Optimization Methods for Civil Engineering

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Lecture - 28
Introduction to R Software

Hello student welcome back to the course on optimization methods for civil engineering. So, I have already introduced you on R software. So, we have already learned how to download and the R software then R engine and R studio as I said that we are working on R studio, but we have to download R engine and then R studio.

So, already I have introduced you what is R and then we also discuss what is vector how to define a vector then what is matrix, then simple matrix operation vector operations, so that we have discussed in the last class. So, today I will introduce you some of the more about R. So, how to write an expression? Then how to plot a particular function, so that I will discuss in this particular class; let us see how we can write a function or an expression on R ok.

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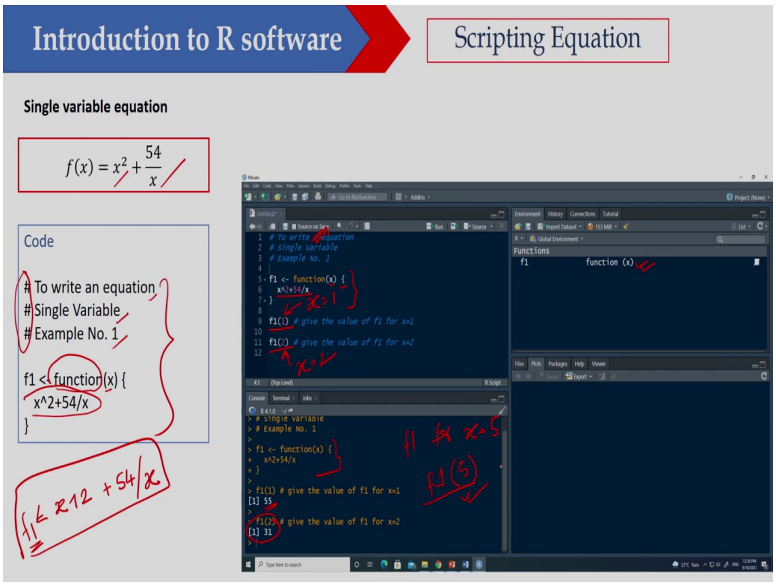

So, let us see I would like to write this equation the equation is f x equal to x square plus 54 by x. So, this is the code I have given so first 3 lines, so these 3 lines are common lines. So, that will not be executed. So, what I have done. So, this is to write an equation, so this particular example is to write an equation and this is a single variable function and this is example 1.

So, already in the last class I discussed that if I would like to write a function, then what I will do? I have to use this particular function keyword ok. So, here what I have done? So I have written f 1 equal to function and then x. So, x is a variable here, so this is a variable x. So, we have only one variable that is your x and here within bracket I have written that is x square plus 54 by x. So, what I have done x.

So, to write square so what I will do this is cap and this is square and this is 54 and then by x ok. So, this is I have written f 1. So, f1 is a so, f1 is a function, so f1 so here whatever this output of this particular function is stored in f1 ok. So, this is the variable and this variable contain the function x ok. So now, if you look at this is again I have executed here this will be n equation ok.

Here you just see I have written that f1 that f1 equal to function x and then I have used second bracket here and I have written the expression here, that is x square plus 54 by x and now if I execute then you can see this particular function here. So, you can see that I have executed these two these three lines then I am getting this particular function and now I would like to calculate what is the value of this particular function for x equal to 1.

So, then what I will do? I will write f1 within bracket I will write one then I am getting 55 here and f1 for x equal to 2. So, here this is x equal to 2 and here this is x equal to 1, so x equal to 2 I am getting 31. So, once you are defining once you are defining the function then after that for any value for any value of x you can calculate the output of that particular function or output of that particular expression ok.

So, I hope this is clear to you. So, I can define this function and if I need to calculate suppose for what is the value of f1 for x equal to 5. So, what I will do? I will write f1 and then 5. So, if I execute this one then I will get the value of this particular expression or function for x equal to 5 I hope this is clear to you.

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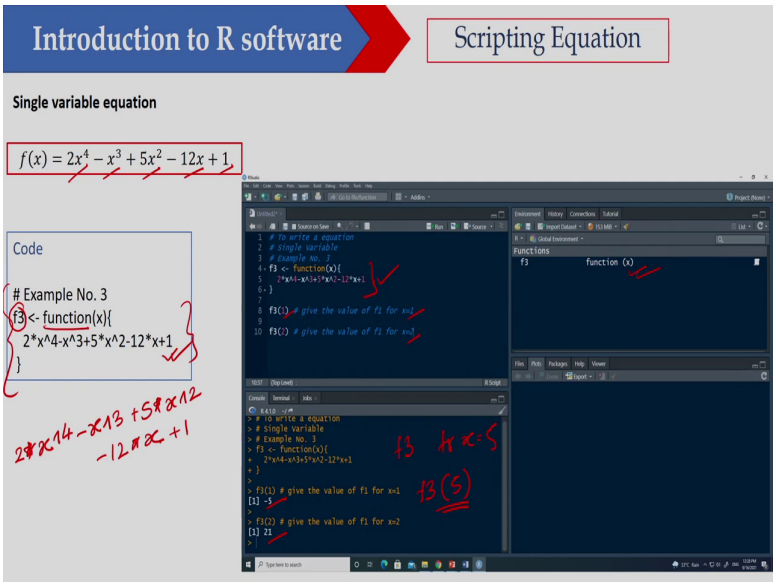

Now let us see another function this function is twice x to the power 4 minus x cube plus 5 x square minus 12 x plus 1. So, this is a function and I would like to write this particular function. So, this is what I have to do this is the code I have shown here and this code is so I have I am writing this is function and I am storing here f 3. And this is so here this is 2 star this is x to the power4 ok, then plus sorry then minus then minus x to the power 3 plus 5 star x to the power 2 minus 12 star x plus 1 ok.

So, I have written here and I am defining this particular function. So, if you look at here so you can see so this is the function I have defined. So, once I am executing this particular 3 line, so I am getting this function and then I can calculate the value of this function for x equal to 1 and x equal to 2. So, I am getting this is minus 5 and this is 21 ok. Now as I said suppose I would like to calculate what is the value of this particular function f 3 for x equal to

5, then what you will do this is f 3. So, you will write 5, so you can calculate the value of this particular function.

