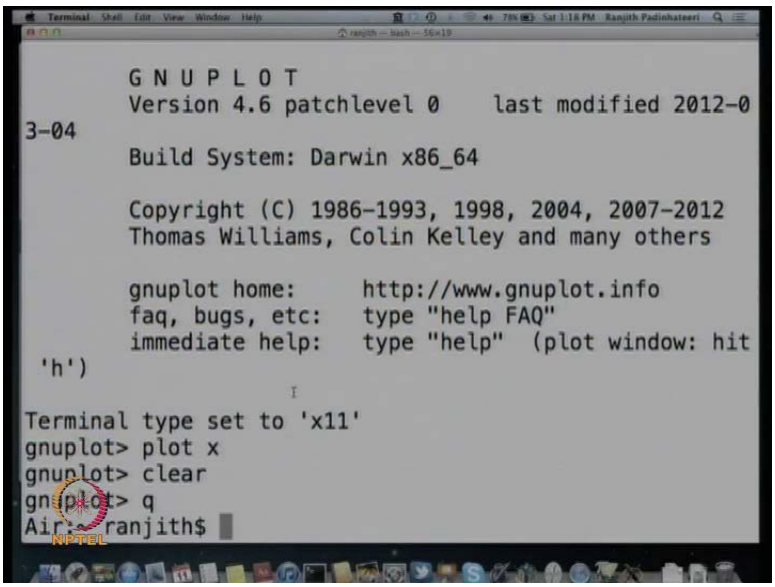

So, let us see, how do we demonstrate, how how do we use g n u plot. So, see please note this demo. So, in a typical Linux set up, if you take a terminal, we can take something

called terminal and then you can see something like this and if you type there g n u plot, you will get this.

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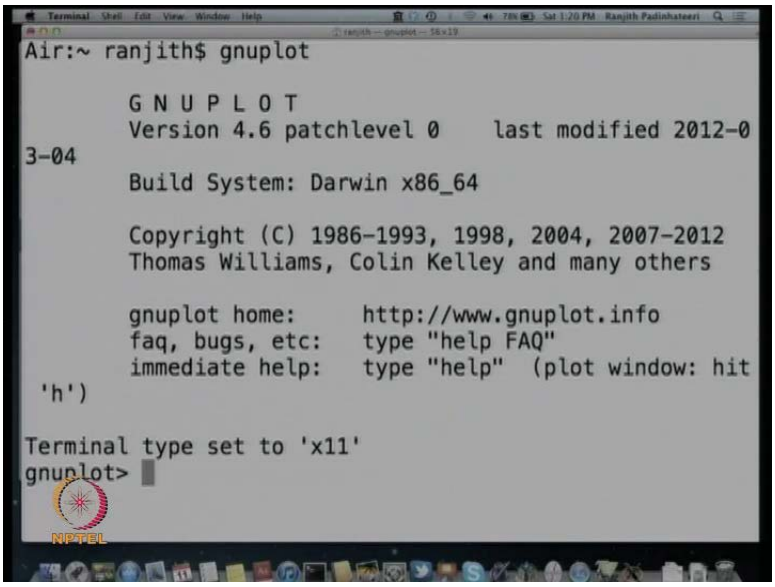

So, you will get something like this, this is what you will get in a in Linux or a Mac O S system, but if you are using windows, if you download the g n u plot and install it then double click on the icon, you will directly get such a window. So, you install double click on the g n u plot icon, you will get such a window, in such a window, what you have to do is just plot. So, let us see how to plot simple functions. So, the first thing we will learn is plotting a linear function. So, let say simple thing, plot f of x is equal to x.

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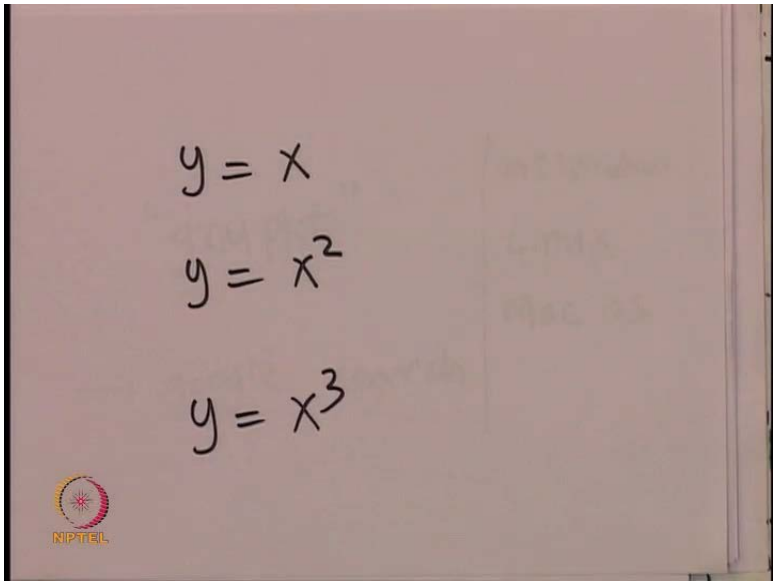

So, let say the first thing we will plot here is, y is equal to x then we will see, y is equal to x square. So, the let us see then we will see anything y is equal to x cube we can plot. So, let us see, how this three things first.

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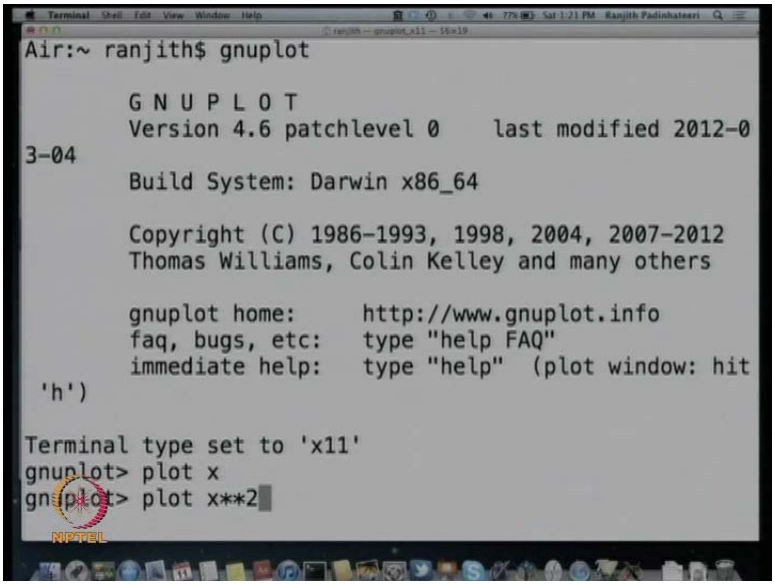

So, here you have to just say plot x. So, plot is the command and the function with the space, you have to type the function. So, then enter and you get this.

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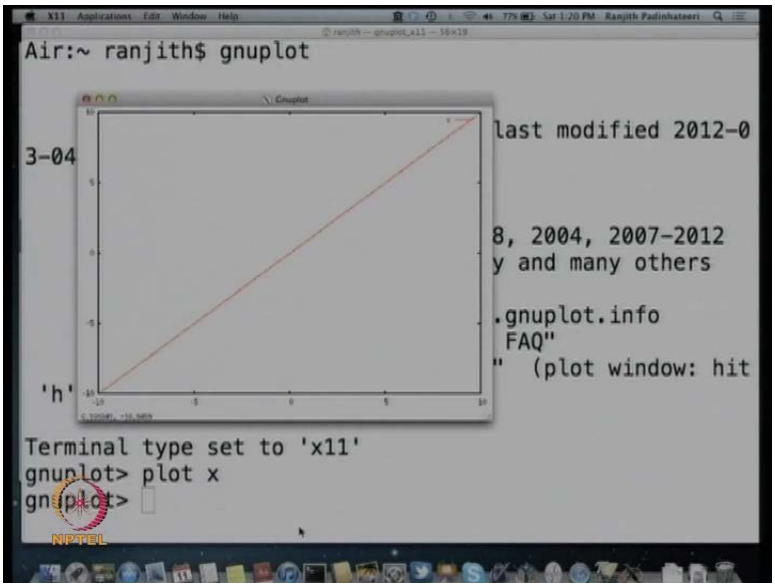

So, you see that, it goes from minus 10 to plus 10 by default. So, this is minus 10, this is plus 10, so, by default, you will get a linear function like this. Now, if you want to plot x square, you go back here and say plot space x, for square it is star star and 2. So, anything power, x power n, it put 2 stars, that means, power 2. So, x star star 2 means, x square.

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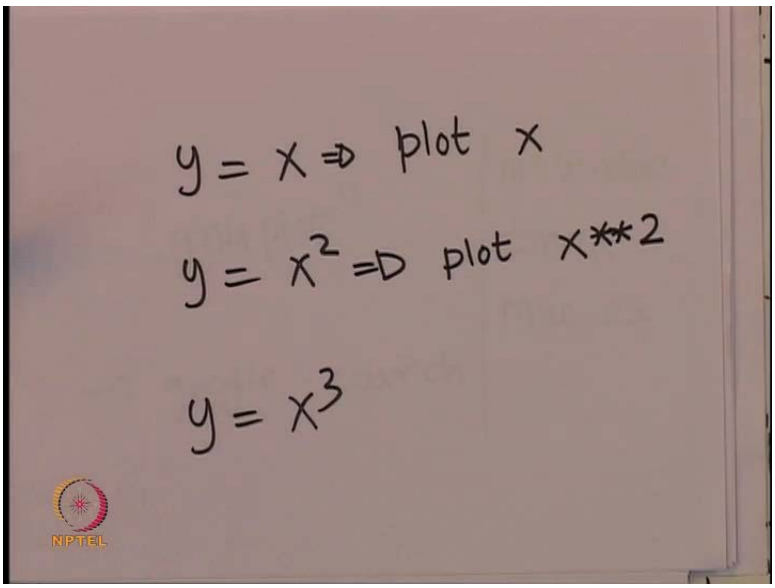

So, for this, what you have to just say that, plot x; for this, you say plot, everything in small letters, plot x star star 2. So, for… So, let us see, what do we get. So, you enter

this. So, you type here, x plot, if you go to this terminal, you say plot x star star 2 and then enter.

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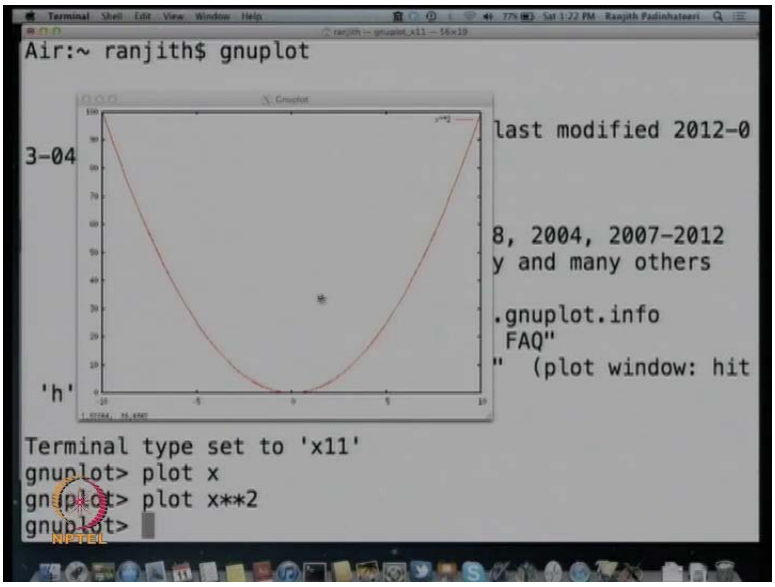

So, you get this. So, here you get a quadratic function like x square, again there is a negative part and the positive part and you get a curve like this. Similarly, for x cube you have to just say plot, instead of star star 2, you have to say star star 3.

