Introduction to Operations Research
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Module - 08
Solving LPs using a solver
Lecture - 01
Setting up the problem and solving simple LP problems

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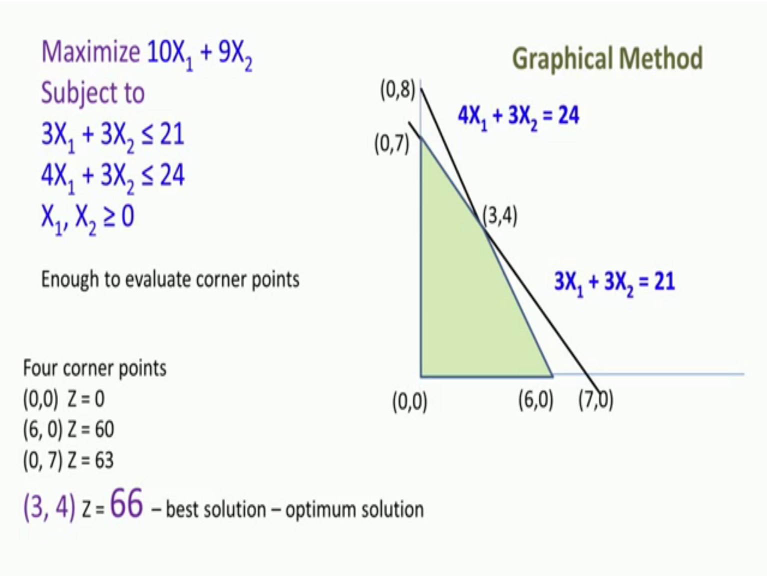

In this module, we will solve linear programming problems using a solver. So far in this course, we have solved the linear programming problem, transportation problem, and the assignment problem using special algorithms. We have solved L P's using the graphical method, the algebraic method and the simplex algorithm, using hand computations. Now, large linear programming problems, large transportation problems, assignment problems, it is difficult to solve them by hand.

We need solvers and there are plenty of solvers that are available, commercial solvers are available, open source solvers are available and other forms of L P solvers are also available. Now, we will use the excel solver and I will demonstrate, how to solve linear programming problems, using the excel solver. You need a valid excel to write these linear programming problems on the excel spreadsheets and to solve them.

So, let us explain this by using the same example that we have used in linear programming. So, maximize 10 X 1 plus 9 X 2 subject to 3 X 1 plus 3 X 2 less than or equal to 21 and 4 X 1 plus 3 X 2 less than or equal to 24. So, this is the example that we will be solving and I will be demonstrating to you, how to solve it using the excel spreadsheet.

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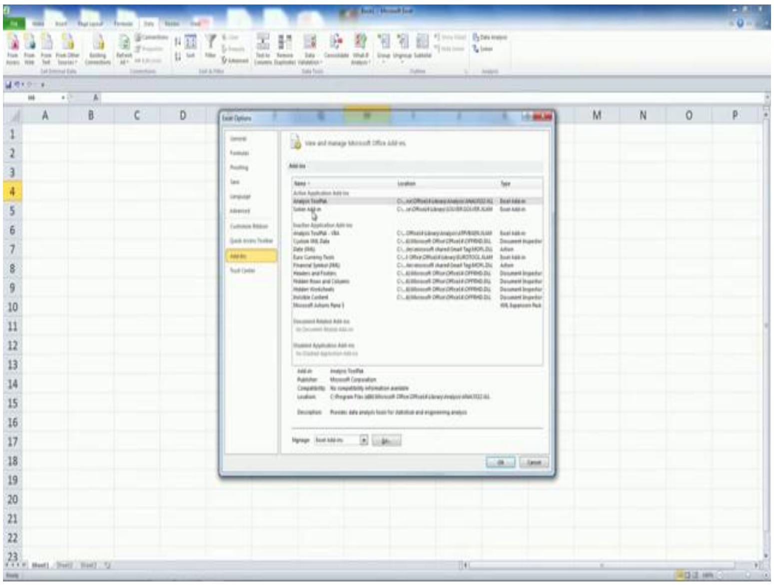

Now, when we open this spreadsheet, there are several and we can go to click on data; that is available here and you find the solver; that is written here. If the version that you have at the moment, does not support the solver, you have to add the solver into. So, you should use addends, depending on the version, now there will be a way to go from file, and then we could look at options. And from the options, we could do addends and then we could do a Microsoft solver addend. And then when we say yes, the Microsoft solver appears here. So, the solver comes as part of the excel sheet.

