Optimization in Chemical Engineering
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Lecture - 56
Software Tools for Optimization

Welcome to lecture 56. So this is week 12 the last week of this course, in this week we will talk about Software Tools for Optimization. There are many software tools available for solving optimization problems. In this course we have seen how to use mat lab optimization tool box which is indeed a powerful solver for several optimization problems. Real life optimization problems will generally require application of soft ware tools.

So, in these lecture we will learn another popular solver for solution of optimization problems which comes along with Microsoft excel, most of us are now familiar with Microsoft excel and Microsoft excel has a built in optimizer known as solver. So, in this week will see how to use Microsoft solver for solution of simple optimization problems.

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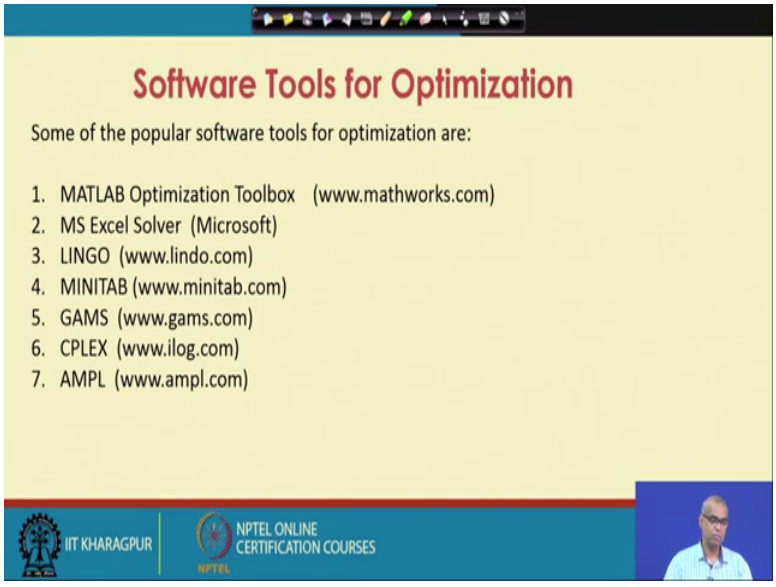

There is a list of some of the popular software tools for optimization, MATLAB optimization tool box have a level from mathworks, Microsoft Excel solver have a level from Microsoft LINGO have a level from LINGO MINITAB GAMS CPLEX AMPL etc. In fact, there are many more but we have just listed here some of the more popular

software's that are commonly used, we have seen to some extent the application of MATLAB optimization tool box. Now let us learn how to use Microsoft excel solver for solution of simple optimization problems, we will consider unconstraint optimization problem we will consider simple constant optimization problem we will also consider linear programming problems for solution of for solution using Microsoft Excel solver.

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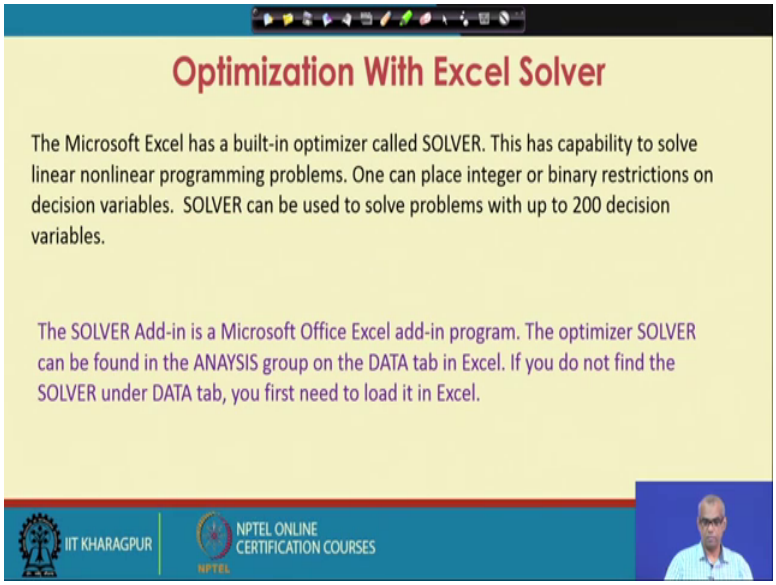

The Microsoft excel has a built in optimizer called SOLVER, this has capability to solve linear non-linear programming problems one can place integer or binary restrictions on decision variables. SOLVER can be used to solve problems with up to 200 decision variables. The SOLVER add in is a Microsoft office excel add in program. The optimizer SOLVER can be found in the analysis group on the DATA tab in Excel. If you do not find the SOLVER under DATA tab, you first need to load it in Excel and we will see how to do that.

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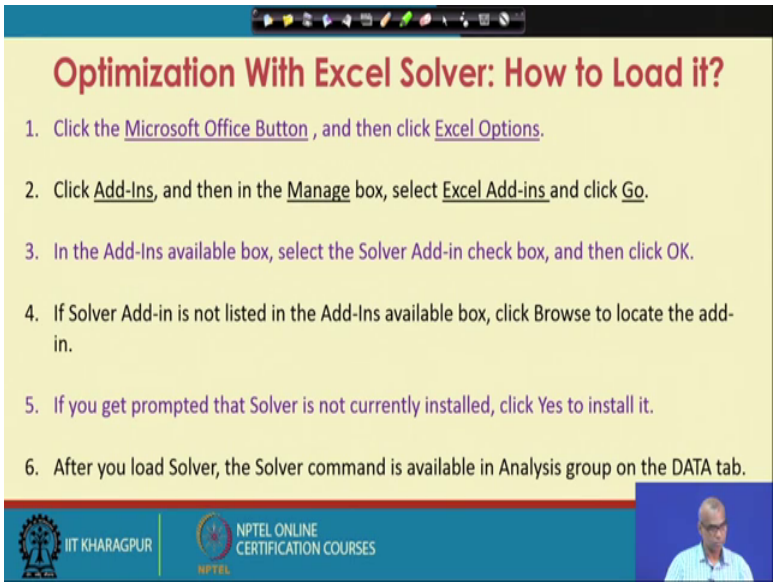

So, how to load solver in excel click the Microsoft office button and then click Excel options, click Add Ins and then in the manage box select excel Add Ins and click Go. In the add ins available box select the solver Add in check box and then click, if solver Add in is not listed in the add ins available box click browse to locate the add in. If you get prompted that solver is not currently installed click yes to install it, after you load solver the solver command is available in analysis group on the DATA tab.