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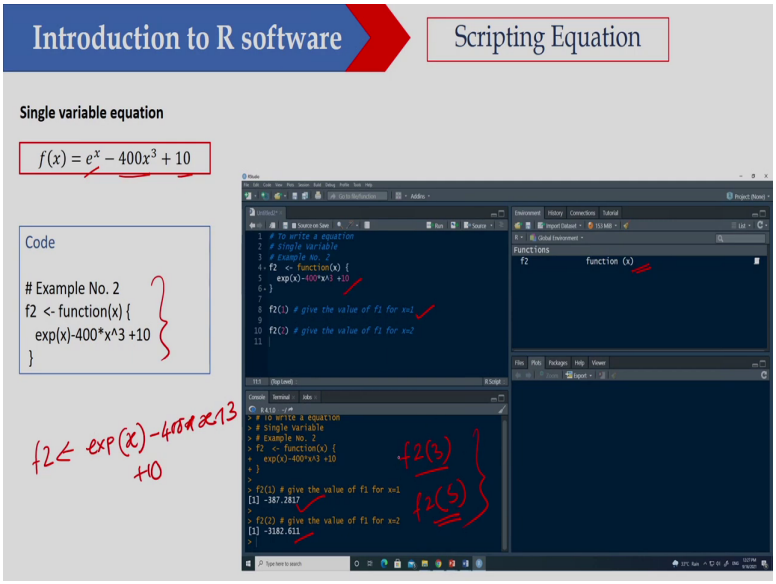

So, let us see this is another function and the function is again it is a single variable function and the function is f of x equal to e to the power x minus 400 x cube plus 10. So, this is the code here and the expression is for f 2 is so here this is exp, so I have to write this is exp x minus 400 star x cube ok plus 10.

So, if I execute then I will get this particular function and then I have also shown then if I need to calculate the value of this particular function for x equal to 1. So, this is I am getting here this is minus 387.2817 and then this is the value for x equal to 2, similarly if I need to calculate for x equal to 3.

So, I can calculate similarly if I need to calculate for x equal to 5, so I can calculate using this one. So, once you are defining functions or for any value of x you can calculate the value of this particular function. So, let us see another function, so this is a multivariable function.

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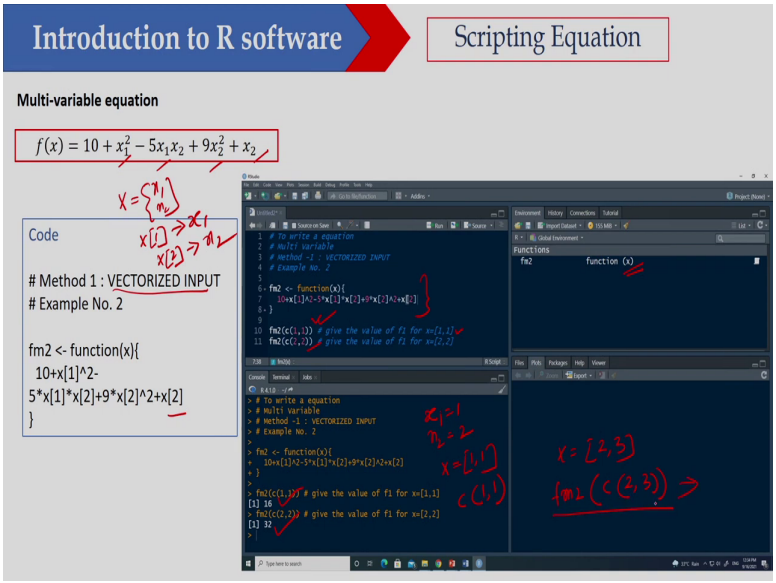

So, we have two variables here, so here we have 10 plus x 1 square minus 5 x 1 x 2 plus 9 x 2 square plus x 2. So, here I am using vectorized inputs. So, what I am doing? So, I am defining a vector x and this x is x1 and x2. So, if I write x 1; that means, this is your x 1 and if I write x 2. So, then this will be your x 2, so here I have written 10 plus x 1 square minus 5 x 1 into x 2 plus 9 x 2 square plus x 2. So, I have written the function here.

So, once you are executing you are getting this particular function and now if you need to calculate the value of this function for suppose x 1 equal to 1 and x 2 equal to 2. So, what you have to do? So you have to define a vector ok so that is your 1 1. So, how we are defining? So

we can define a vector by c that is 11. So, I am putting here, so this is for 11 that means x equal to 1 x 1 equal to 1 and x 2 equal to 1 so you are getting 16 and similarly for 2 2 you are getting 32.

Suppose I would like to calculate for x equal to 2 3. So, then what I will do? I will write f m 2 and within bracket then I have to write 2 3. So, c equal to 2 c 2 3 so then I will get the value of this particular function.

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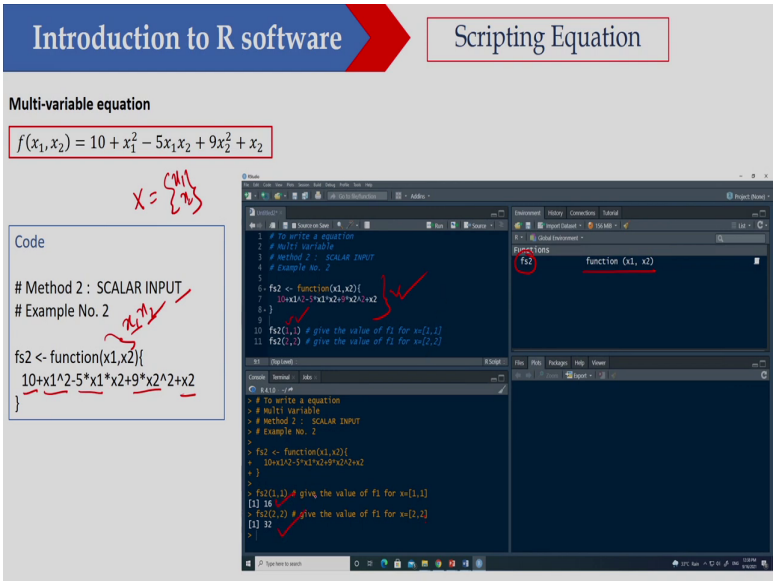

Now what I can do? I can also give the scalar input. So, in this case in the function itself so I am writing this is x 1 and x 2. So, in earlier case I have defined it as a vector. So, which contain x 1 and x 2, but in this case I am actually giving the argument x 1 and x 2 here. So, in that case so I can write it 10 plus x 1 square minus 5 x 1 into x 2 plus 9 x 2 square plus x 2.

So, this is the function I have defined here and if I execute this particular function. So, I am getting this function now this fs 2 is there and you can give the arguments or input for this particular function. Suppose here I am calculating for 11 and then I am getting this particular value this is sixteen and this is 32. So, now let us see a multivariable function.