Now, I am going to use this solver, there are also smaller or simpler versions of the same solver, which is available for download up to a certain period and you can use them as a free download and you can use the solver. Now, this is a solver addend along with excel. So, I am going to use this, you could also use a freely available download of this solver, which you can use for a certain period. So, let us take the same linear programming with two variables and try to solve them.

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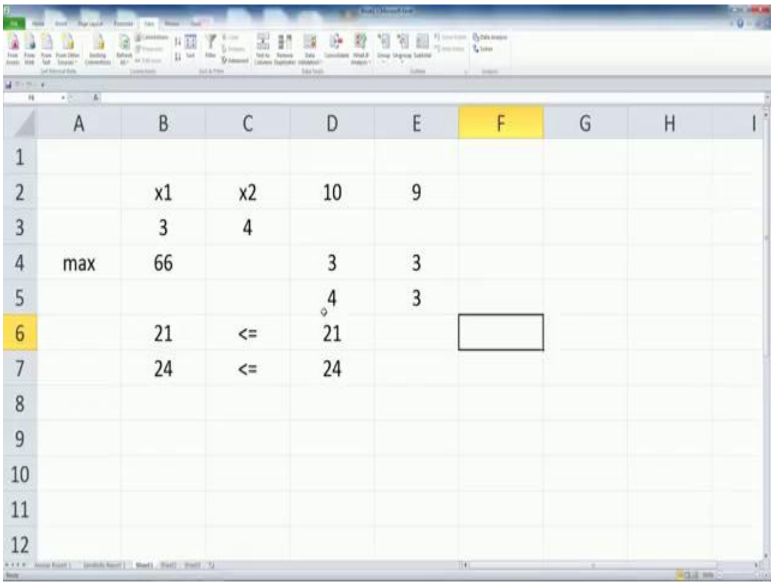

So, I am going to write the two variables as X 1 and X 2. So, I am going to write these variables as X 1 and X 2. So, I am going to write them as X 1 and X 2 here. So, to begin with, I just give some values to them, say 2 and 3. I am just giving two values to them. Now, my objective function is to maximize. So, I am just writing max here to show that, I am maximizing.

Now, the function that we are maximizing our objective function for this problem is 10 X 1 plus 9 X 2. So, I am just writing the coefficients 10 and 9 here. So, I am maximizing 10 X 1 plus 9 X 2. So, I just write a max here notionally to represent I am maximizing. So, what I am maximizing here is equal to 10 X 1, 10 into X 1 plus 9 into X 2 and for the values that I have given, which is 2 and 3. The objective function value is 47, which is 10 X 1 plus 9 X 2, which is 47.

Now, I have two constraints, the first constraint is 3 X 1 plus 3 X 2 is equal to 4 less than or equal to 21 and the second constraint is 4 X 1 plus 3 X 2 is less than or equal to 24. So, I am going to write the two constraints in these two positions. So, here I am going to write the left hand side of the first constraint. So, I say equal to, the left hand side of the first constraint is 3 X 1 plus 3 X 2. So, this 3 multiplied by the value of X 1, 3 X 1 plus this 3 multiplied by the value of X 2, which 3 is my left hand side.

So, this is 3 X 1 plus 3 X 2 for the given values of X 1 and X 2, which are 2 and 3. So, 3 X 1 plus 3 X 2 is less than or equal to 21. My next constraint is 4 X 1 plus 3 X 2 is less than or equal to 24. So, I write this left hand side is equal to 4 into the value of X 1 plus 3 into the value of X 2, which is 17. So, now, this should be less than or equal to 24. So, I have now created the L P on this sheet, I have defined, I have named the two decision variables as X 1 and X 2. And I have given some arbitrary values to the variables, which are 2 and 3.