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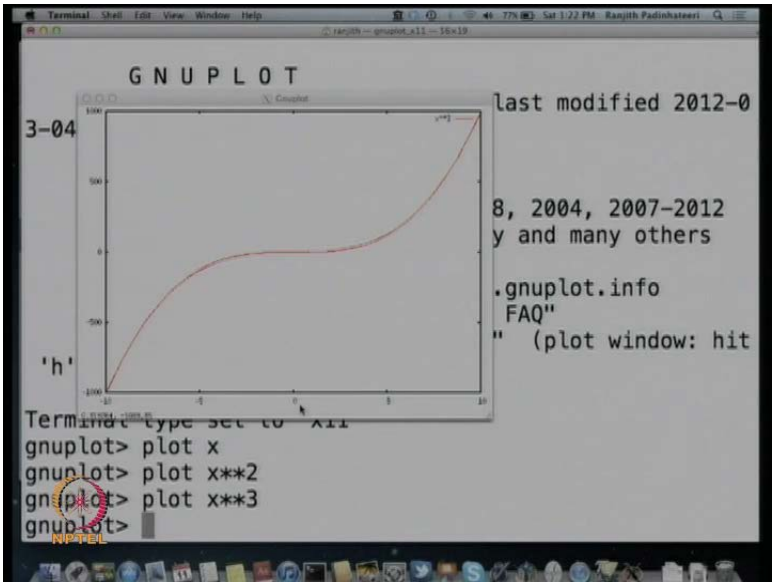

So, you get x cube which is the function like this. So, you know how to plot this function, three functions we learnt, x, x square, x cube. So, now let say, I want to plot

this only from 0 to 10. So, I want to plot this function only from 0 to 10, we do not (( )), if I do not want the negative part, what I can do for example is. So, let me make this lightly bigger (No audio from 09:10 to 09:15). So, if I want only the positive part of it, I say that plot put two square brackets and in the bracket, you put the range 0, 10. So, this means, the range of x values should go from 0 and 10 x then you say x cube. So, this this, what is this command means, plot square bracket 0, 10, x cube means, plot the function x cube between 0 and 10 only.

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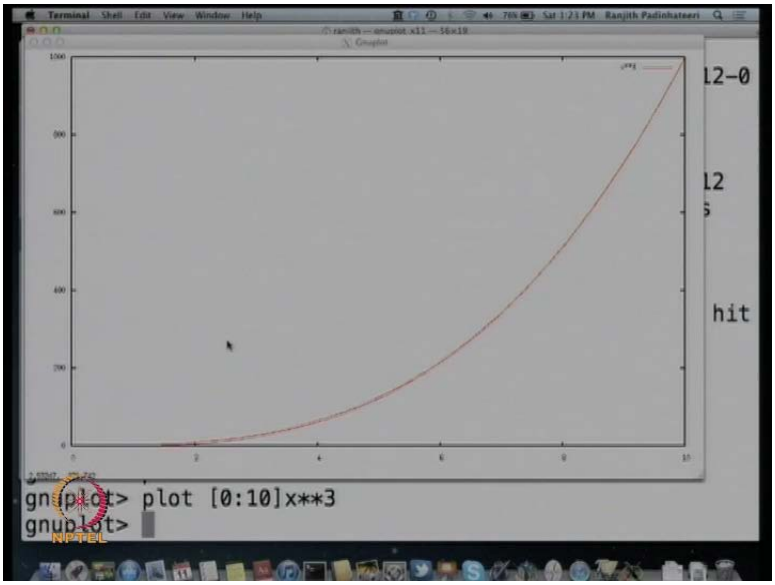

So, then you enter this. So, then you get starting from 0 only the positive part of it. Here, also you can see then it is going from very large values 0 to 1000, let say I want, this I only want up to 100, the y axis. So, let say, I y axis, I want only up to 500 then I can say that, y axis also the another second bracket you can put then I can say, y axis I want only from 0 to 500 then only 0 to 500 will come because the y axis is restricted to 500.

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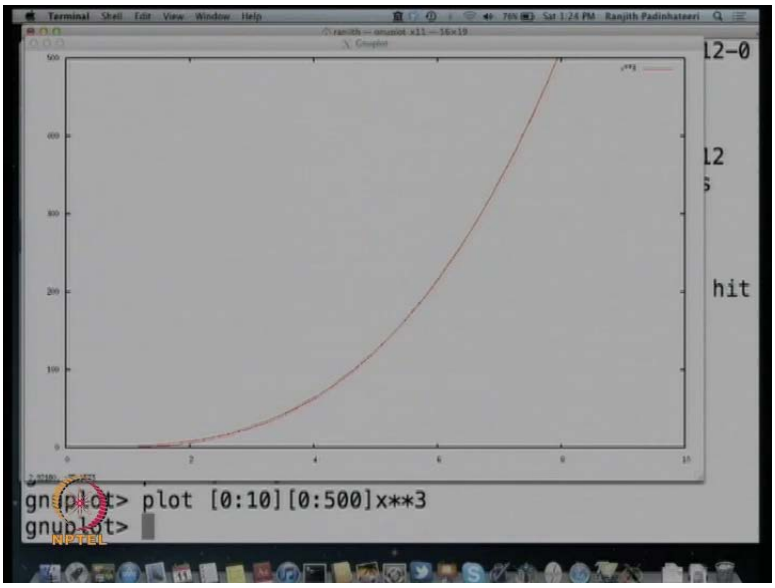

So, this two square brackets by putting values in two square brackets in this particular way, you can control the x range and y range. So, one more thing here, in controlling let us say, you have to plot this function x cube and you do not care the x axis, you have to only control the y range.

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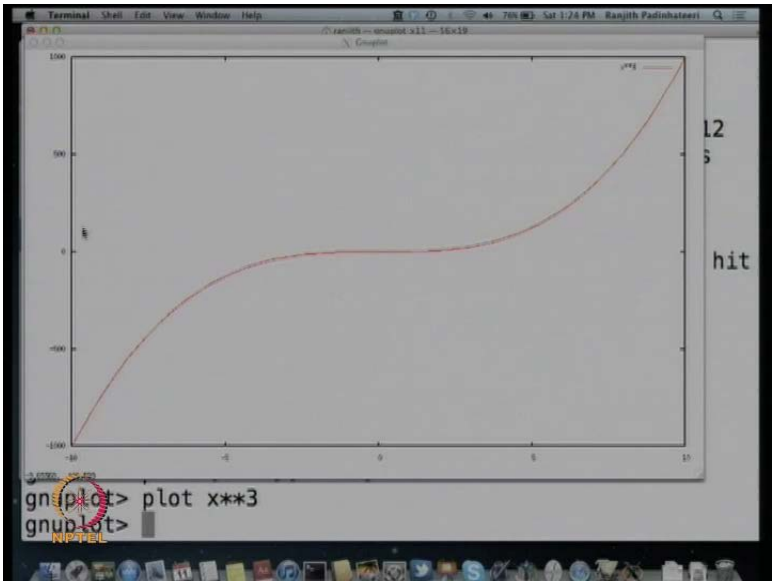

So, let us see this, say plot x cube without any range, it will plot the whole minus 10 to plus 10 by default. Now, let say, I want to control plot only from minus 500 to plus 500 in the y range. So, or let say, I want to plot y range only from 0 to 500. So, if I want to

plot y range, if I want to control y range only, first put a bracket without any thing then put the second bracket and then put 0 to 500, what is this mean is that, the first bracket say is that, x range which you are not specifying. The second square bracket implies y range which you are specifying. So, if you look here, look here the first square bracket, you are not specifying anything, the second square bracket 0 to 500 with (( )) specifying, this is basically the (( )) y range. So, this is the range of x values; this is the range of y values. So, I am restricting only the range of y values. So, then I am plotting this.

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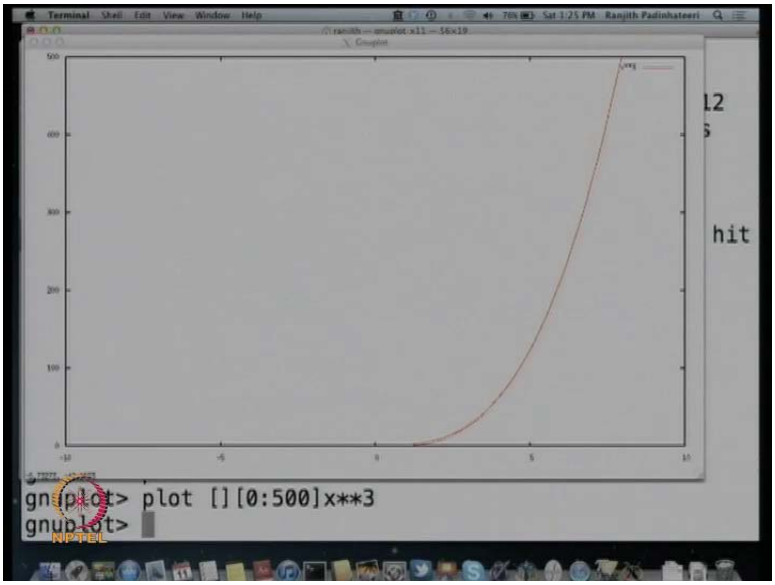

So, I get, I x and x axis I am getting x range and getting from minus 10 to plus 10 because I did not control it, but if I control y range, the y range only the range goes from 0 to 500. So, this is the way to control range, x range and y range. So, let me say that here. So, controlling x range and y range.

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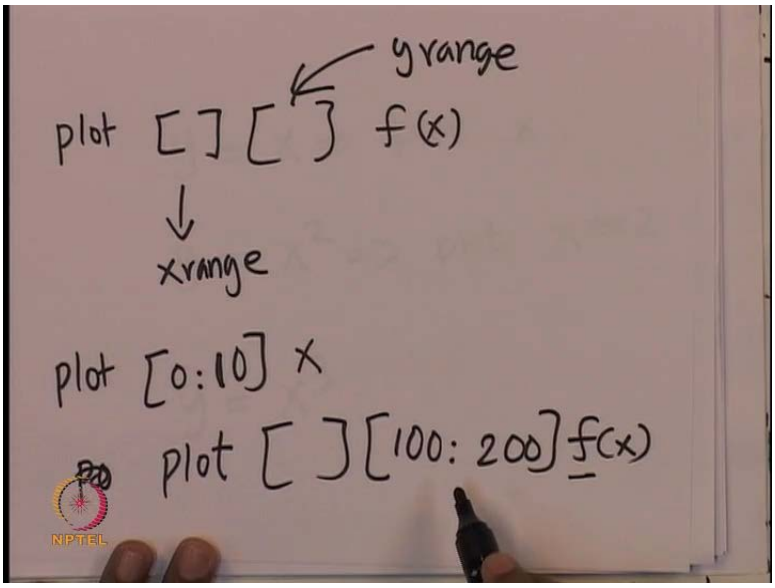

So, plot space first square bracket, second square bracket, the function you want, x, x square, x cube whatever you want. So, this implies the x range - the x range will be specified here, y range will be specified here. So, if you say plot 0 to 10, the function if the first square bracket implies the x range, this would plot x value between 0 and10, but if you say plot, you leave the first square bracket without putting, specifying anything, and then in the second square bracket.

So, leave the first square bracket blank, but you have to put the square bracket, but leave with blank then the second square bracket you put, let say 100 to 200, the function you want, you write f of x whatever we want, whatever the function we want then you will get the y range only fixed. So, this is the way to fix the y range alone. So, similarly, we can plot other functions.

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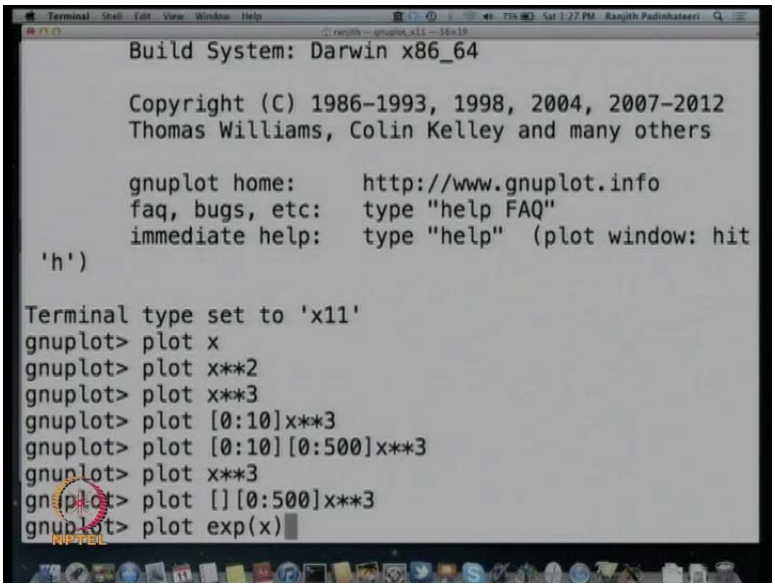

So, another way of plotting some other function is for example, let us go back here and let us plot, how do we plot exponential function. So, the way to plot exponential function is e power a e x p of x. So, this is the way of plotting exponential function.