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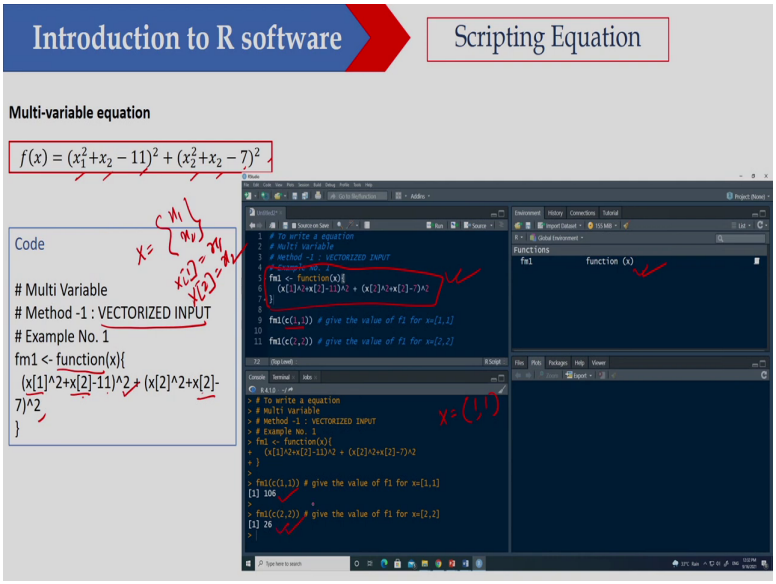

So, the function is x 1 square plus x 2 minus 11 whole square plus x 2 square plus x 2 minus 7 whole square ok. So, I would like to write this particular function, so here what I am doing? I am using this function ok and I am defining it as a function and this is x 1 square plus x 2 and here I have used factorized input so that means x has x 1 and x2.

So therefore, x 1 means x 1 and x 2 ok, so x 2 is equal to x 2 ok. So, I have used x 1 square plus x 2 minus 11 whole square then x 2 square plus x 2 minus 7 whole square. So, I am I have written this particular function here. So, if I execute this line so I am getting this

particular function and then if I need to calculate the value of this function for x equal to 11 ok. So, I am putting c 11 this is a vector in I have to give this vector input ok. So, this is I am putting c equal to 11 and I am getting 106 and for 2 2 I am getting 26 ok.

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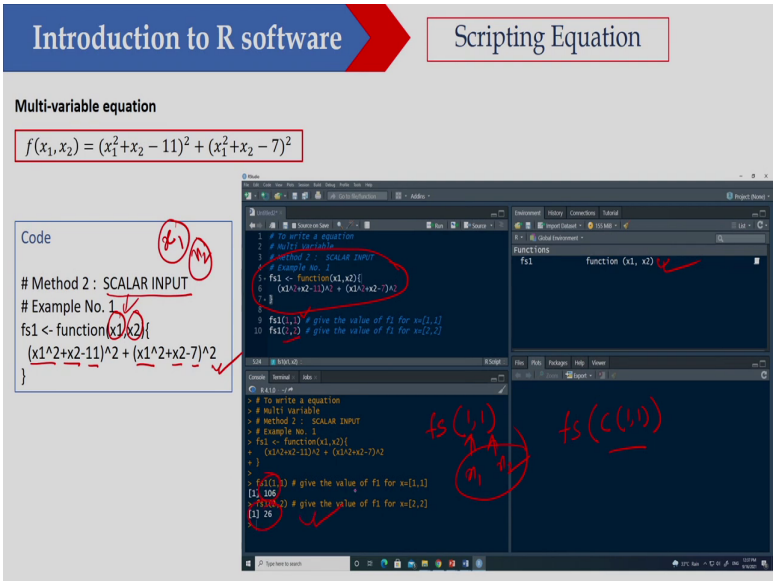

For this problem if I can also give scalar input. So, in that case what I am doing? I am defining x 1 and x 2. So, here again so now this is x 1 is a variable here. So, I am I am writing as a scalar and this is also scalar so x 2. So, I am actually in the argument itself I am giving scalar input. So, this is x 1 square plus x 2 minus 11 whole square plus x 1 square plus x 2 minus 7 whole square.

So, if I execute this line so I will get this particular function and now here you just see this is scalar input. So therefore, what I have to do? I have to give 2 input that is 11 and this value is x 1 and this value is x 2. So, in the earlier case so what I have done I put vector input so this

is 11 ok. But in this case this is scalar input ok. So, I have also shown here suppose I would like to calculate the value of this particular function for x 1 equal to 1 and x 2 equal to 1. So, this is I am getting 106 and for 2 2 I am getting 26. So, in R there is another function that is called abline function ok.

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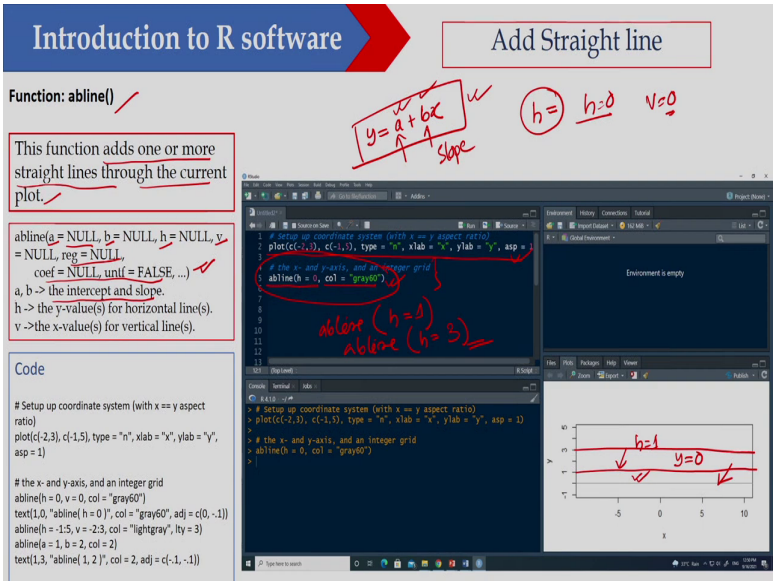

Now abline is an inbuilt function. So, what I can do basically? So, I can use this particular function. So, and to draw a particular line suppose I would like to draw a horizontal line, I would like to draw a vertical line or I would like to draw a line suppose y equal to m x plus c ok. So, if I would like to draw a line so can use this abline function.

So, now let us see how I can use this particular function or and what purpose I can use and how we can use this particular function. The function name is abline the function adds one or

more straight line through the current plot, suppose if you have a plot current plot and on that particular plot I would like to draw a line single line or multiple lines.

So, I can draw using this particular function and this is the syntax for this particular function. So, here I need to define a if I am not defining by default value is null then similarly I have to define b then h then v then the other arguments of this function.