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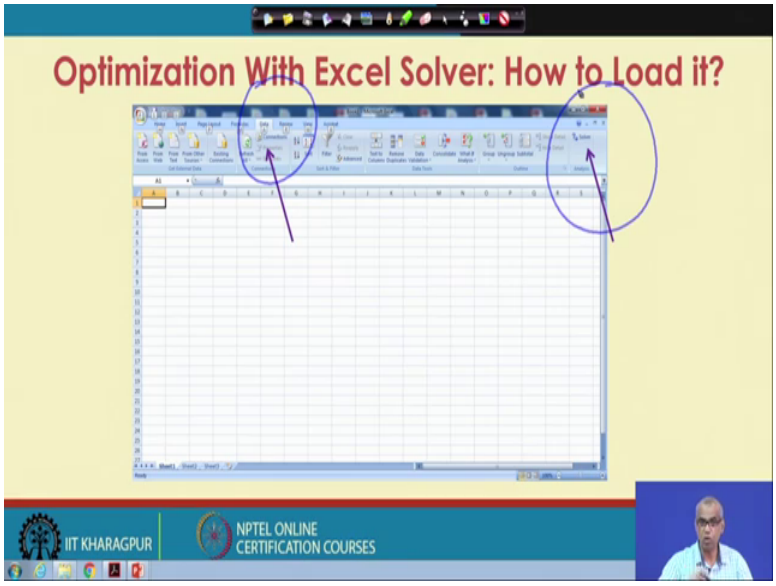

Software you launch Microsoft Excel you click on the data tab, if the solver is loaded you will find the solver here.

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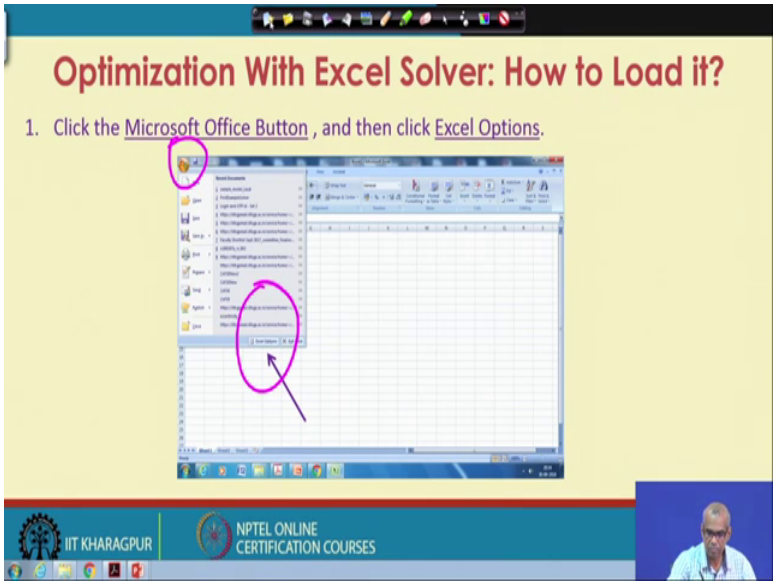

Now, let us see the solver is not loaded and you need to load it. So, click the Microsoft office button and click excel option.

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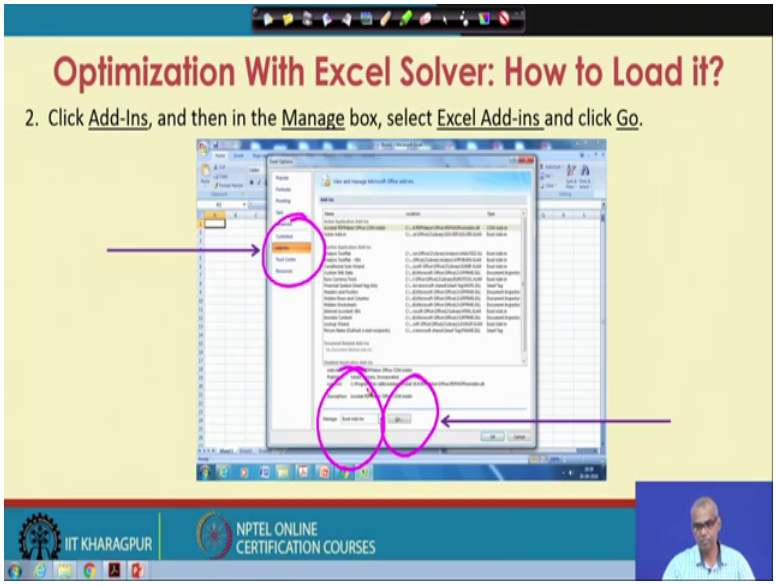

Click Add Ins and then in the manage box select Excel Add ins and then click Go.