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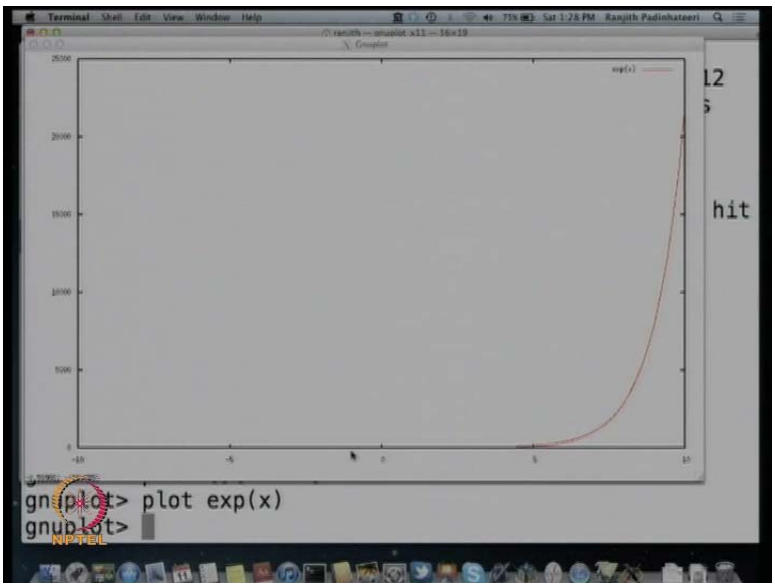

So, this is exponential function which which again from minus 10 to plus 10 and if I want to plot it only from 0, I say 0 to 5 and I want to plot exponential function.

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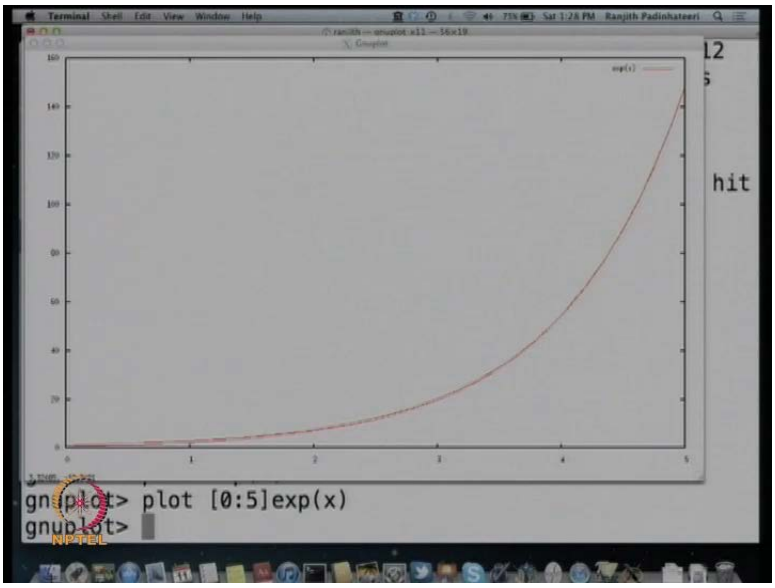

So, I have 0 to 5 exponential function this particular way. Similarly, if I want exponential minus x, I can plot exponential with the minus sign here.

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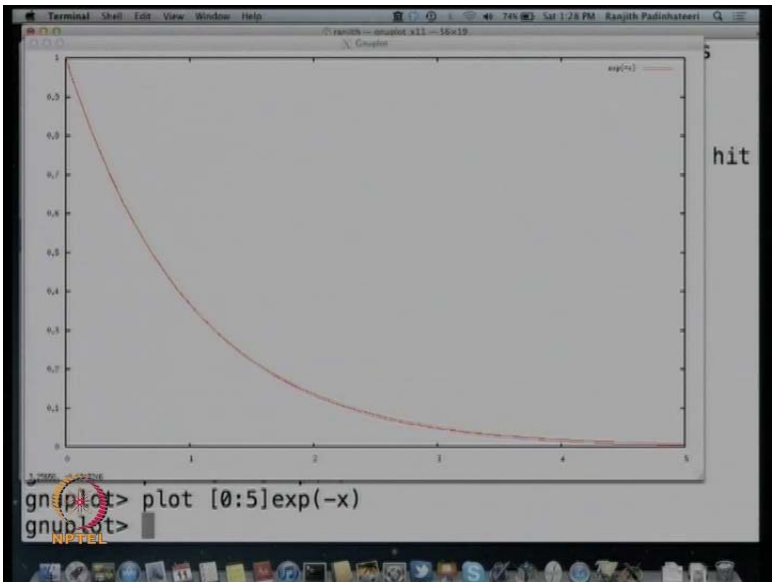

So, exponential minus x it will plot exponential minus x from 0 to x. So, similarly, you can plot log x plot log x.

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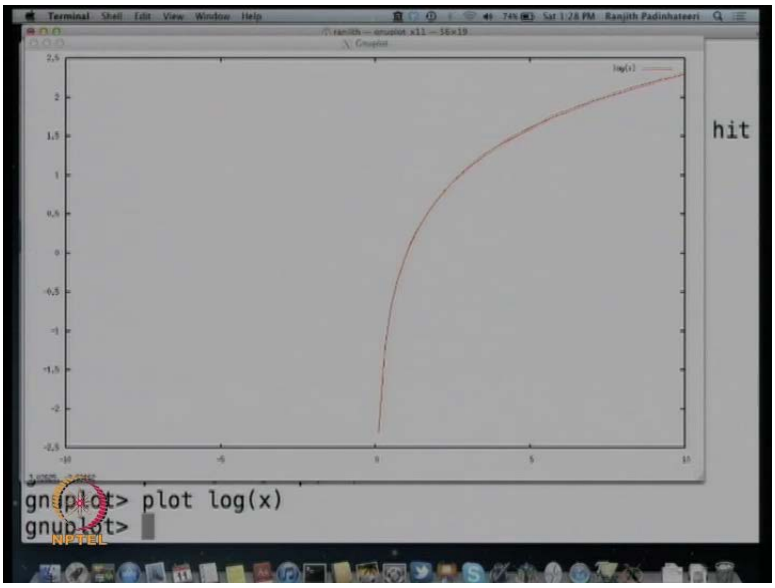

So, again this will go from minus to minus 10 to plus 10, but minus of log as no value. So, let start from 0 only. So, let say 0 to 5, let say 0 to 10.

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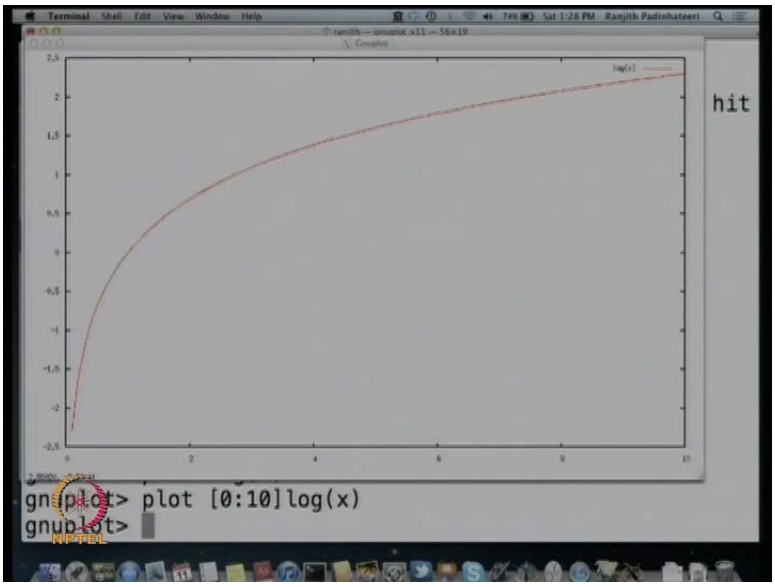

So, if you look here at 10, the value is not is 2.3 something. So, this means, this is the natural log. So, just plot log x will plot the natural log, this is equivalent of log l n. So, this is natural log, if you want log to the base 10, you have to say log 10 x, you have to plot 0 to 10 log 10 x, this will plot natural log to the base 10.

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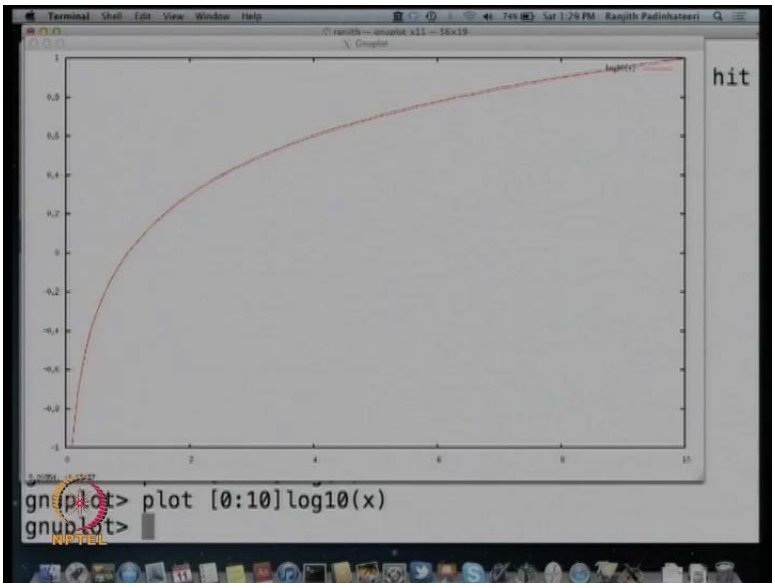

So, this will be log to the base 10 and then 10, the value will be one. So, this is another way of plotting exponential, this is the way of plotting log function, another there are many tricks that you can do. So, you can also plot ,if you want to plot square root of x of course, x star star 0.5 will do this, there again you can control the range there, you can also say plot s q r t of x I think, I think it should work yes this works. So, s q r t of x will also work.

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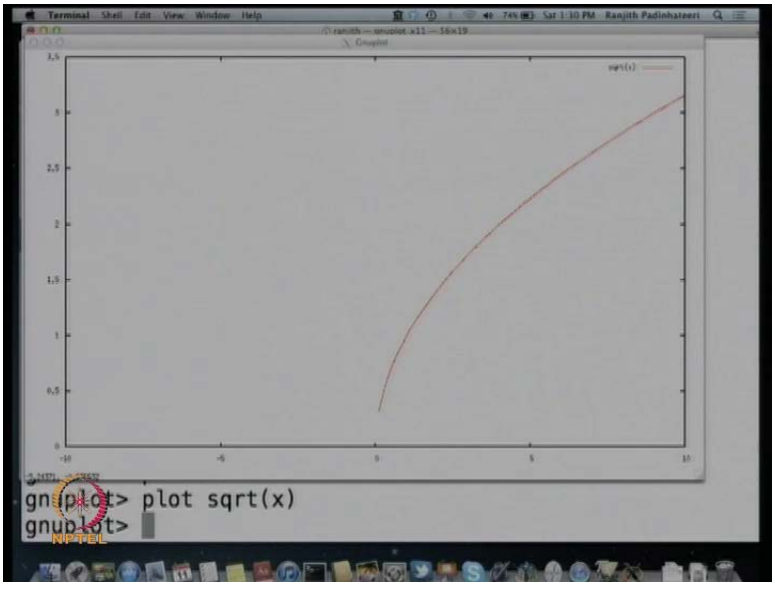

So, this is a way of plotting square root, but if you want to plot some other like cube root or some other root, you have to use x power like x power 1 by 3, x star star 1 by 3. So, you have to put a 1 1 by 3 1.0 by 3.0 and this will give you this. So, this particular way, you can plot whatever value you want, any any x power anything any any exponential any power you can plot in this particular way. So, another thing you would want to learn is plotting sin x for example, plot sin x. So, this is the way to plot sin x.

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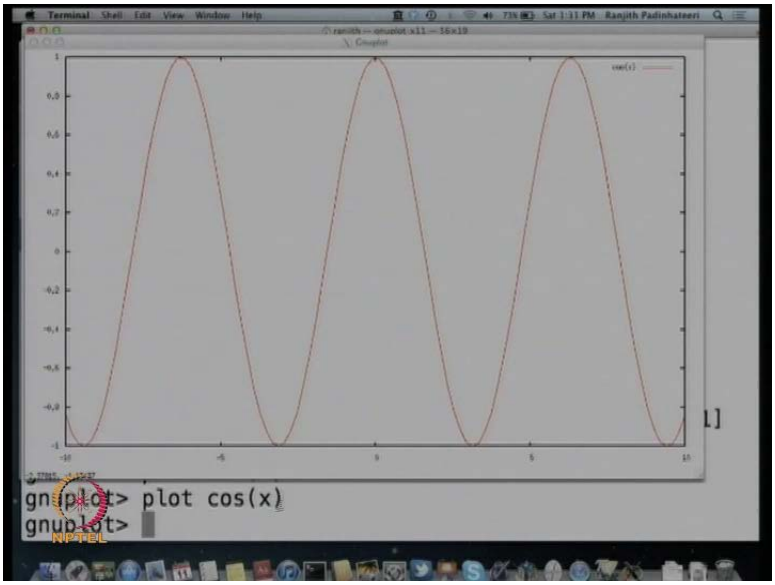

So, this will give you sin. Similarly, for Cos x, you can say plot Cos x. So, this will plot us Cos x and the argument should be always x, it only detects x only, you cannot say Cos theta or Cos p will not work, you cannot say Cos p, this will not give you anything because it does not say undefined variable p, it does not understand what p is, it always takes this as only as x.