Now, what a, b? So a, b is the intercept and slope so; that means, if I that y equal to a plus b x ok. So, here this a is the intercept a is the intercept and b is the slope ok. So, this is slope ok. So now I can define a and b, so I can draw this particular line. Similarly if I write h, h value; that means it will draw a horizontal line suppose h equal to 0 I am putting. So, I can draw a horizontal line through that is at 0. Similarly I if I put v equal to 0, so I can also draw a vertical line at your 0.

So, I will show you that one let us see this particular function. So, what we are doing basically that suppose this is a b line I am not putting the other arguments. So, only I am putting h equal to 0 and I am putting a color this is gray60. So, this is the color I am putting. So, before that just I plot this one, so what is this will give a plot ok and this is a blank plot I can draw using this plot function.

So, I am just drawing one plot, on this particular plot I would like to draw a horizontal line for y equal to 0 ok, so this is y equal to z line ok. So, what I am doing basically that I am putting I would like to draw a horizontal line for y equal to 0 and then I am putting h equal to 0 here and I am getting this particular horizontal line. So, if I execute this particular line. So, I am getting this particular line.

So, I can draw a horizontal line using this a b line function. So, only if what I have to do? So, I have to write a b line a b line and I have to define h equal to suppose here I have defined h equal to 0, but if I define one then it will draw that y equal to 1 ok. So, a line so, this is h equal to 1 ok. So, similarly suppose on 3 you want to draw then what you will do a b line ok and in this case h equal to 3 ok. So, it will draw a horizontal line.

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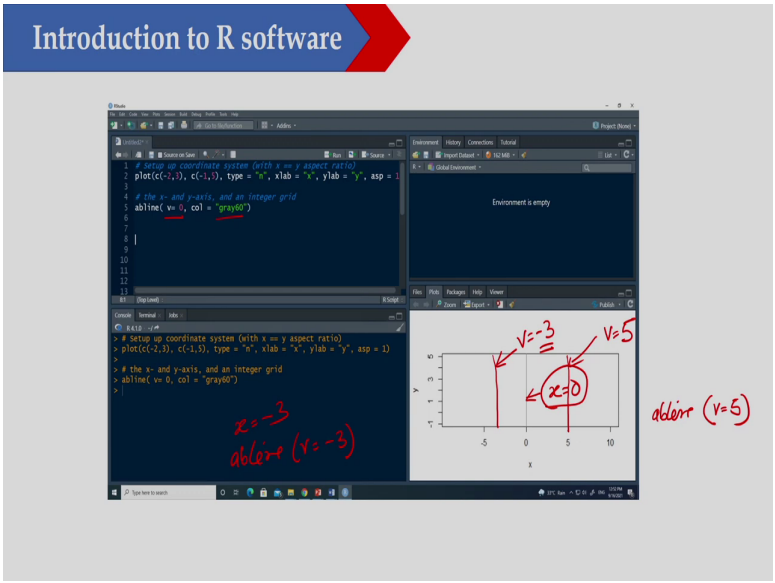

Now, if I would like to draw a vertical line ok, so here at x equal to 0. So, this is a vertical line at x equal to 0 ok, so x equal to 0. So now, what you will do basically. So, you will just write v equal to 0 and in this case color you can define any color, so I am defining gray60. So, in this case what I have done here. So, I have drawn a line for x equal to 0, similarly if I would like to draw a line for x equal to minus 3. So, what I will do? I will use a b line ok then v equal to minus 3 similarly. So, I can draw somewhere trees here, so I can draw a line similarly I would like to draw a line for x equal to plus 5.

So, what I will do? I will write a b line and then v equal to 5. So, I can draw that v equal to 5 and this is v equal to minus 3 ok, I hope this is clear. So, I can draw a horizontal line a vertical line.

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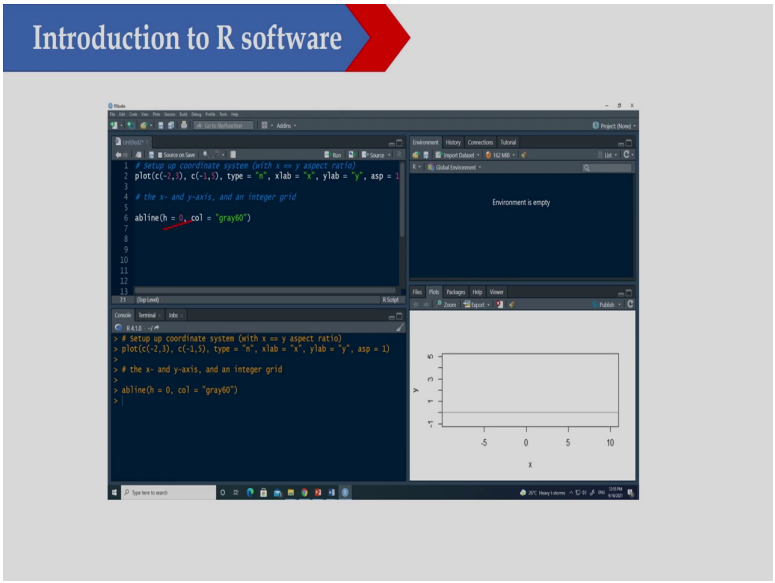

Now I would like to draw a horizontal line ok. So, this is h equal to 0; that means, y equal to 0.

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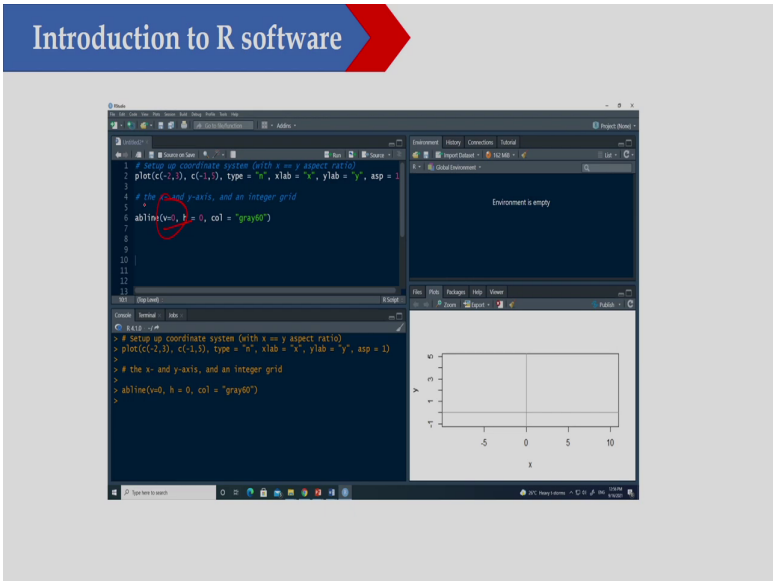

Similarly if I draw a vertical line then I am writing v equal to 0.