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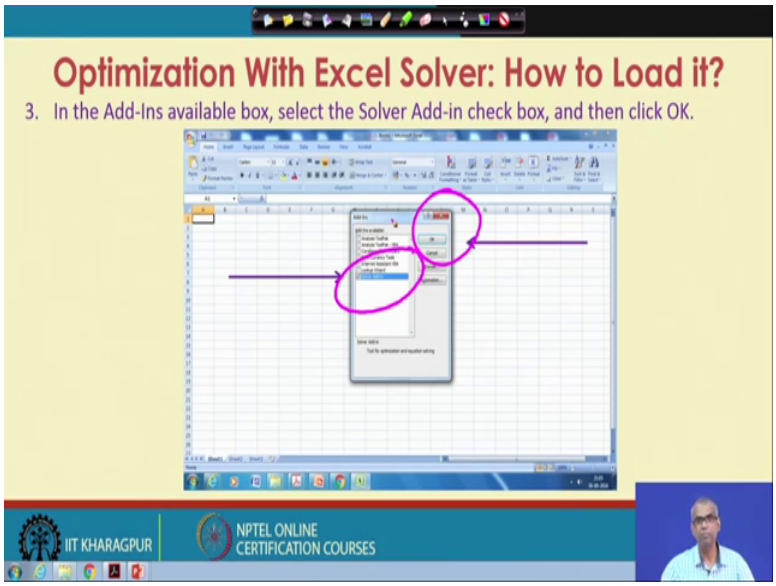

In the Add Ins available box select the solver add in check box and then click.

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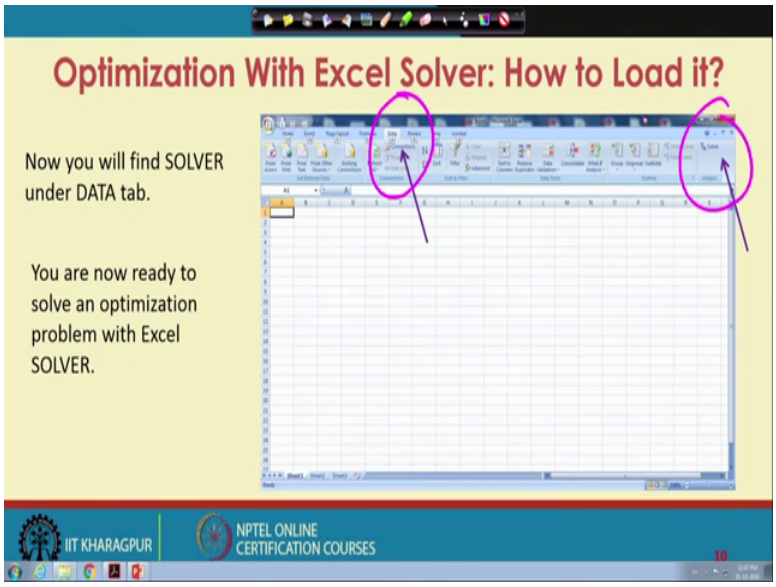

Now, we will find solver and the DATA tab you are now ready to solve an optimization problem with excel solver.

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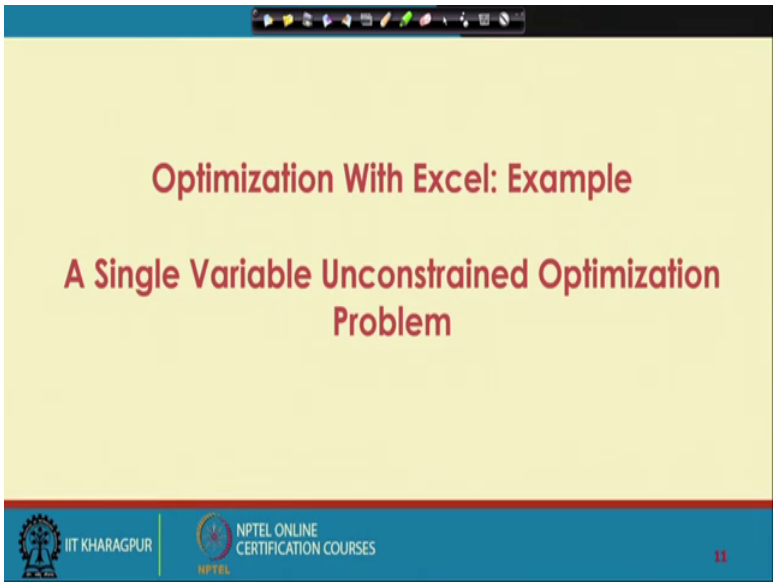

So, let us take an example and go through the steps, let us first consider a single variable unconstrained optimization problem.

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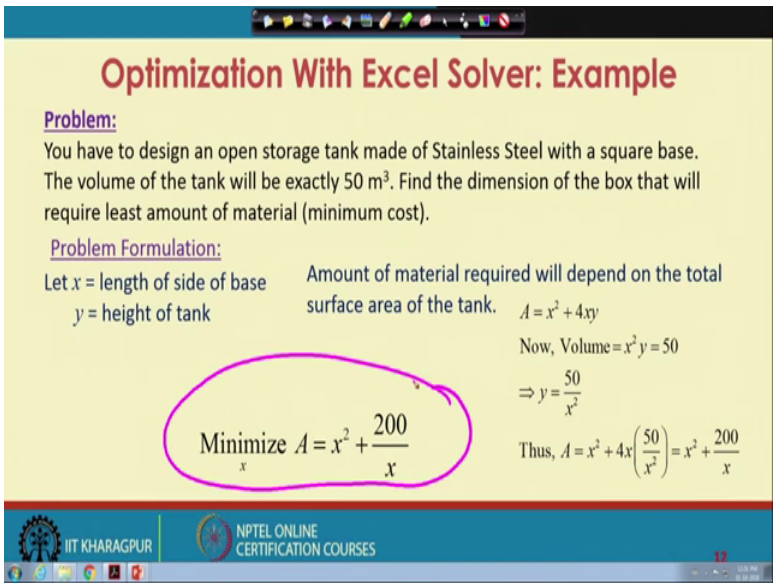

The problem we consider is as follows you have to design an open storage tank made of stainless steel with a square base, the volume of the tank will be exactly 50 meter cube, find the dimension of the box that will require least amount of material. In other words we want to find out the dimension of the storage tank that will require least amount of material that will lead to minimum cost. So, I repeat you have to design an open storage

tank made of stainless steel and this storage tank will have a square base, the volume of the tank will be exactly 50 meter cube.