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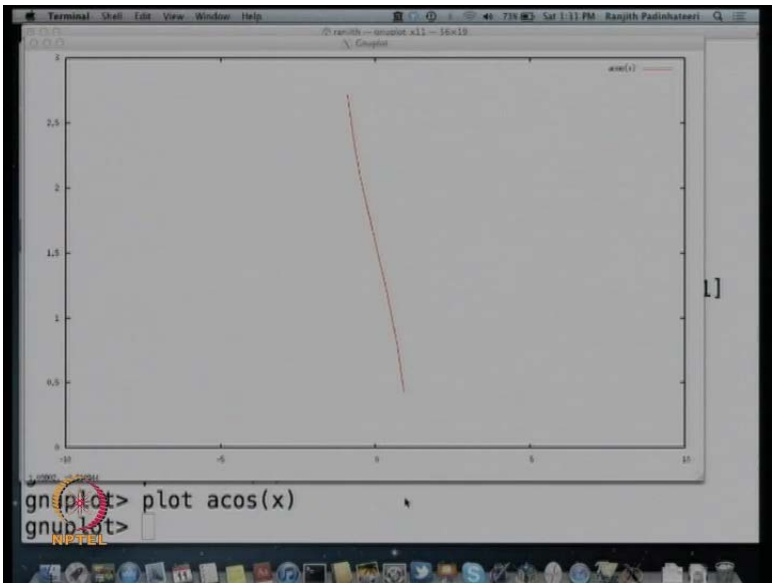

So, you have to give whatever in terms of x is the variable, so, Cos x. Similarly, if you want cos inverse, you have to say a Cos x, I think this is what cos inverse I think or so, even sin inverse is a sin a sin sin inverse x. So, similarly, you can plot many other functions. So, another thing is you can say f of x is equal to x power 4 minus x square or let say x power 4 plus 23 x. So, you can define f of x then is a plot f of x, this will plot f of x.

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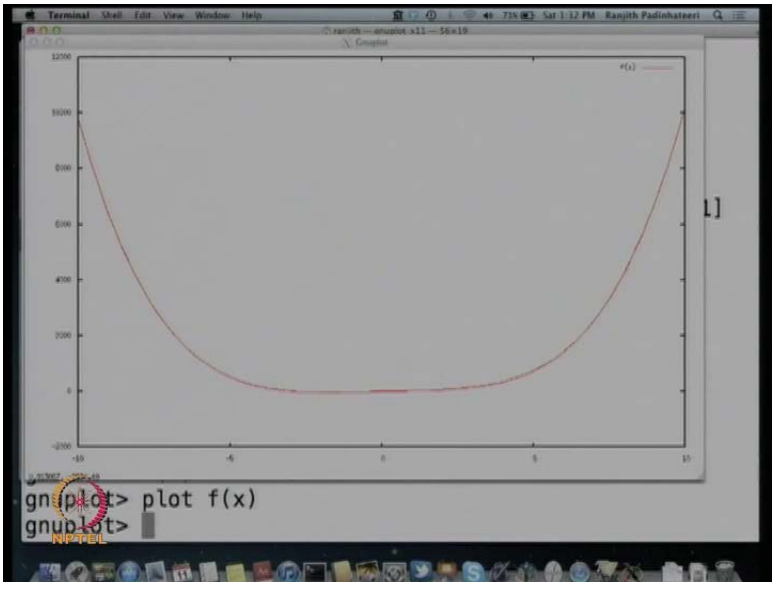

So, you can say this parti another something some other function (no audio from 18:41 to 18:45) then say plot f of x, this will give you a (( )) this is something something we learnt, some kind of double well, the well is very small here. So, you can I can say, the y axis only two hundred. So, I say x y range, I say y range is only up to 100.

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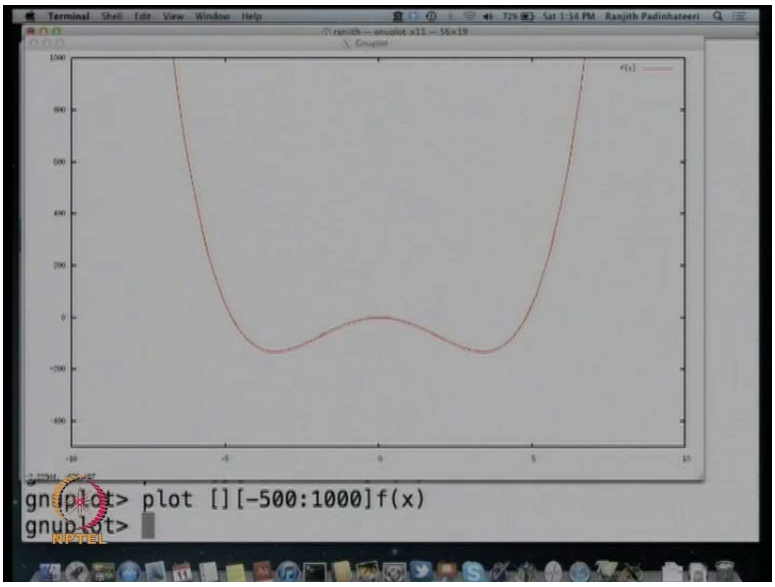

So, I specify the y range, I should specify the y range little more higher and let specify the x range also little down. So, I specify the y range is to minus. So, I want to specify the my my range for minus 1000 to plus 1000 or minus 500 to 1000. So, if I specify the y range from minus 500 to 1000, you get a nice double well potential. So, what did we plot, we plotted f of x is equal to x power 4 minus 26, 23 x square. So, this was our function, f of x is x power 4 minus 23 x square and I plotted that function from minus 500 to plus 1000 f of x.

So, I defined f of x in this particular way then I plotted plot f of x then that also gave me. So, this is another trick of doing this, you can play around this with this and get whatever we you want, another question immediately comes is how do I plot a data function, how do I plot a function, let say data file you have you have file. So, we will now take a… So, we can make a data file in your computer in the appropriate folder, in the folder of the g n u plot where it is. So, and then you can can can go there and plot the data file also, we we will see, how do we do that. So, this is what, I am going to demonstrate next.

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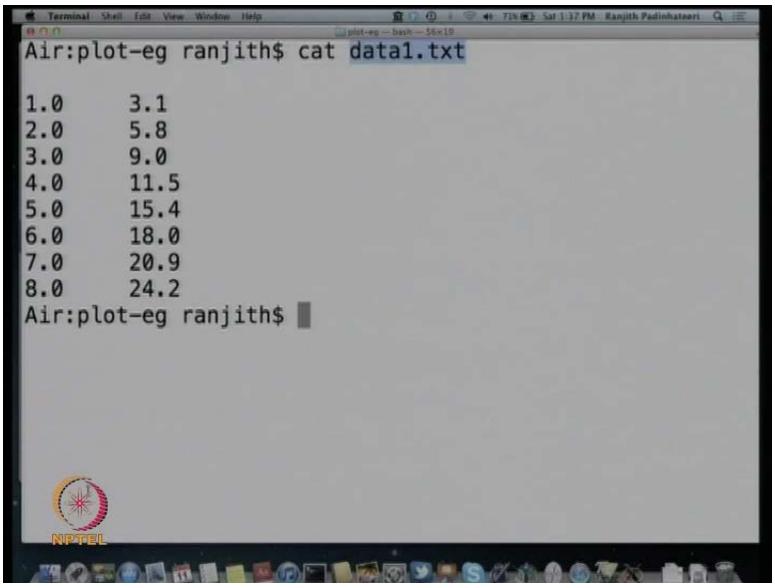

So, first we will see, we, what you see on the screen is the data file. So, have a look at this data file. So, you have x axis 1, the y value is 3.1. So, typically, if you do for example, in experiment you will get such a such a data file 1, 3.1, 2.0, 5.8, 3. So, I name this data file as data1 dot t x t. So, data1 dot t x t is the name of this data file.

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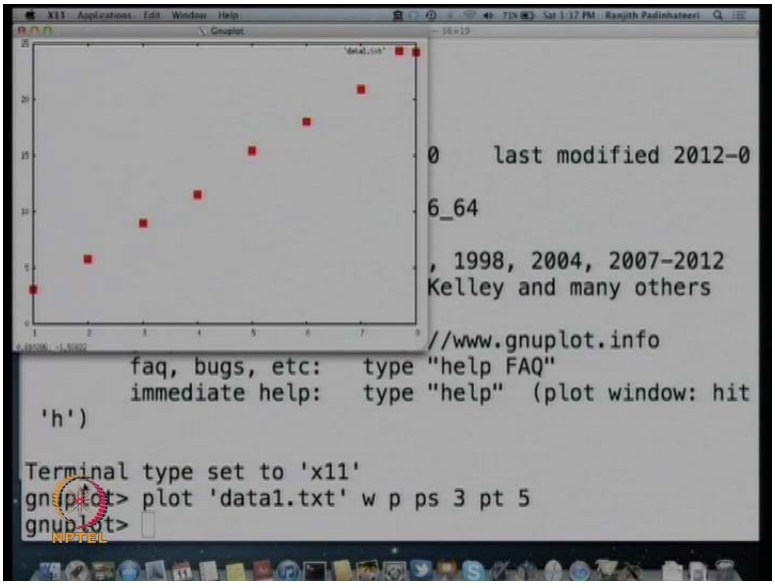
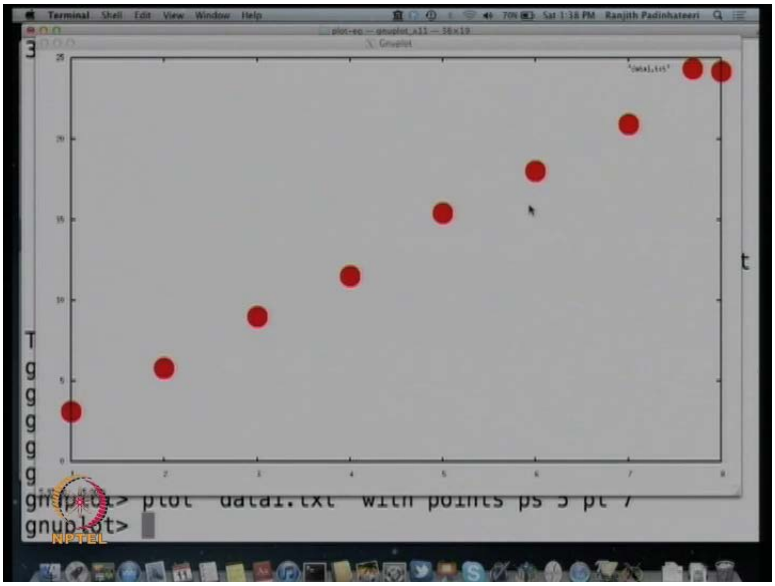


So, if you are in a particular folder, let say you are in a in the folder that, where this data file is there you saw take the g n u plot or you put the data file in the folder of the g n u plot and say plot the file name with work codes. So, you can say codes, single codes for

example, can you either the single quote or double quote data 1 dot t x t, this will give you and you can say with points, point size 3. So, this gave me data file like this.

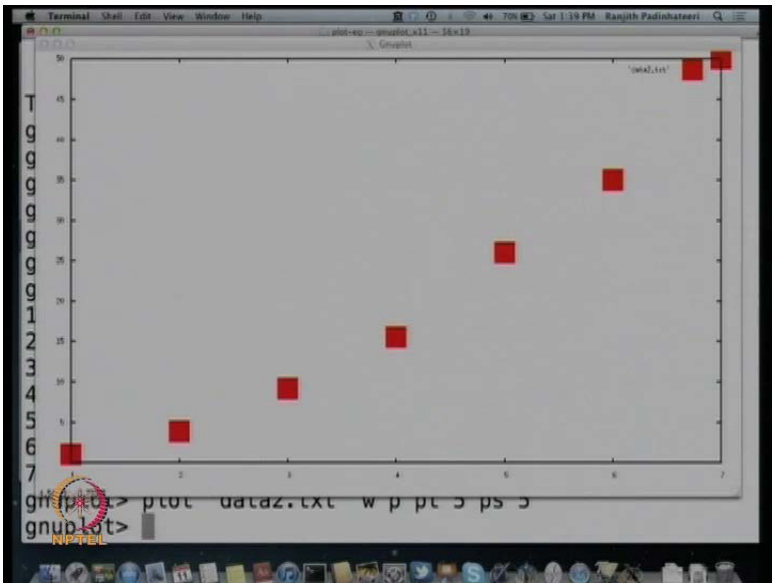
So, what did I do, why did a simple thing, I said that plot data 1 t x t, the file name in quotes, in single quotes and with w p means with points and I can specify points size 3, point type 5. So, this is, even without this, it will plot, it will be very small, but so, this is very small, which even you cannot see, that is why I said plot data 1 dot t x t, you can either use double quote or single quote then is a with points with I can type everything in detail with points, point size 3, point type 5. So, point type 5 typically means squares like this, fill squares like this and you will get this, I can change this to point type 6, I will get something else.