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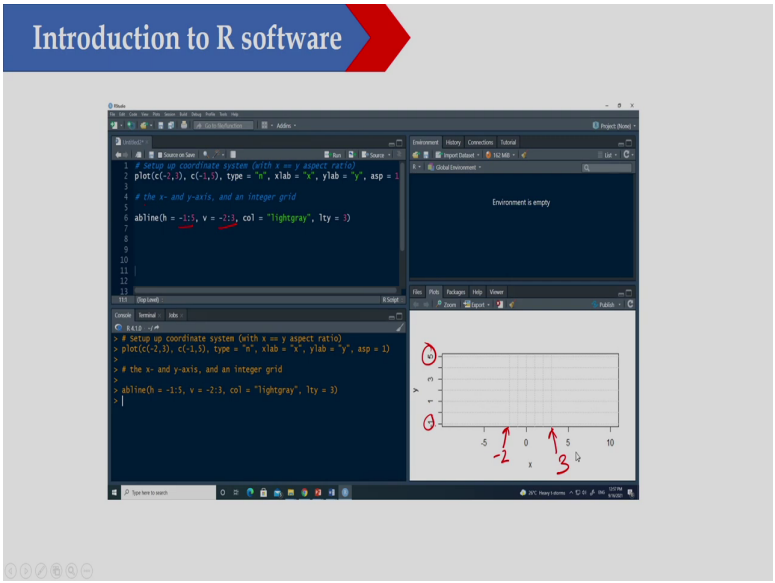

And if I draw suppose multiple lines I can also draw multiple lines here, suppose here I am writing a b line that h equal to minus 1 to 5 ok. So, minus 1 to five that means, this is minus 1 and this is up to 5. So, I am drawing horizontal line from minus 1 to 5 and similarly here this is minus 2 to 3 ok minus 2. So, this is somewhere it is minus 2 and this is fine somewhere it is 3 ok. So, I am drawing this horizontal line so I can also draw multiple lines.

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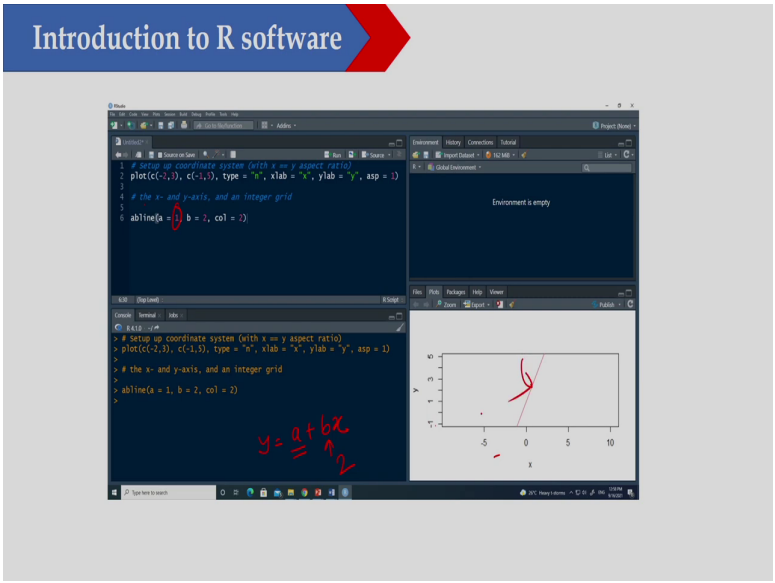

Now if I need to draw a line suppose here I have defined that y equal to a plus b x, so here a is the intercept. So, here intercept is one and slope is 2, so this is the line I am getting.

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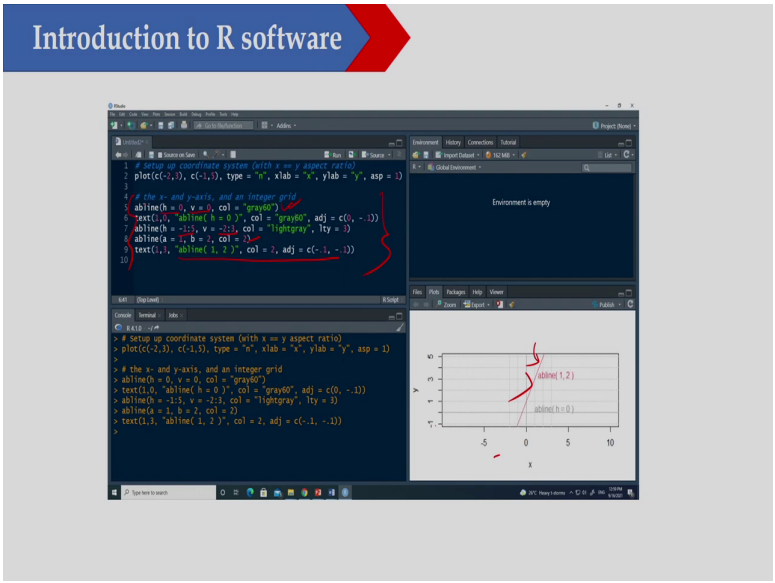

Now, if I execute all this codes. So, what I am doing here? So, I have drawn a horizontal line for y equal to 0 a vertical line for x equal to 0. So, this is the first one and then I am writing the horizontal line for minus 1 to plus 5 and this is minus 2 to 3 ok and then I am drawing this a b line ok. So, this particular a b line and I can also write the level this one so using the text command ok. So, now, what this a b line is doing a b line can be used to draw either horizontal line or vertical line or multiple lines you can draw or basically you can also draw a line with intercept and slope.

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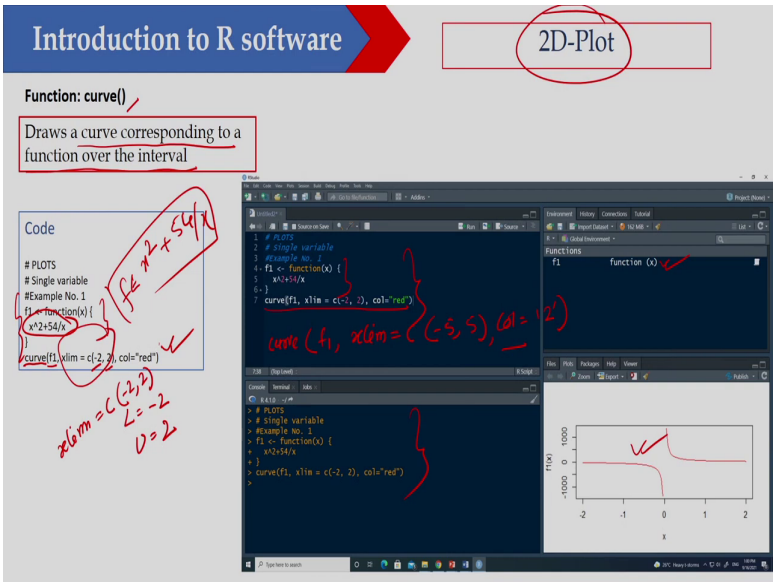

Now, there is another function that is called that is there is another function the function is curve. So now, if I would like to plot a curve, so in that case I can use this particular function so this is for 2 D plot. So, draw a curve corresponding to a function over the interval. So, I have to define the interval, so here suppose I would like to draw this particular function. So, already this function I have defined so you know how to define this particular function. So, this function is that x square plus 54 by x so this is the function.