In this position I have defined the objective function, which is the value of 10 X 1 plus 9 X 2, which takes 47 when X 1, X 2 are 2 and 3. There are two constraints, this portion represents the two constraints, this portion represents the two constraints, which are here. So, the first constraint is 3 X 1 plus 3 X 2 is here less than or equal to a value 21 and the second constraint is the value of 4 X 1 plus 3 X 2 less than or equal to 24. So, we have just set up the problem, we have not optimized it.

For example, if I just change this value to 6, you realize that, this becomes 27, this becomes 33 and the only thing, I can tell right now is the solution, 6 comma 3 is not feasible. Because, the left hand sides are greater than or equal to the right hand sides, I have not yet optimized them. So, whatever value I give, the left hand sides can be calculated, the objective function can be calculated.

Now, we have to solve this problem, which means, we should get the correct values of this 6 and 3 positions, we should get the correct value. So, what do I do, I now call the solver, so I go to data and I click on this solver and I get something like this. So, I just move this sufficiently. So, my objective function, which happens to be 10 X 1 plus 9 X 2 is given in this position. So, I just click here to say that this position, B 4 position is my objective function.

So, I just click that, objective function is in this position and this objective function is to maximize,, therefore I click the maximize. There is a maximize here, which you will see when you actually do it and you click that maximize. Now, there is another thing called by changing the variable cells, which means, what are the positions that correspond to the variables.

Now, these two positions B 3 and C 3 correspond to the variables. So, I just click here, and then use shift and move it here, now I get here B 3 and C 3 as the positions. Now, when you actually do it, you will be able to see, even though at the moment, because of the small size, you are unable to see that. So, B 3 and C 3 is written here. Now, I have defined the objective function position, I have defined that it is maximization and I have also defined the position of the variables.

Now, I have to add the constraints. So, I go to the thing called there is an add here on the right hand side, there is an add button. So, I just click that add button here and I get a another window like this. So, I go to the first constraint, this is the left hand side of the first constraints, so I just click that to say that, my first constraint is given by the position B 6.

Now, this is a less than or equal to, so I go back to this position and click the less than or equal to which is already there and the right hand side position is here, which is D 6. So, I just click the D 6 position to say that the right hand side is D 6. So, this is my first constraint and I add the first constraint to it. Now, I have to go to the second constraint, the left hand side of the second constraint is the B 7 position. So, under the cell reference I click this, so I get the B 7 position.

By default I have a less than or equal to, so I keep it as it is. The right hand side of the constraint is D 7, so I just click there to get D 7, so I add. Now, I have added both the constraints, so I come out of it, so I press cancel to come out of it, now the problem is defined here. Now, the objective function is shown under something called set objective, which you can see in the sheet, if you are doing this along with me; that is the position B 4.

The maximization is clicked; the variable positions are B 3 and C 3, which are clicked. The two constraints are B 6 less than or equal to D 6 and B 7 less than or equal to D 7. Now, we go to options here, and then we could put, there are several options that are there. So, we will go back and say automatic scaling and we could keep it as it is, we do not need to really check the options so much. So, at the moment, it is enough to keep this, and not necessarily do the options. So, the problem has been set and we are ready to solve.

So, there is a button which says solve. So, click that button and when you click that, you get the solution, the solver has already solved it to give u X 1 equal to 3, X 2 equal to 4 with value equal to 66. So, there is something called keep the solver solution, which you can do, you can also create some reports here. So, you can create a report called answer.

So, just click that answer and press okay, it creates a report here called answer report 1, which you can see below.

Again, just solve it, one more time, so solve, you get the same solution, now create this report called sensitivity and click okay, so it creates a sensitivity report. So, we have now created two reports, which are here. We already know that the solution is, from this thing you know that the solution is X 1 equal to 3, X 2 equal to 4 with objective function value equal to 66.