We have to find the dimension of the tank that will minimize the cost, so the cost will depend on the amount of material that is required. So, asking to find out the dimension that will require least amount of material and asking to find the dimension that will minimize the cost as synonymous. So, let us formulate the problem so let x is equal to length of side of base and y equal to height of tank. So, area of the base is x square and area of 4 walls will be 4 into x y, note that the base is square amount of material required will depend on the total surface area of the tank and the total are of the surface tank is x square plus 4 x y.

Now x and y are actually related because we know the volume the volume is exactly 50 meter cube. So, volume of the storage tank is x square into y and that is equal to 50, so from these we can find out y is 50 by x square. So, now I can put y equal to 50 by x square in the expression for area and then we can get the expression per area as a function of x alone, where x is the length of side of square base.

So, while putting y equal to 50 by x square I get an expression for area as A equal to x square plus 200 by x. So, the problem now becomes minimize A equal to x square plus 200 by x. So, I have to find out the value of x that minimizes x square plus 200 by x.

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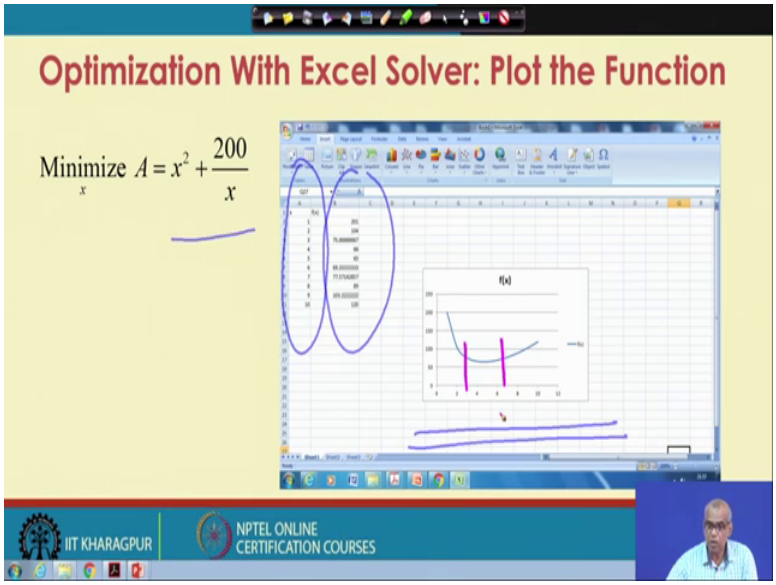

So, first thing that I can do is I can just plot the function because this is single variable function. So, I can just plot how area changes will change in x by taking various values of x, can use the excel sheet itself to find out x square plus 200 by x and then can again use excel to plot f x versus x or A versus x. If you do this you will see that the minimum lies somewhere here. So, between may be 3 to 6 or may be close to 4.5 or so the minimum lie, so it actually gives me an idea about the range over which the minimum of the function lies. So, whenever we have a single variable optimization problem it may be a good idea to plot the function to get an idea of about the location of the minimum.

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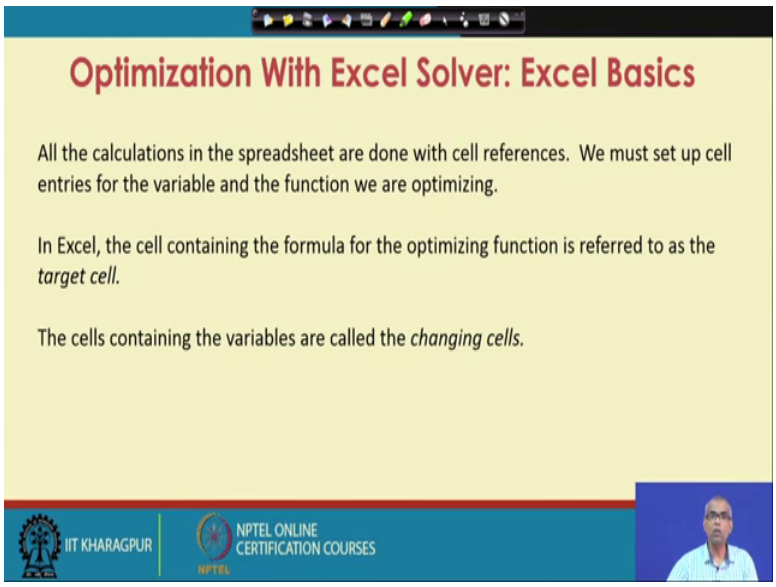

All the calculations in the spreadsheet are done with cell references, so few points about excel basics all the calculations in the spreadsheet are done with cell references, we must set up cell entries for the variable and the function we are optimizing. In excel the cell containing the formula for the optimizing function is referred to as the target cell.

In excel, the cell containing the formula for the optimizing function is referred to as the target cell. So, target cell contains objective function, the cells containing the variables are called the changing cells, the cells containing the variables are called the changing cells. So, target cell contains objective function and changing cells contains the variables that you are going to find out as a solution of the problem.

So, variables containing cells at changing cells in the previous problem minimize A equal to x square plus 200 by x. So, the cell that contains x will be changing cells and the cell that contains the objective function x square plus 200 by x will be target cell.