So, now this function is defined here. So, here f1 is this particular function and now I would like to draw this one. So, how you can draw? So, you can use curve and which is your f1 now I have to put the limit ok. So, I would like to draw this particular function between minus 2 and 2; that means, lower bound is minus 2 and upper bound is 2. So, I am putting the limit

here, so I can put the limit that xlim ok. So, xlim and here c I have defined this is minus 2 and 2 and I am putting a color red here.

So, I have written this code here, so you can see that initially I have defined this function. So, you are getting this function and once you are getting this function you can plot this function using the curve function. Now suppose I would like to plot this particular function between minus 5 and plus 5.

So, what I will do? I will writes curve ok. So, curve and this is your f1 then xlim, xlim you will define now c equal to minus 5 to plus 5. So, anyway you can define color ok. So, what color you want to use you can use red or basically you can also put some number ok. So, this is the suppose 2 is basically red ok. So, I can do that and if I execute that one, so I will get this particular fun this particular plot here ok.

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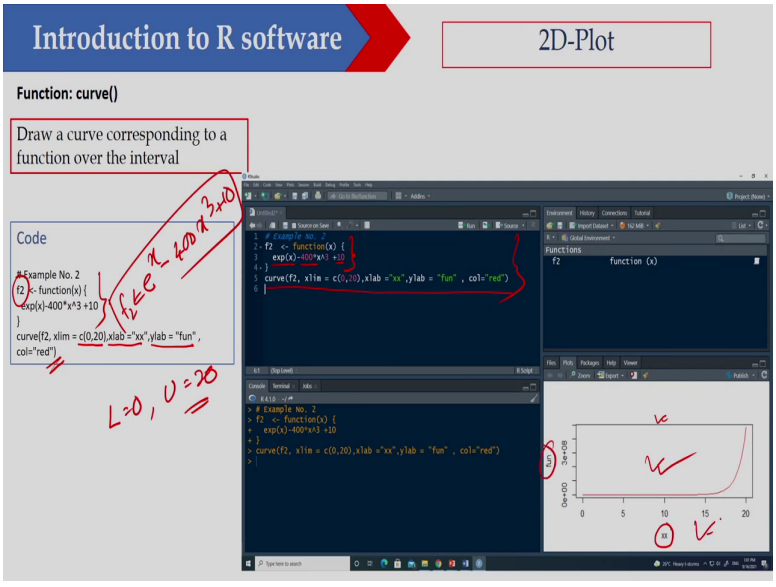

Now this is another function the second function that is e to the power x minus 400 x cube plus 10 ok. So, this is the function and this is your f 2 ok. So, here I have defined this function this is your f 2 and now I plot this function between 0 and 2. So, here lower limit is 0 and upper limit is 20 ok and I can also put level the x level is xx and y level is fun ok this is the function and color is red here.

So, you just see I have defined here this function. So, how I am defining that f 2 equal to function and this is a single variable function we have only x and this is exp x minus 4 hundred x cube plus 10 and after that I am plotting this function using this curve function.

So, this is quite easy so I am getting this particular function, once you are executing this one then you are get you will get this function here. So, you just see I put the level here so this is the x and this is your fun ok. So, this is so you can also change your level.

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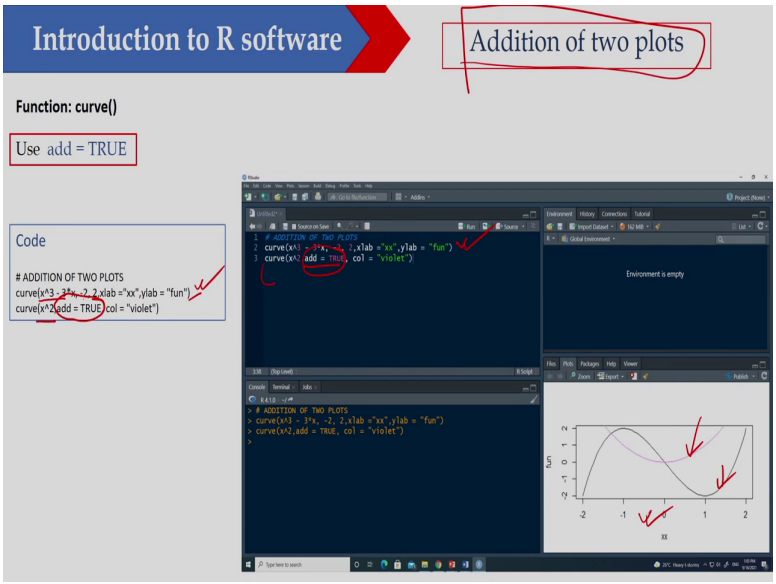

Now, I can also plot 2 function on a single plot ok. So, what I will do here. So, this is very simple suppose I would like to this is one function. So, this is the first function that is x cube minus 3 x ok and this is basically so I have given this is minus 2 and plus 2. So, lower limit and upper limit is minus 2 and plus 2 and then this is the level I am doing and this is another function this is x squared ok. Now you just see so what I have to do here I have to just write add equal to TRUE ok.

So, if you are if you are executing the first line. So, if you are executing the first line. So, you will get the first function ok. So, you will get the first function and on the second function you just write add equal to TRUE; that means, what you will do? It will add the second function on this same plot.

So, I have to write add equal to TRUE then in that case I can actually plot 2 function on a single block ok. So, you can see both the function are here, so second one is violet ok. So, this is the second function and this is your first function. So, I can plot on a single plot.