(Refer Slide Time: 22:54)



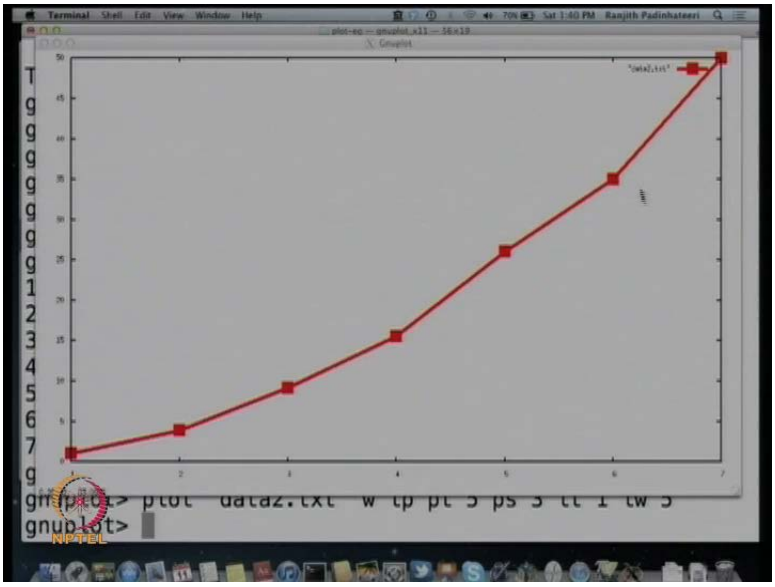
So, if I change point 6, I get open circles. I can make it 7, point type 7, I get filled circles. So, this is the way of changing this. So, I can say point size, instead of 3, I can put point size 5, you get huge points. So, I get bigger points. So, these are this this almost looks like a straight line, I have another set of files here, data 2 dot t x t which is another set of files, let us plot this plot, data 2 dot t x t with point point type 5, point size 5.

(Refer Slide Time: 23:37)



So, this looks like, in order this like a some curve. So, it is like a more more like a quadratic function. So, this is now, if you want to plot this with line, you can say instead of, you can say that plot data 2 dot t x t with line points l p and you can say point type 5, point size whatever you want, let say 3, you can also say line type 1 and sorry no comma line type 1, line width 10 or let say 5.

(Refer Slide Time: 24:23)



So, the you can specify the line type and line width, just like point type and point size you said and that will give you something with line end points. So, there is a line through

that and there is a point. So, this is the way to plot data functions data files. Now, g n u plot also can be used to fit some functions. So, let me write it here, quickly what did I do now, to plot data. So, that it will be useful for you.

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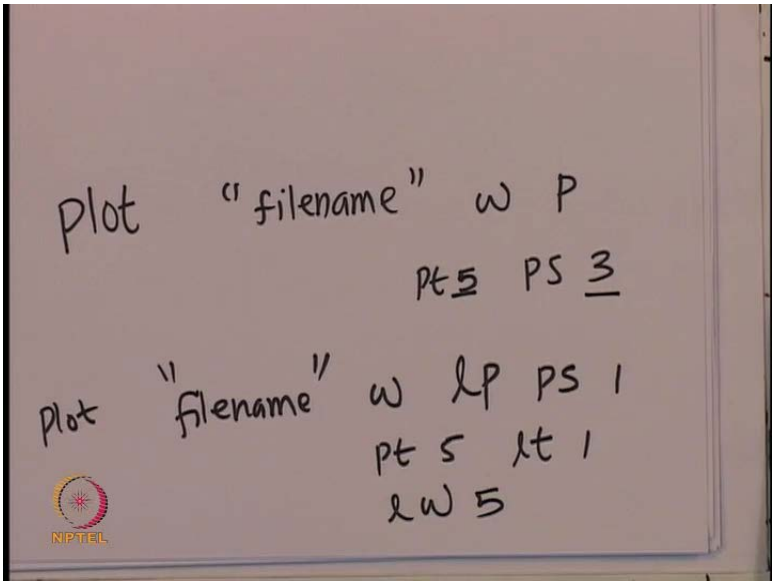

So, the to plot data you have to say plot, file name whatever the file name, it will be just simple text file. So, whatever the file name with extension you can say and you can say with points and specify point size 3 and you can specify point type point type one, two, three, four, five, there are various numbers. So, you can change this number one, two, three, four, five and you will get, you you can play around with then you can also plot the data file with line points and you can say point size, point type, point size one or point type, whatever 5 and you can specify line type, one line width some number 5 or 3.

So, this is the way, you can you can use it for plotting various functions, various data functions and various data files. You can also use this for plotting, let us say fitting for for for fitting data. So, you have a data file now, how do we get the best fit. So, that is the second next thing that we will demonstrate, how do we get best fit from this, from a simple data. Let say, let us look at the first data that we did.

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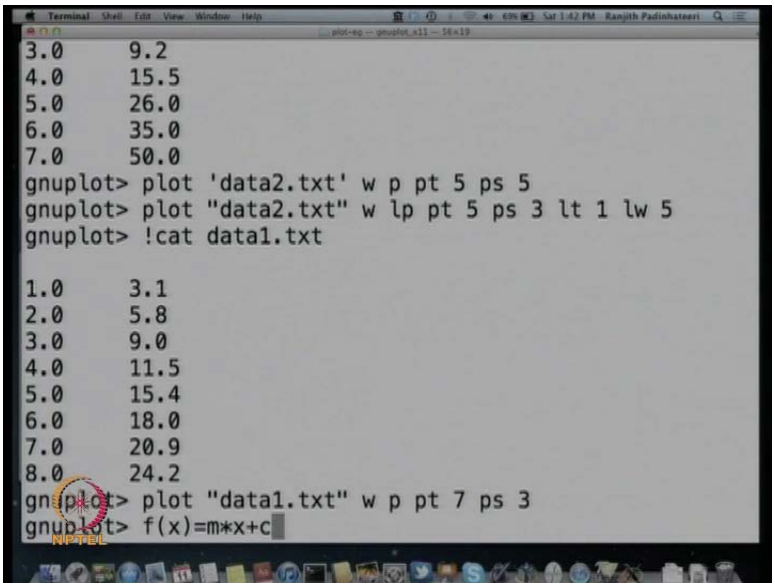

So, we had this data called data one dot t x t. So, if you look at here, 1, 3.1, 2, 5.8. So, let us plot here first, plot data 1 dot t x t with point, point type 7, point size 3. So, this this is almost looks like a straight line. Now, if this is, (( )) if you know this is straight line, the way to fit is the following. So, first then that the, you know that the function you want is the straight line. So, give a command f of x is equal to m X plus C.

So, this because, this is the equation of this straight line, f of x equal to m X plus C is the equation of the straight line. So, you say that f of x is equal to m X plus C, you enter that. Now, you want to know the value of m and C. So, the command is fit f of x, space the file name you want data 1 dot t x t via m comma C, fit f of x data 1 dot t x t via m comma C.

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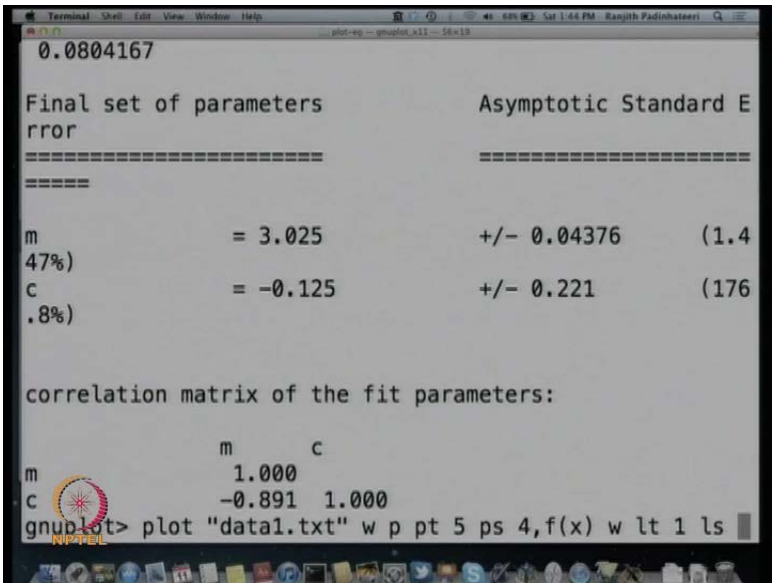

So, if you give this command, you will get lot of calculations here and you will get some values here. So, which and it comes back which means that, the calculation is finished, it has done some calculation and it has some generated some parameter you can see that, final set of parameters.

So, m is equal to 3.0 to 5 and C is equal to minus 0.1 to 5, this is the parameters it got. So, then you can say a plot, the data file data 1 dot t x t with point, point type 5, point size let say 4 then you can plot the f of x with line type 5 and line type 1 and line size 4 sorry, you can say f of x with line.

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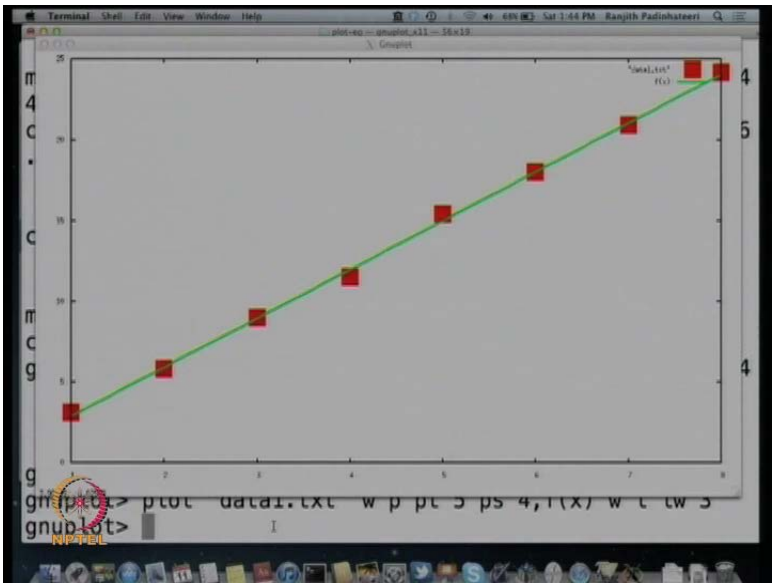

So, you have f of x with line. So, this is the best fit. So, you can say, f of x with line line width 3. So, here you have, this is the best fit. So, to do the best fit, let me do this once more, if you know the function and if you know the data file.

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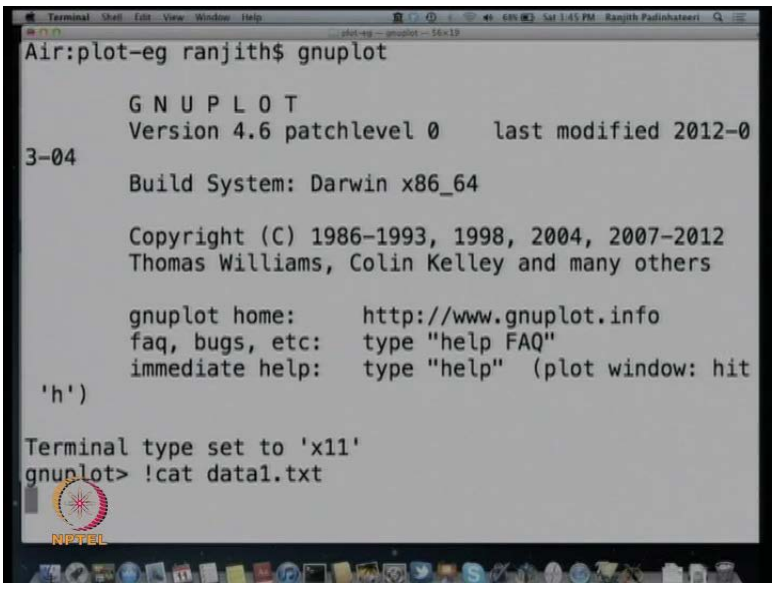

So, let me do this, let me clear this and take it again, if you know that the file, it plot is data 1 dot t x t and if you know that this, what you have to fit is the straight line, first you have to define a function f of x. So, define f of x is equal to m X plus C, m in to m star X plus C then say fit f of x space the file name, data 1 dot t x t via m comma C, these are

the two parameters, that we have to find out and enter and calculate the parameters and will give you, what are the final parameters here and then to plot it, plot data1 dot t x t with point, point type 5, point size 3 then you have to say f of x, this is the function that we now, when you say f of x, it is it is already taken the value of m and c, which you get here.