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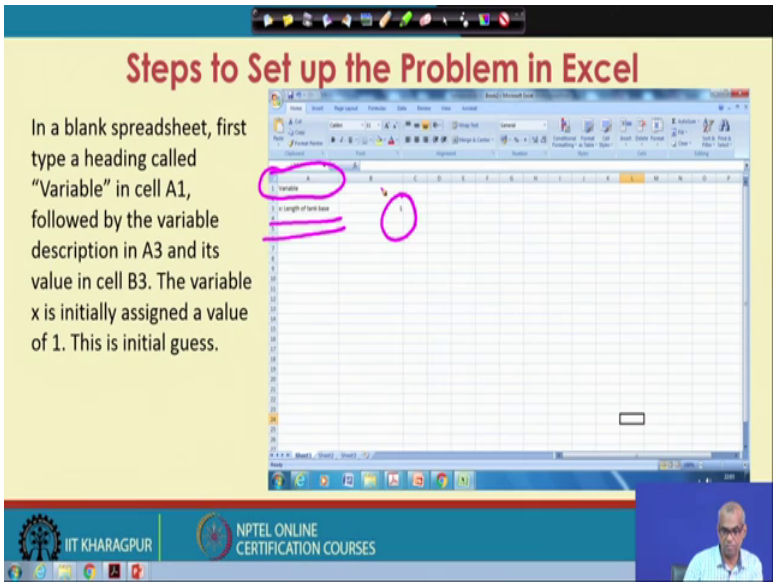

So, how do I setup the problems in excel, so when you solve an optimization problem using Microsoft excel solver there are 2 things, first we have to setup the problem in excel and then we have to use the solver to solve the problem. So, first let us see the steps to setup the problem in excel, in a blank spreadsheet first type a heading called variable in cell A1 followed by the variable description in A3 x, I am defining in A3 as length of tank based and I am giving an initial guess for x as 1 in cell B3. So, the first step is you just create a cell in A1 called it variable and the variable description in A3 and it is value in B3. So, the value in B3 will be taken as the initial guess for the variable description in A3.

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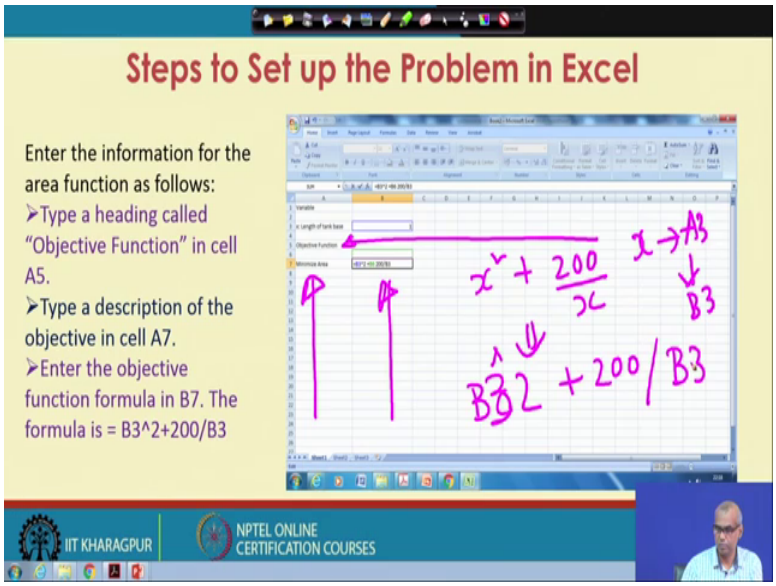

Now, enter the information for the area function as follows type a heading called objective function in cell A5 type a description of the objective in cell A7. Similar to variable I first wrote variable and then get the variable description in A3, similarly I type objective function and give the description of the objective function in A7. Now, enter the formula for the objective function in B7, so note that the formula is x square plus 200 by x is the expression. So, x is in A3 it is value is in B3, so this will be x square plus 200 by x will be written as B3 square plus 200 by B3.

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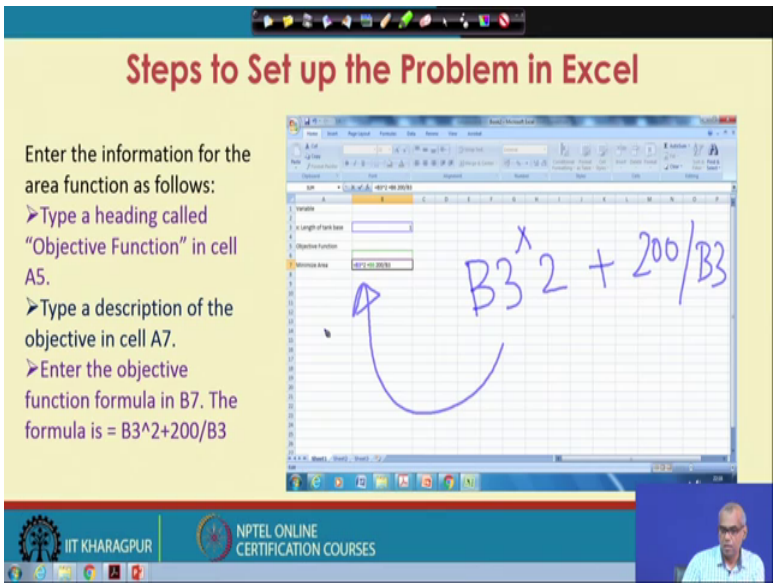

So, B3 square plus 200 by B3, so this is what you write in B7.

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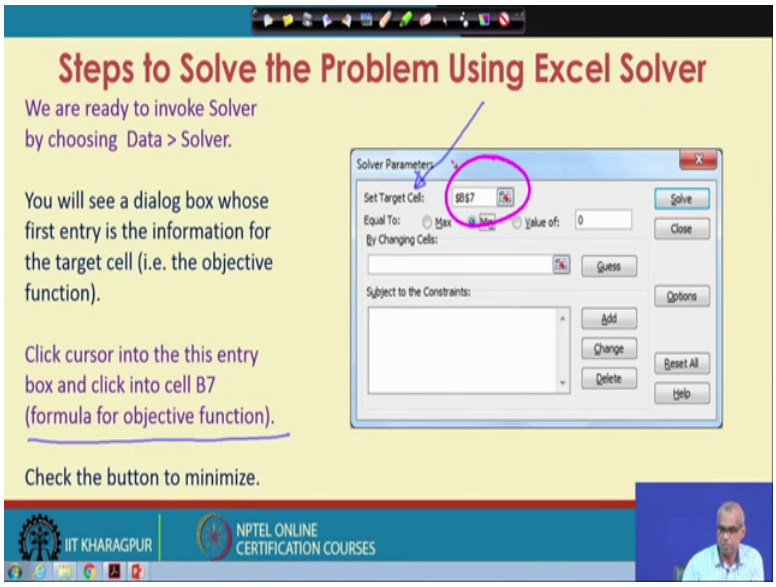

So, now after I have setup the problem in the excel, that means after I have described my variables and objective functions and put the formula for the objective function I am done with the setting up the problem in the excel, now we are ready to solve it using solver. So, I ready to invoke solver by choosing data tab and you now can locate the solver under data tab. So, click on solver you will see a dialogue box whose first entry is the information for the target cell that is the objective function. Now the appearance of this window may be slightly different depending on what version of excel you are using.