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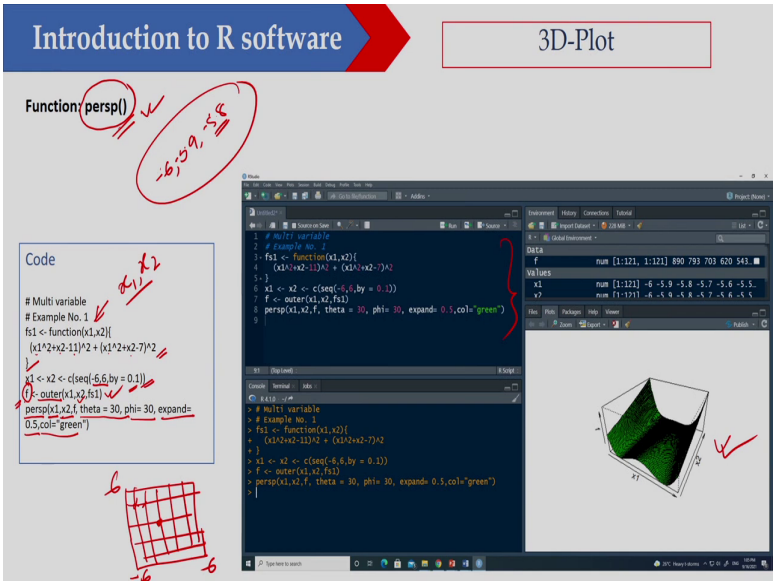

Now, let us see how we can plot a surface ok or how we can plot a surface ok or you can say that is your 3 D plot ok. So, for that there are several function different functions are available. So, I am using persp, so I am using this particular function persp ok. So, this function is available in R.

So, here what I have to do? I have to define the function first ok and here this function has to be defined as a scalar, so that means I have 2 variable that is x 1 and x 2. So, I am defining

this function and this function is x 1 square plus x 2 minus 11 whole square then plus x 1 square plus x 2 minus 7 ok.

So, I am using this particular function now here. So, I am defining this particular function. Now the range for x 1 and x 2 I have defined minus 6 to plus 6 ok. So, minus 6 to plus 6 and then I am just the increment I have used 0.01. So that means the value will be minus 6 ok and then this is minus 5.9 then minus 5.8 something like that ok. So, this is the basically I am using from minus 6 to plus 6 and the interval is 0.1 then I am using this outer function to calculate the function value at different grid point ok.

So that means, what I am doing I am dividing it in grid basically ok. So, in grid ok so here this is minus 6 to 6 and here also minus 6 to 6, so somewhere 0 is here. Now at each grid point I am calculating the value of f ok and this is for that I can use this outer function. So, once you are getting this particular value of f, so then you can use this particular function persp and then I have to define x 1 and x 2.

So, I have to define what is x 1 and what is x 2 then what is the value of f and then at what angle I use I should get horizontal angle and vertical angle that is theta and phi. And then I these are some of the argument of this particular function and then color is green here. So, you can see. So, once you are executing this one so you are getting this particular function. So, I can plot a 2 D function using this persp function.

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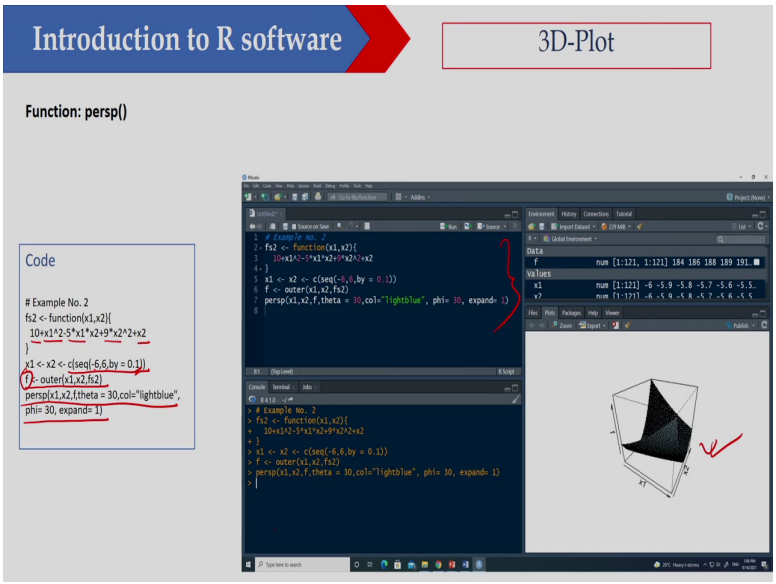

So, this is another function so again this is a 2 d function you can see the function is 10 plus x 1 square minus 5 x 1 x 2 plus 9 x 2 square plus x 2. So, here also so I am using the sequence function ok.

So, and this is x 1 and x 2 I have defined here and this is also minus 6 to plus 6 and then interval between 2 points is 0.1. And then I am using the outer function and then I am getting the value of f and then I am calculating I am using this persp function to plot this one. So, I am getting this particular plot. So, code is given here and you can see I can I can basically get this particular function.

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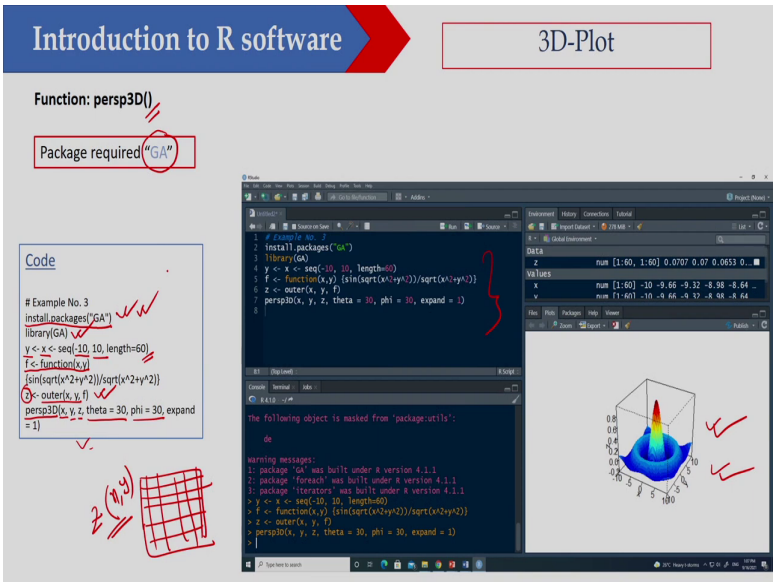

Now, I can also get this surface plot using persp 3 D ok and for that what I have to load? I have to load this GA package ok. So, in the last class I explained how to install the packages. So, you can use install packages so this is GA and then you have to include it in include the library and here now I have to define what is y and x.

So, I have defined it between minus 10 and plus 10 ok and this length is your 60 ok and then you are using this particular function ok. So, the function is this is a function of x y and this is the function I have used here to plot this particular function here. That and then you calculate the value of z; that means, at each grid point you calculate the value of this particular function and then I am putting at z. So, I can write z is the function of x y.

So, I am using the outer function and then I am using the persp 3 D. So, the syntax of this particular function is x y z and then you give the angle at which angle you would like to see

that one. And if I execute this particular function, so I will get this particular plot ok. So, this is not that difficult. So, here what you have to do you have to include the GA library ok GA package.