So, it is already taken the value of m and C from here and then has generated in f of x then you can say that with line, line width 4 and that will give you this. So, you also learnt, how to plot, how to fit it, you can fit the same thing using instead of f of x equal to m X plus C, I can say f of x equal to m X square some other function. So, let us see this. So, let say you have data, let us have a look at it plot, data 2 dot t x t with point, point type 5, point size 3.

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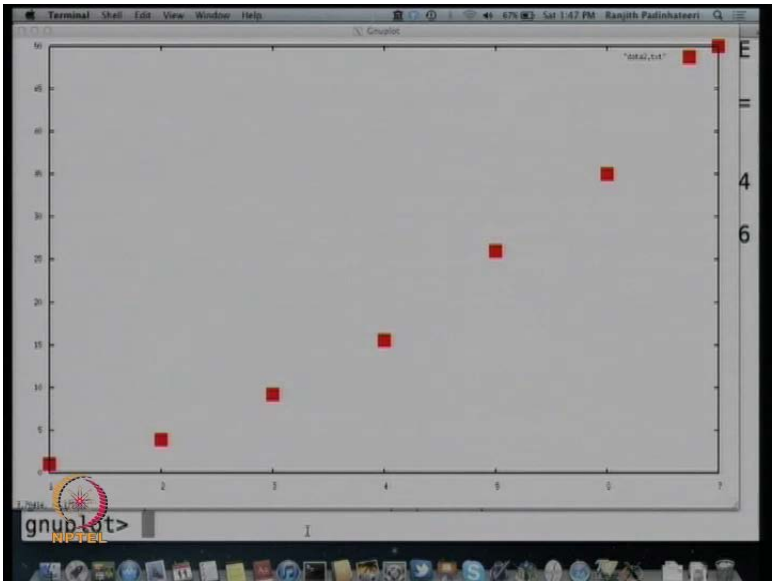

So, this will give you some function like this. So, this is the data 2, this looks like a quadratic functions. So, let us fit a quadratic function to this. So, if you how do we fit a quadratic function. So, to fit it, fit this let us say f of x is equal to k in to x square.

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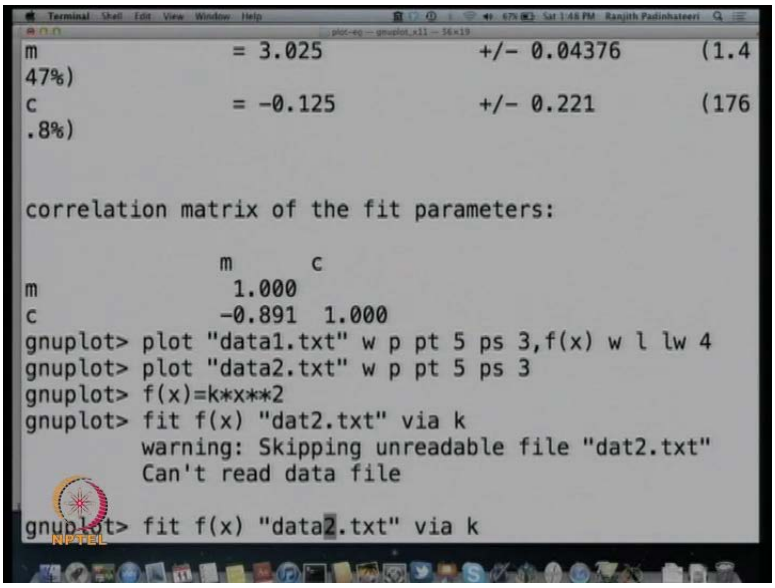

So, I said f of x equal to k star x star star 2, k star x means k in to x star star 2 means k x square. So, now, say that fit f of x data 2 dot t x t via k, k is our parameter here, I have made a mistake data 2, so, data 2 dot t x t.

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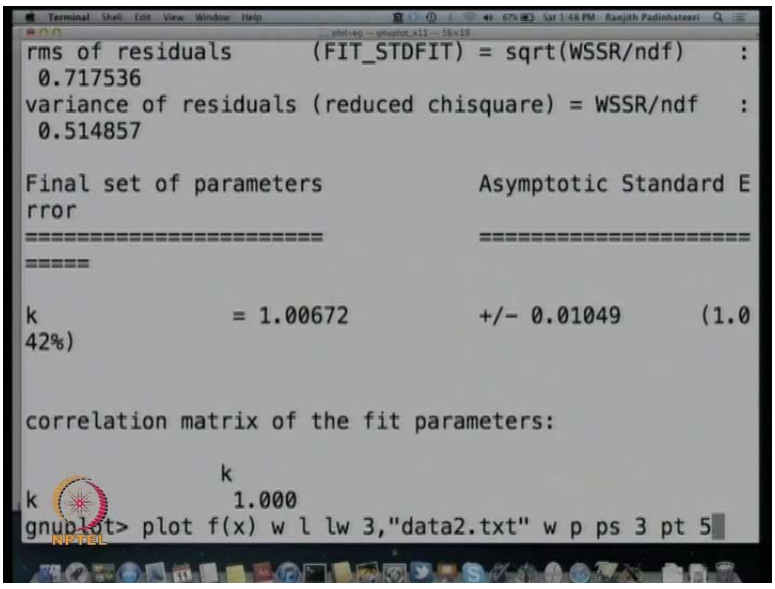

So, it gaves and generated some k just 1.00672 then now, I say plot f of x with line, line width 3 and then data 2 dot t x t with points, point size 5, point size 3, point type 5, this is the best fit. So, this is the way to do best fit.

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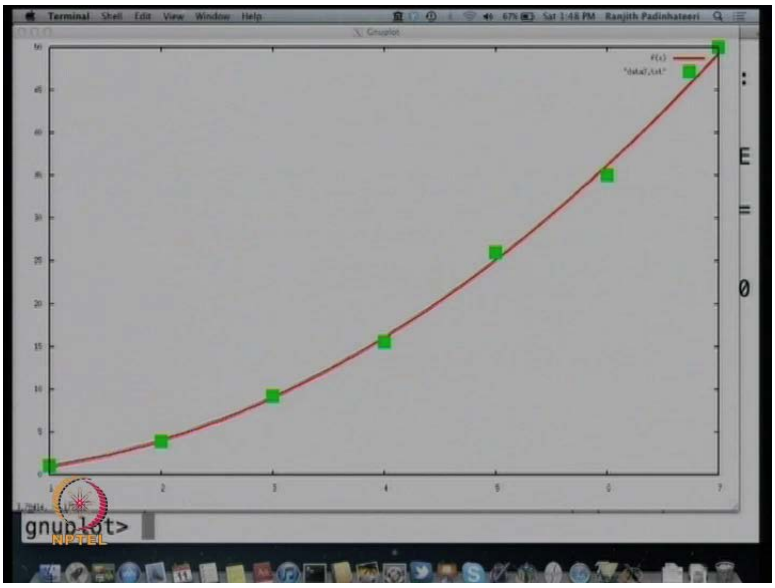

So, what we saw is, how do we fit a function. So, let me quickly write here to fit, you have to have a data file and a functions.

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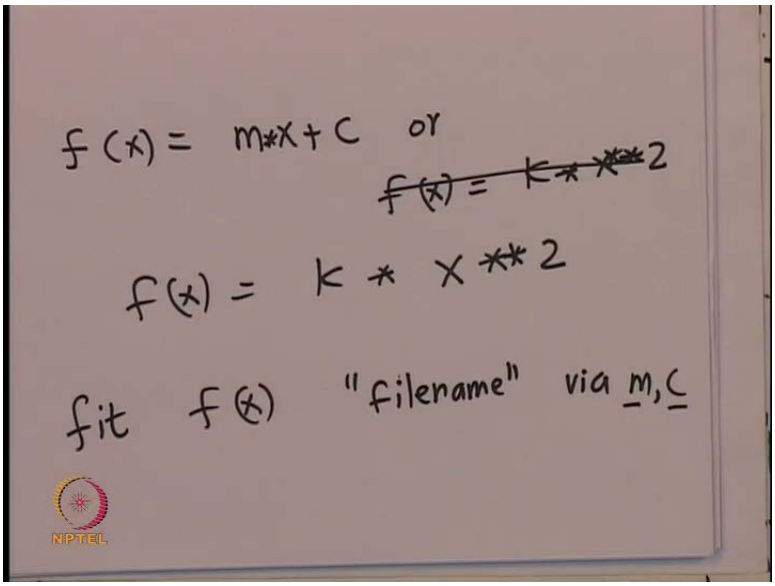

So, then the command is first, you do define f of x for example, is equal to whatever function you want, either m X plus m star X plus C or you can say, f of X is equal to K star X star star 2, 2 stars then you write it f of X is equal to K star X double star, double star means K X square then you say fit f of x then the (( )) file name (no audio from 33:28 to 33:33) via the parameters. Here, the parameters in this case m and C m C.

So, you can say, m comma C. If you have more parameter, you can say m comma C comma something else. So, the are enter, you done then you get the final parameter (( )), it will g n u plot will calculate this parameters m and C. Now, there is only one more thing will discuss about g n u plot, one thing you would want to do is to learn, how do we save a file from g n u plot, an export it has either post script or p d f or any other format. So, the command to do that is said terminal.

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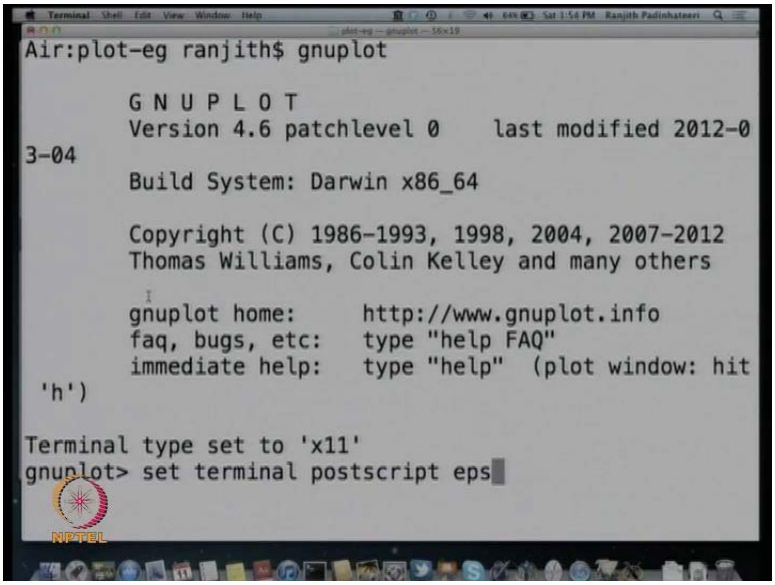

So, let us do this. So, let let us say, we are doing an exercise which is plotting sin x and saving it is. So, we take g n u plot and let say you want to plot sin x and save it has e p s file. So, the way to do is as I said terminal post script e p s, e p s is the format enhancelate enhanced post script actually encapsulated post script. So, this is the particular format which is used widely it for printing and all that. So, let us save a file into the e p s format. So, you type the command set terminal post script e p s then you said that plot.