So, what you see now is version 2007 and I will save you a more newer version after few slides and then also I will demonstrate with excel 2013 that is loaded in this computer. So, you see a dialog box whose first entry is the information for the target cell target cell is the objective function, if you remember in the previous slide we said that the objective function formula is written in B7 cell B7. So, click the cursor into this entry box and click into cell B7 which writes the formula for the objective function we will see that B7 appears here.

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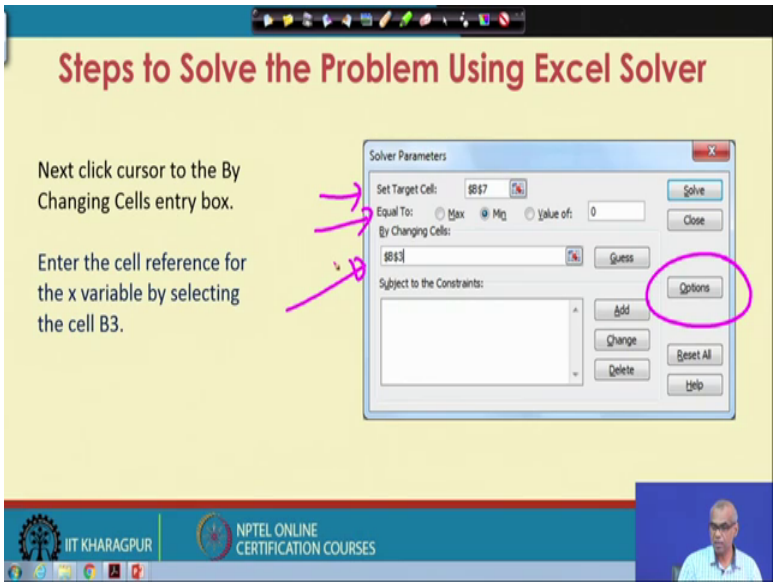

So now I have set the target cell that means set the objective function, after that you are solving a minimization problem so click the button to minimize. Next click cursor to the by changing cells so by changing cells refers to the cell that contains variable, if you remember cell B3 contain the value of the variable x. So, let us enter the cell reference for the x variable by selecting the cell B3, so you click here and then click on cell B3 and we will get B3 here.

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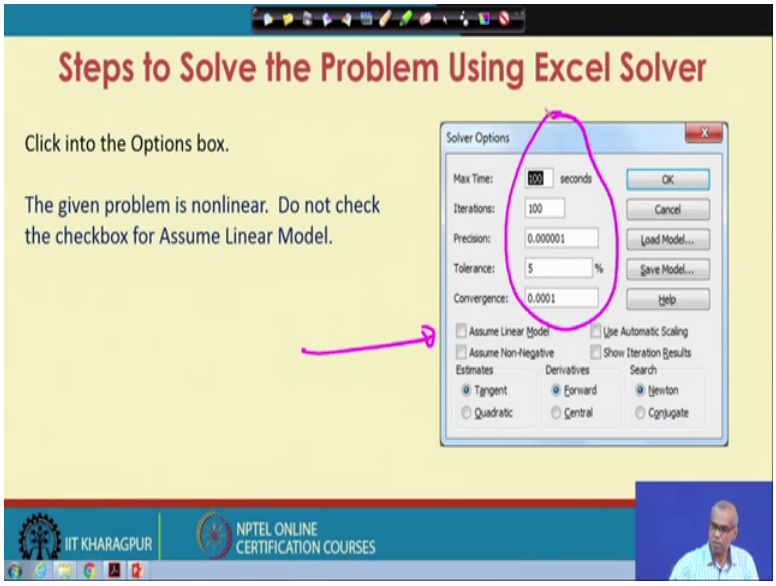

Now, look at here there is an option button, so after you have set the target cell you have indicated whether you are solving a minimization problem or maximization problem and you have indicated the changing cell, you now click on the option button. So, click into the option box and you will get a window which you see on the screen the given problem is non-linear. So, do not check this box which refers to assume linear model this box must remain unchecked, you can leave this parameters unchanged these are all default settings.

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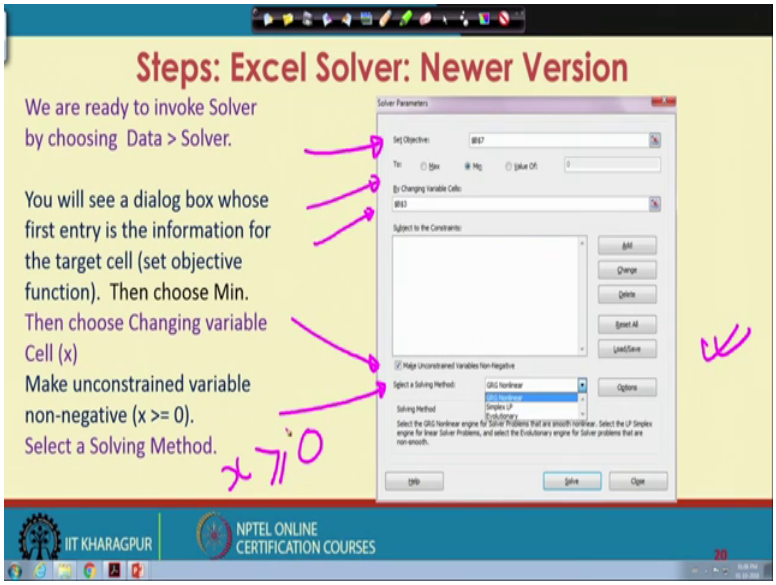

Now, as I mentioned that depending on the version of the Excel you are using the appearance of the last 2 windows may be slightly different. So, once you click on solver the newer version of excel will give you an window which looks something similar to what you see on the screen now. You have the basic entries are all same we have set objective you have to solve a minimization problem and the changing variable. Now, note the difference here you can select a solving method you have options GRG non-linear simplex l p and evolutionary GRG non-linear is generalized reduced gradient method for solution of non-linear programming problem.