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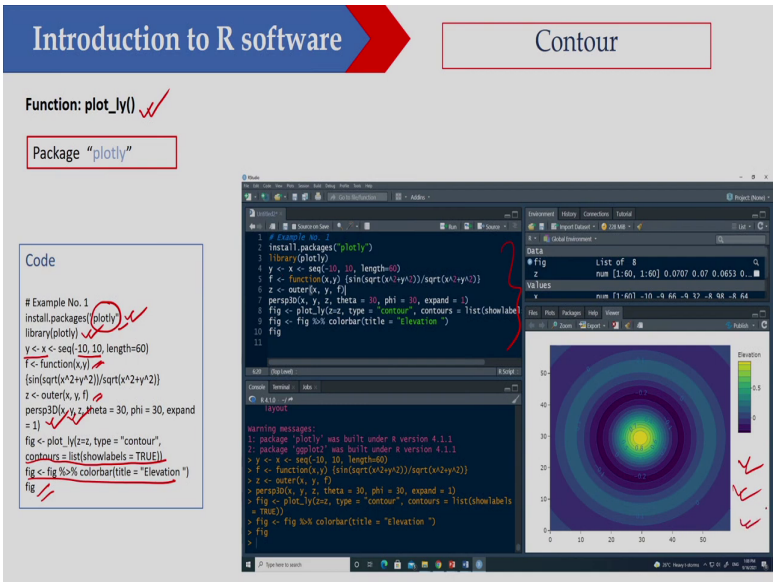

I can also use the plot l y ok, so plot l y your function to plot the contour ok. So, to plot the contours, so here this particular packages you have to install first. So, this is plot l y. So, this is the or plotly. So, this is you have to install and then you include this library and then you have to define the x value and y value.

So, here it is between minus 10 and plus 10 and then I have defined this particular function here and this is to plot the 3 D plot or to get the 3 D plot and but I am using this contour ok. So, this is the contour I am using here and this is this will basically show this particular plot

ok. So, here I have shown the code here and once you are executing this these few lines, so how many lines around 9 lines so you will get this particular plot.

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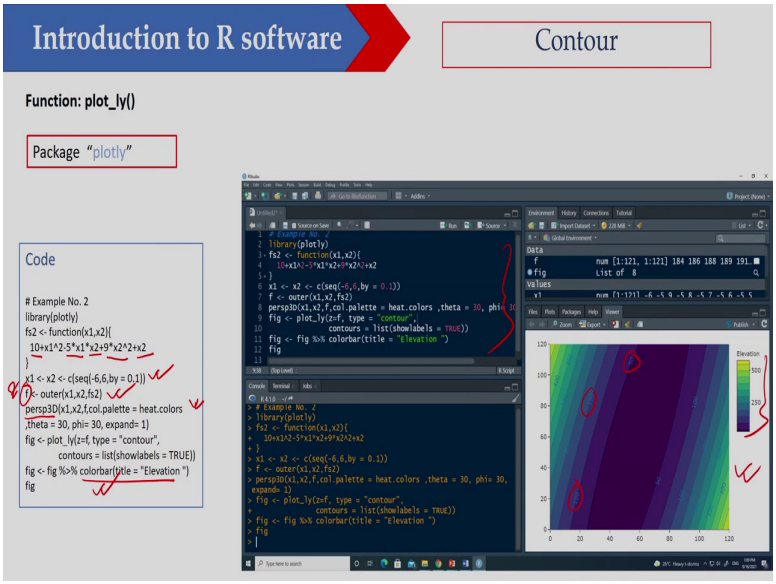

So, here I have shown a different function and this function is 10 plus x square minus 5 x 1 into x 2 plus 9 x 2 square plus x 2 and here also I have defined this 1 ok. So, this is the x and x 1 and x 2 I have defined and then I have used outer function to get the value of f or you can say z and then I am using the persp 3 D ok. So, to get the 3 D plot and then I use this to get the contour plot. So, if you are executing this lines you will get the plot and you can also see that I am getting the color bar here and the color bar is also showing here.

So, you can also put the color bar and this is for different value of z basically. So, you can see the contour values, so this is for 50 this is for 150 this is for 100. So, that also you can plot ok.

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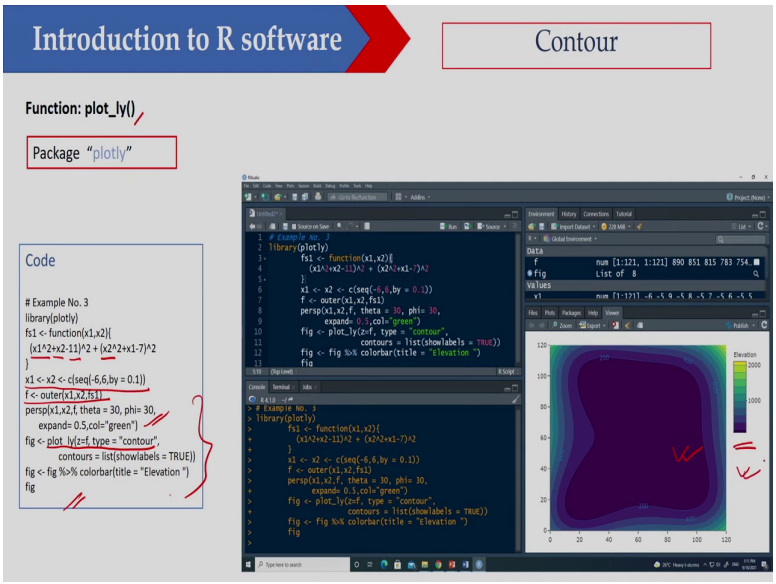

Now again I have used this plotly function to plot the controls here for this particular function ok. So, this is x 1 square plus x 2 minus 11 and whole square plus x 2 square plus x 1 minus 7 whole square and then I am using the sequence function then I am using the outer function and then I am plotting it using persp ok.

So, this I am using it ok. So, I am using this plotly function to get this contour map ok and also the color bar is also here ok. So, in this particular class, so I discuss how you can define a function how you can write an expression, so that is not difficult. So, you can write an expression and then how you are defining a function. So, once you have defined a function then I can calculate the value of this function for different inputs ok.

So, that also I have explained here and then I use a b line function to draw vertical line horizontal line, vertical lines you can draw multiple lines you can draw multiple horizontal lines you can draw multiple vertical lines you can draw a line with intercept and slope ok.

So, you can use a b line, so this abline is used to plot a line on a on existing plot then I have used the curve function. So, this curve function can be used to plot a function and then also discuss some of the function to plot the surface like your contour plot ok and then persp, so you can plot the surface so.

Thank you very much.