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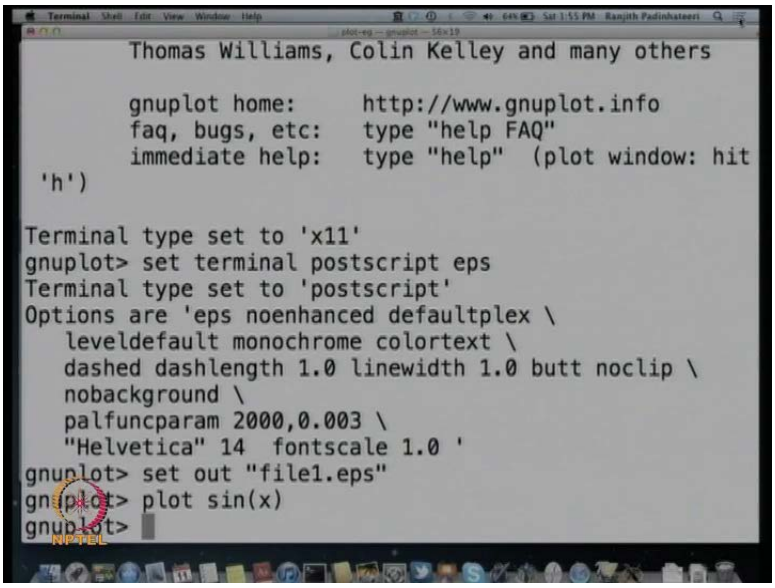

So, then you have to say, set out put file name dot e p s whatever file name you want, let say, I want to save file 1 dot e p s, set out put, out, set out file 1 dot e p s; that means, you have to set the output file has the file name related to this file then I say plot sin x. So, the output will be saved in a file called file1 dot e p s.

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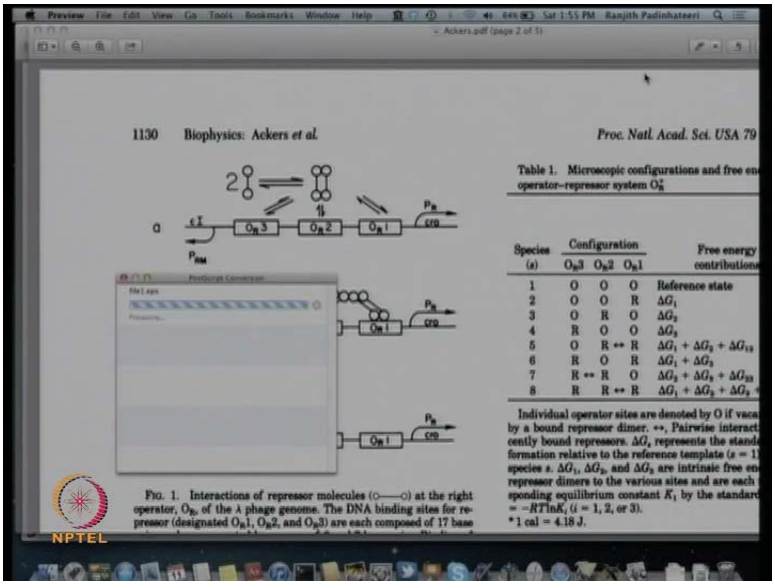

So, if you just look for file 1 dot e p s, what you will get is, this file which you just saved from this, what you will end up getting this just just this file sin x. So, you will you will

see that this sin x plotted, you will you will get the sin x plotted here. So, this is the way basically to do this. So, you got the, basically you got the sine x for this plotted here.

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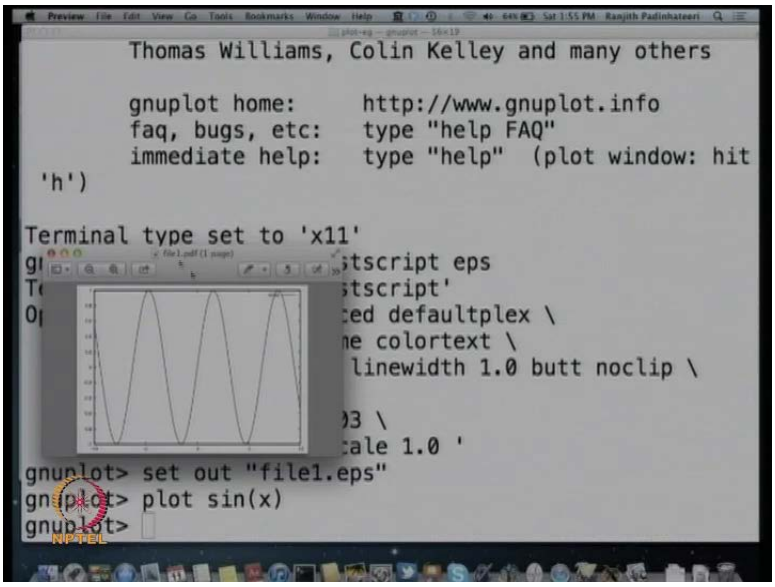

So, you you can of course, do this set terminal color and so more, there are many more things, but this is just an overview, you can do Google search and learn many more things, there are help files in the internet, my aim here is to just introduce you to a very simple software called g n u plot, which is the open source free software which will help you to plot, pretty much any function do any vari various simple things and how do we you say, how do we you said, can be seen from the internet, there are manuals, you can read them, I just gave you a very quick guide for you to start, you can use the help command for example, here, if you go to g n u plot and type help plot, it will show you various things like plot various things.

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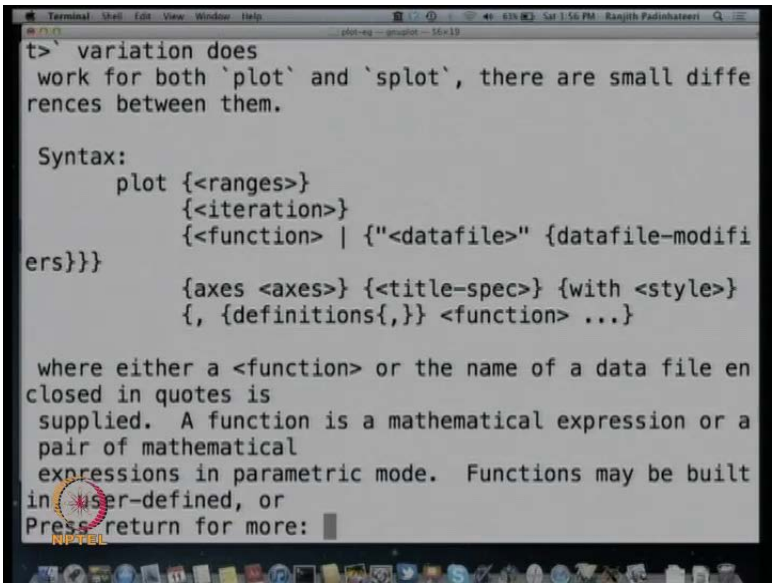

So, you can do use help, you can you can help set terminal, it will show you how do you help set. So, you can use help files here or help files in the internet or you can Google search pretty much anything you want related to g n u plot and you will it is there is a very wide range, very large community of users.

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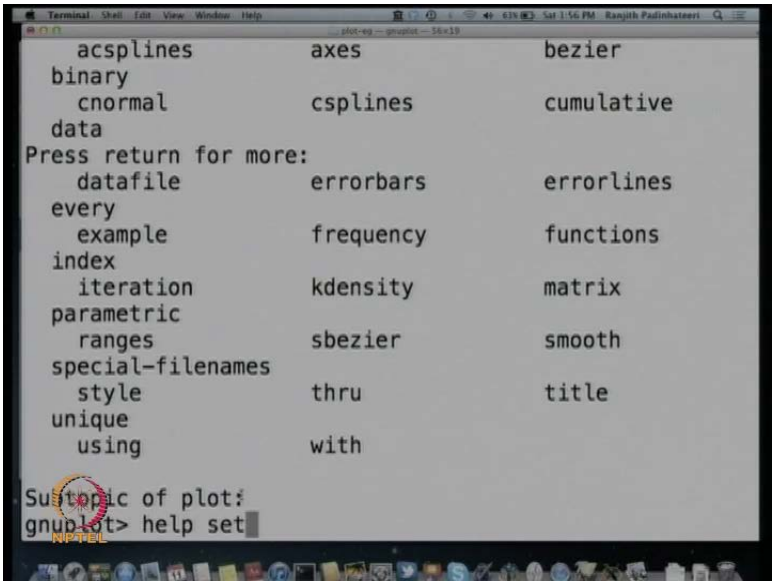

So, they will have almost everything given how to do this very simple, how do you, how do I save a file from g n u plot Googles, you do the Google search on that, you will get

the answer and pretty, that is the simple and dirty way of doing this and you can use it. That is the way to start learning it and I think you should use it.

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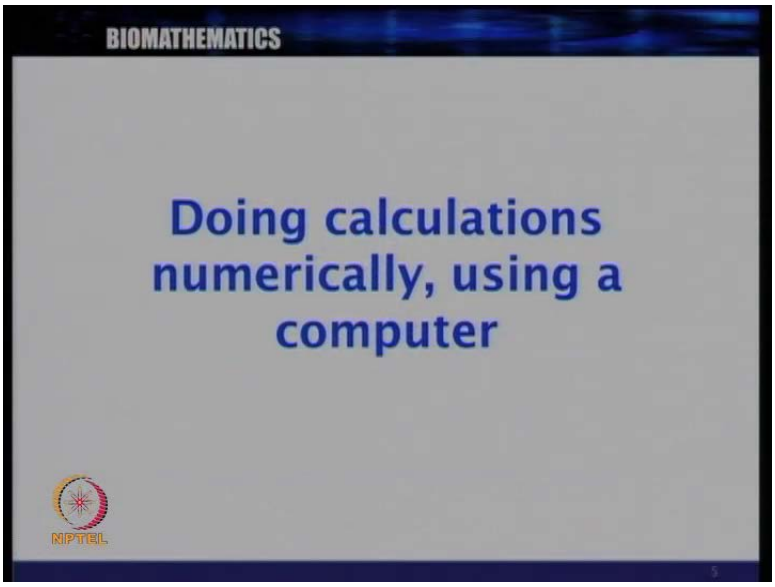

So, this is one important thing that we learnt and we will quickly go through some other questions that people might have. Another thing is this doing calculation using a computer. So, this can be done, there are many software's like mathematic obvious will help you, if you want to do many of this calculations using computer. I would not go and discuss, how do you use mathematical (( )), let me write here, this software called mathematica which you can do analytical calculations using computer.

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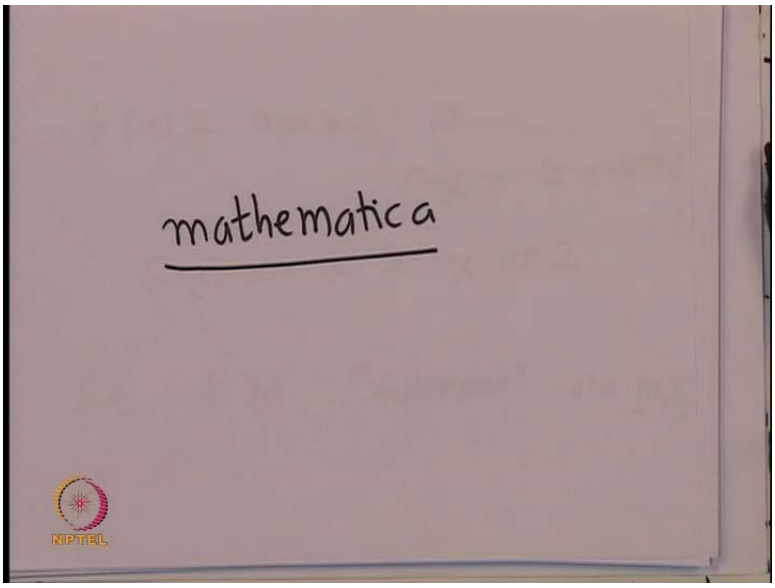

So, this is a software, it is seems to buy, but therefore, it is not freely available. So, it is not it is not an open source software, we would not discuss that in detail, but it is one software where you can do such calculations analytical analytical calculations and you can do a many other things numerically, you can do integration numerically, there are various in numerical schemes. So, use software's like math lab will help you do things numerically. So, you can give a data file and inte do the integration numerically or you can write programs for example, there are like books itself called like numerical recipes which will give you various numerical methods to do various, many of this calculations numerically.

So, this is something which you would want to go and look at it, look this both this programs, how do you do this numerically because that itself is a separate course, but I just want to mention that, all this things when you do like when you you you can, if you can do it analytically, you have data set and you cannot do this calculations analytically or you cannot do integration of a function analytically or you cannot solve a differential equation analytically, you can do that numerically, there are numerical methods like Runge kutta and various other methods.