So, let us choose GRG non-linear we can make unconstrained variable non negative by checking this box, this means that we are ensuring the decision variable x greater or equal to 0, again you note you have an option button here. So, if you click on the option button we will get a window like this.

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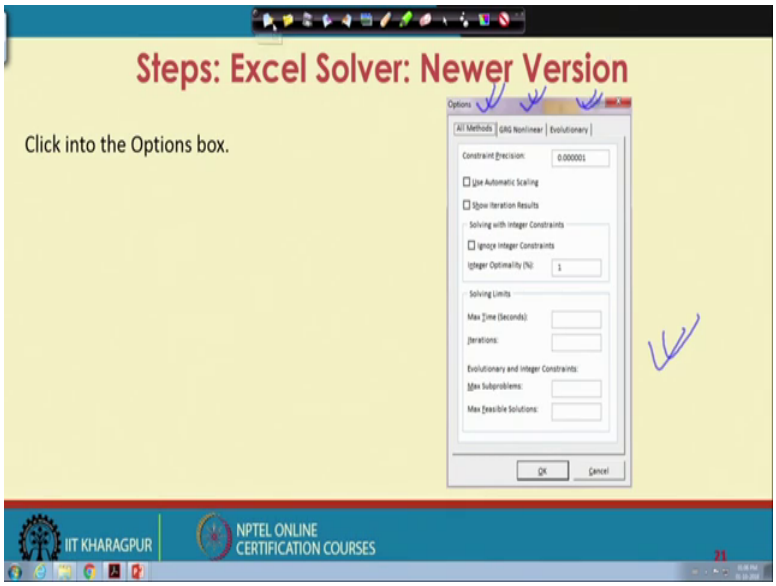

So, you have options for all method GRG non-linear evolutionary method etcetera.

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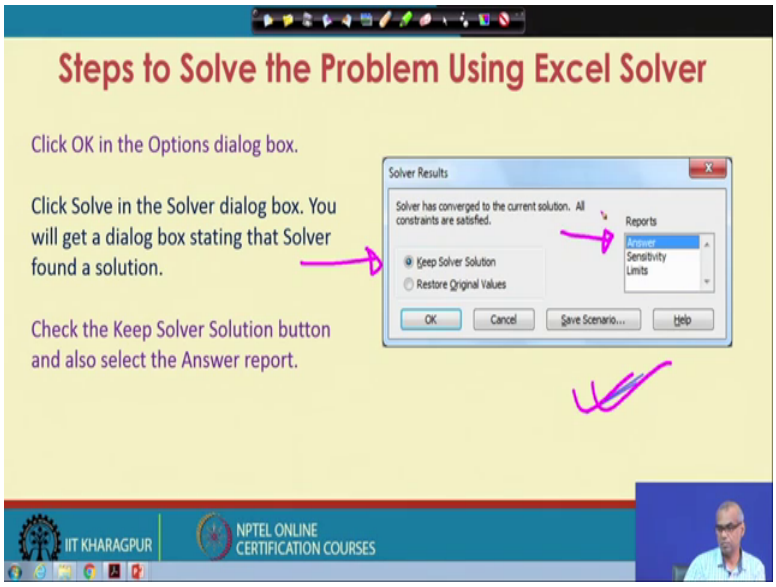

Now, once after clicking solver you have indicated your objective function, the kind of problem minimization or maximization you are solving and we have indicated the decision variable that is the changing cell in the newer version you have chosen the solver. That means, GRG non-linear in this particular example and after you have indicated options you are now ready to solve the problem.

So, you have button here to solve the problem, so once you solve the solver will indicate the results and you will get a window like this, it says the solver as converged to the current solution all constraints are satisfied. So, after indicating the options you click in the option dialog box.

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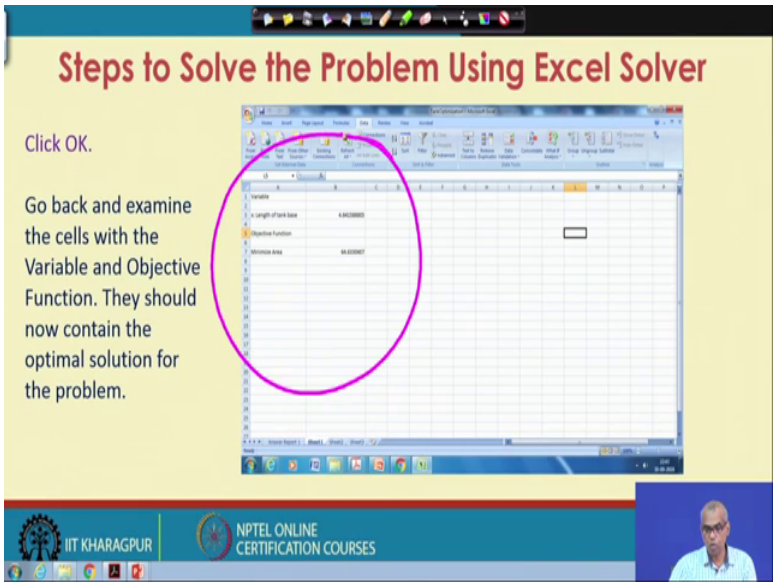

Then click solve in the solver dialog box you will get a dialog box stating that solver has found a solution, check the keep solver solution button and also select the answer report then click ok. Now, you go back and examine the cells with the variable and the objective function this should now contain the optimal solution for the problem. Like we note that B3 and B7 now has the optimal solution for the problem. B 3 contains the value as 4.641 and B7 has the value for the minimum area 64.633.