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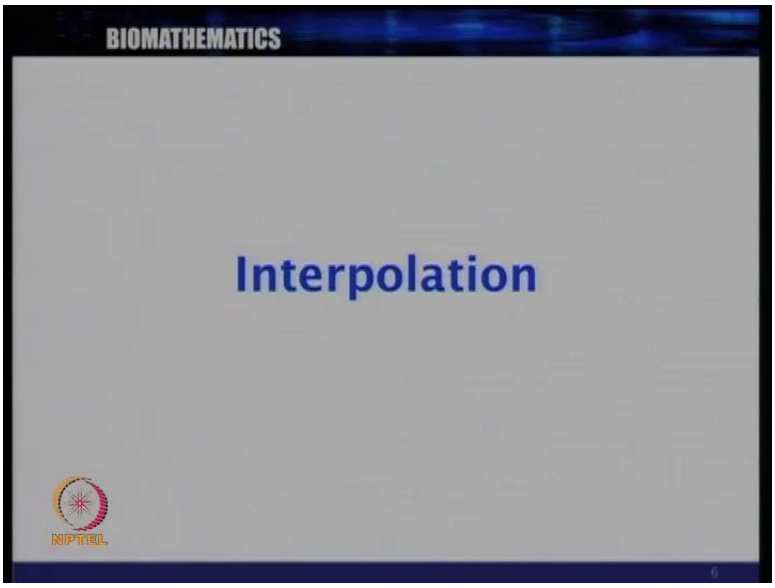

So, one can, one has to go and learn this methods, but the basic idea, what we learnt, so far, it will vary useful for all this. So, now, another question will be something like interpolation, what it means, I will do there are various interpolation methods. Let us do a simple thing.

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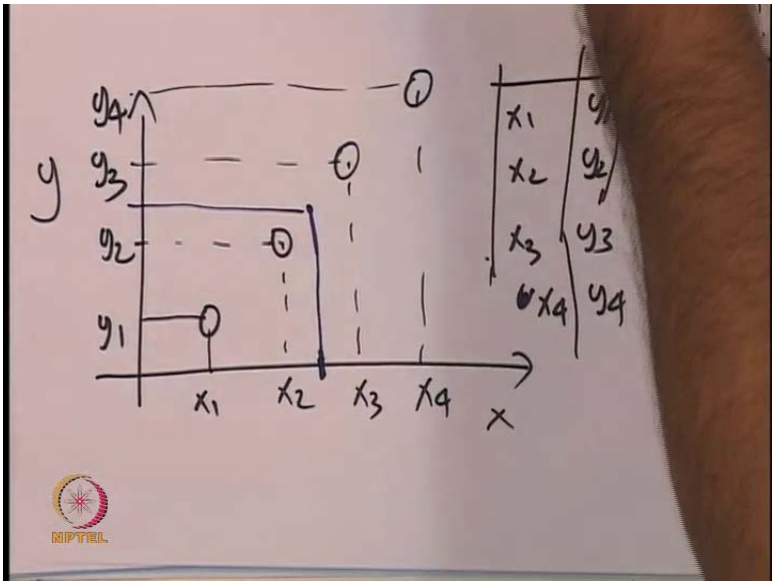

So, let us see have a graph and you have function here and you have data points like this. So, this is, what you get here, you have an x and you have y and you have y of x and I know that, this is the data points you get from an experiment and there is an x value and

there is the corresponding y value; there is this the x value, this is the corresponding y value; this is the x value and this is the corresponding y value; this is the x value and this is the corresponding y value. Now, let me call this, x 1, x 2, x 3, x 4; y 1, y 2, y 3, y 4.

Now, one simple question is that might arise is that I, so, here I have this table, which is I got from experiments which are basically x 1 and y 1, the values x 3, y 3 and x 4 and y 4. These are the values, corresponding values and this is the table I got in this function I got. So, if I have some function like this. The simple question that might arise is, how do I find, what is the value of the function here. Let us say for this particular value of somewhere in between this, how how do I how do I get this particular point.

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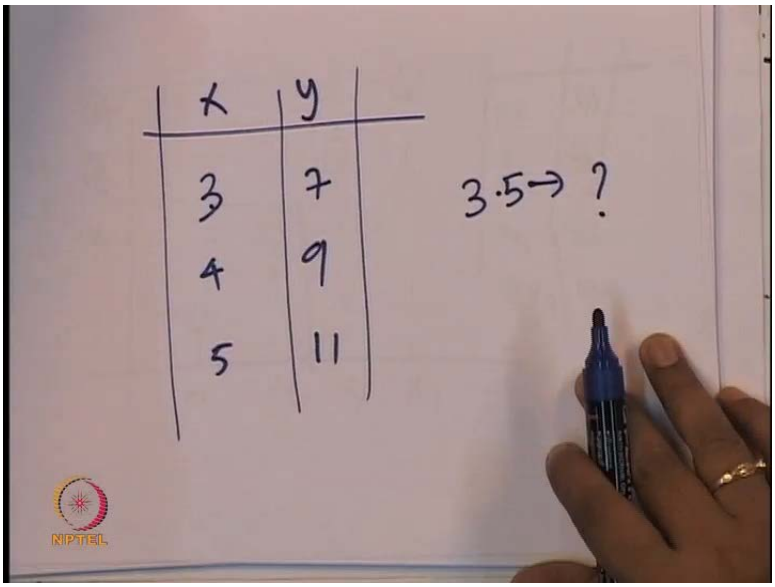

So, if I know for example, a table and I know this value 3 and I have 7; 4, I have let say some other function here, let say 9; 5 you have 11 and so on and so forth. So, how do I get the corresponding, the value let say, I want to get the value, what is for 3.5, what is the value corresponding to 3, I have, corresponding to 3, I have 7, corresponding to... So, this is x and y, corresponding to 4, I have 9; corresponding to 5, I have 11, but what is the value corresponding to 3.5.

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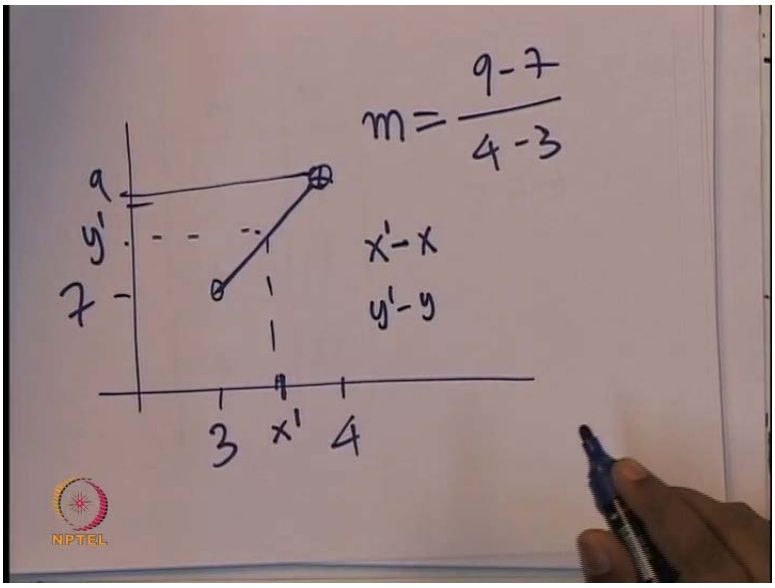

So, the simplest way of finding this is that, to assume that between 3 and so, if you plot this, what do I have, I have corresponding to 3, I have 7. So, I have a value here, corresponding to 4, I have 9. So, 4, I have 9, let say corresponding to 4, I have 9 here. So, this is my second point, this is 9 and this is 4 and this is 3 and this is 7. Now, the simplest assumption to, so, I want to know, what is for 3.5, is it here.

So, this is the simplest assumption, if you make that, it is a straight line between this and this, what does the mean is that, if I know that this, if I assume that, this is the straight line between this then the value of this can be easily found. So, this means that, the slow up of this straight line m is d y by d x; that means, 9 minus 7 by 4 minus 3, this is my slope. So, if I know this slope, I can calculate then I can this calculate the new value, which is between this 3.5. So, let me call this x prime. So, then from what do I know. So, this is d y by d x.

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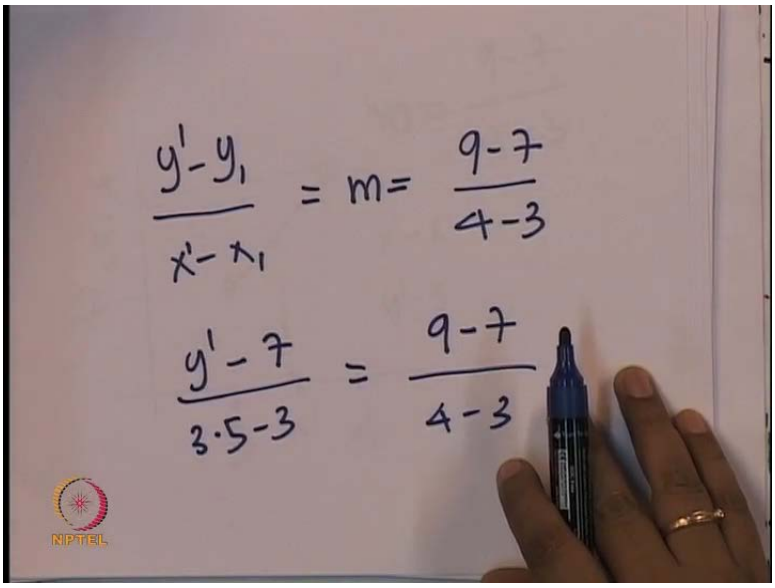

Now, let me, I want to get this new value x prime and new value y prime and what do I know, I know that x prime minus x and y prime minus x y, if I find out this and the ratio of this, that is, I what I want to find out is the x prime and y prime and if it is the straight line, we know that the y prime minus y divided by x prime minus x has to be m which is same as 9 minus 7 by 4 minus 3. This is the slope, 9 minus 7, 4 minus 3.

So, here, I know the value of this. So, this is my y 1 and x 1. So, this is my for example, this is 7 and 3. So, then based on this formula, if I know x prime is 3.5, I can say that y prime minus 7 divided by 3.5 minus 3 has to be equal to 9 minus 7 by 4 minus 3. So, I have an equation, the only unknown is y prime. So, in this, from by solving this, I can calculate y prime. So, what did I do. So, what did I do here, let me explain this once more.

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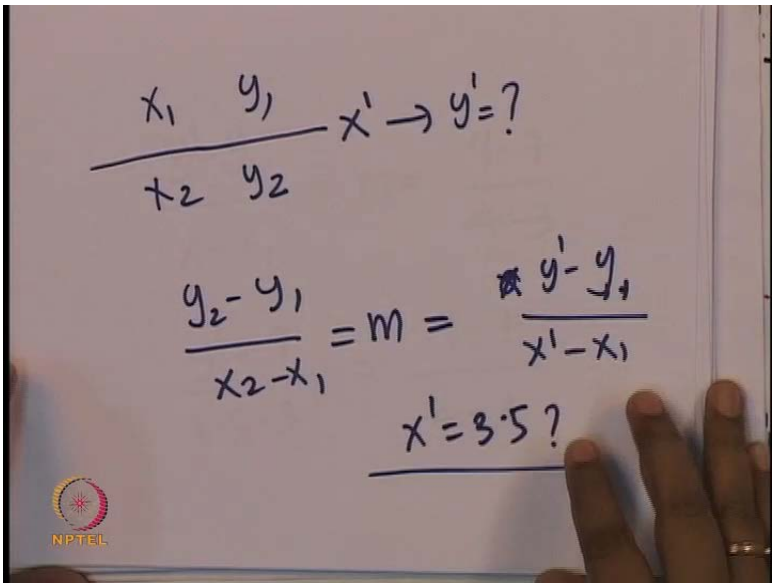

So, we had X 1, y 1; X 2, y 2 and we know that, y 2 minus y 1 by x 2 minus x 1 is the slope m, if you assume it is a straight line and let say, I want to find out a point in between this which is ahead corresponding to x prime, what is the value of y prime. So, if I know the x prime and if I want to get y prime, (no audio from 45:34 to 45:38) immediate thing, we can say that, this is also equal to y prime minus y 1 divided by x prime minus x 1. So, I know y prime, I know y 1 sorry I do not know y prime, I know y 1, I know x prime, I know x 1 then I can solve this equation and get this. In the previous example, we had x prime is equal to 3.5.

So, what is the corresponding value, we can solve this and you can get this. So, this is some kind of useful thing which people to sometimes wants. It is very simple thing assume in this idea of slope which we learnt. So, with this lecture… So, with this some other simple questions which you would want to use, simple idea that you would want to use. So, basically, if the main thing of this lecture was to use g n u plot and how do we do this plotting a functions using a computer.

So, with this, we had (( )) of how do we plot using computer with this, I will stop today's lecture, and this as move with through this you learned, how do plot various functions using computer. And you can also, I just also told you that you can use computer for doing many of this calculations, but before using computer one has to understand, how all this things work and that is what we discuss in this course, how do how do all this,

what are how do we do this by pen and paper and once you understand that. You can go and use computers for making things things simple and faster, but the underlying ideas, we should learn ourselves and this is the what, this course I hopefully will help you. Bye.