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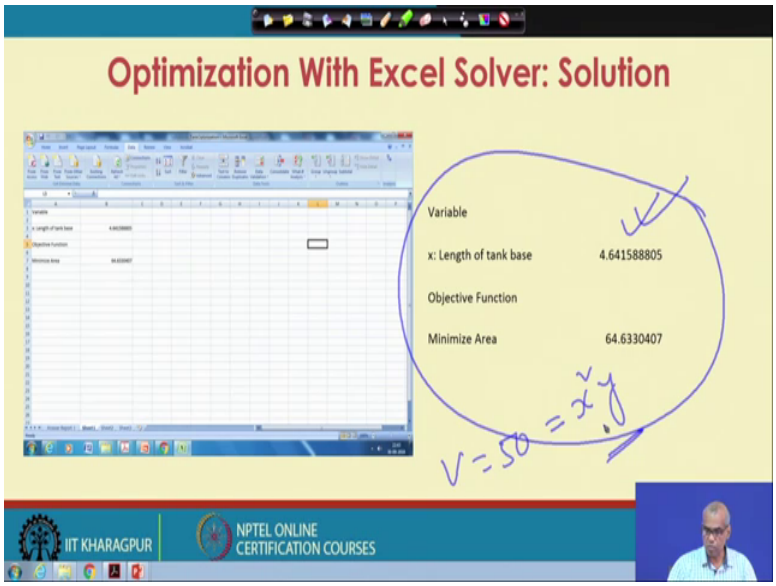

So, this is the solution; 4.64 should be the length of the tan base, so height can now easily found out because you know v equal to 50 equal to x square into y. So, y can be found out. Note that the graph also indicated that the solution lies somewhere between 3 to 5.

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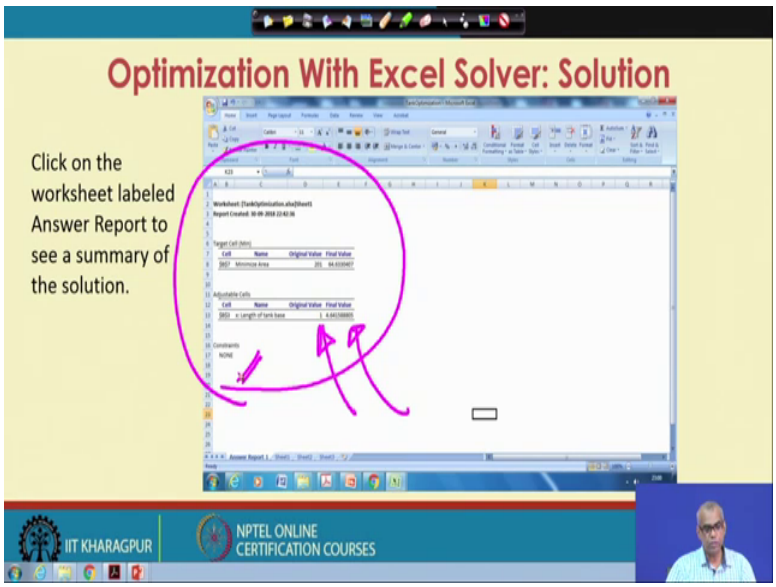

So, this is the answer report note that you clicked on keep solver solution and answer. So, this is the solution and this is the answer report, click on the worksheet labeled answer report to see a summary of the solution. So, this gives you the summary of the solution.

Look here x length of tan based original value was 1 that means that was the initial case and the finally the converged value is 4.6415 there was no constraints, so the answer report gives you a summary of the solution. So, this is how you can solve a simple optimization problem using excel solver.

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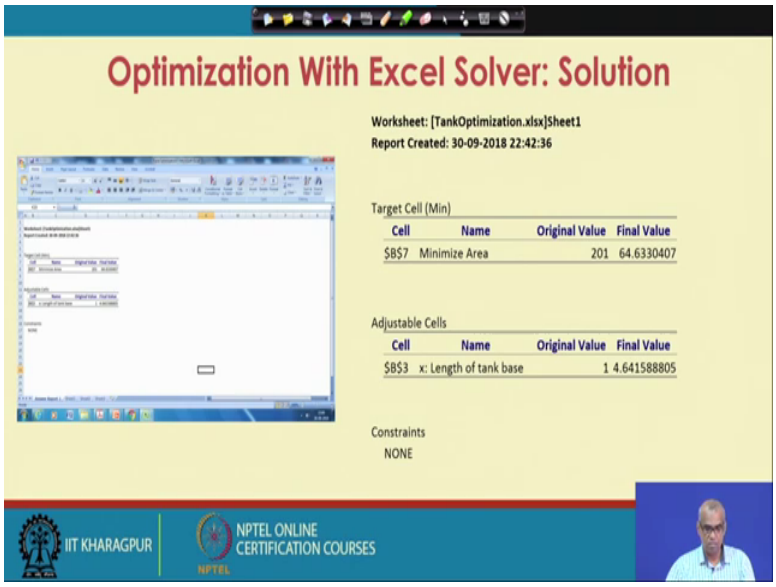

These values are written in a bigger font, so that it is readable to you. So, the solver can be used easily to solve an optimization problem, for the time being we saw an example of unconstraint optimization problem solver also allows you to put constants in it. In the next lecture we will take this problem again and launch the excel solver on this computer and go through the steps, so that we understand the steps one more time and we will also take example where I will have constraints. So, both unconstrained non-linear programming problem and constant non-linear programming problem can be solved efficiently using solver, after that we will see application of solver for solution of linear programming problem with this we stop lecture 56 here.