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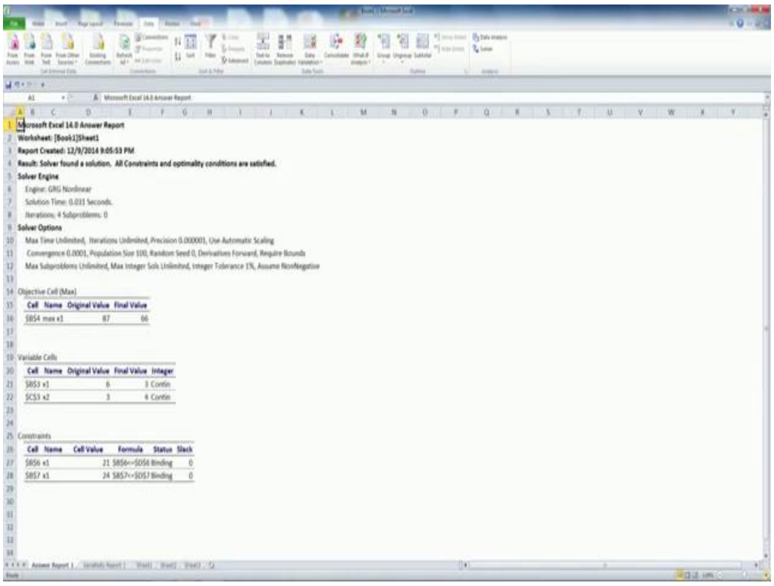

So, if you click the answer report, from the answer report, you will get X 1 is equal to 3, final value is 3, X 2 the final value is 4. You can see these two values that are here 3 and 4 are actually here. So, now, you observe that, the final value of X 1 is 3, the final value of X 2 is 4 from this. So, this is the answer the objective function value is final value is 66, which we got in our answer. Now, let us go back to this sheet, sheet 1, when 3 and 4 are the solution with value is equal to 66.

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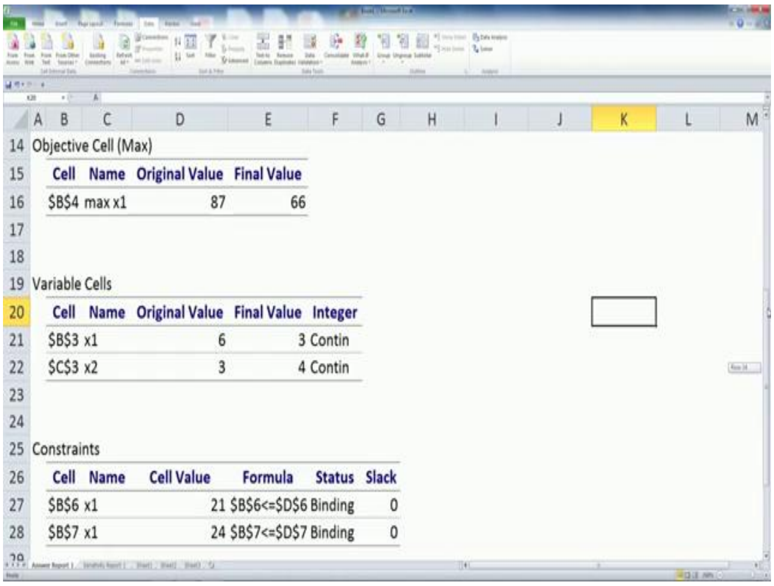

The sensitivity report also tells us something, in fact we go to this, we go to the answer report, we also look at two more things, it also says the first cell is binding. So, cell value is 21, slack is 0, second cell value is 24, slack is 0, which means the solution 3 comma 4 uses up all the 21 and 24 resources. So, that is also there that we can see in this. So, we see the value of the objective function, we see the solution, we also see that the constraints are, both the constraints are satisfied as equations.

((Refer Time: 15:40)) Now, we again, so try to get another report, we solve this one more time, and then we get another report called limits and let us see, if something can be made out of the limits report. So, at present, we have solved this problem and we use the answer report to give us the solution, which is final value of 66, X 1 equal to 3 and X 2 equal to 4, gives us the final value of 66.

So, this is how we solve the linear programming problem for a maximization objective and just one more time. ((Refer Time: 16:47)) Once, we set the problem, you can click on the solver and you can solve this to get this solution, which is given by X 1 equal to 3, X 2 equal to 4 with objective function value equal to 66. Now, let me explain a minimization problem that we have actually solved. Now, we go to a minimization problem, which we can solve.

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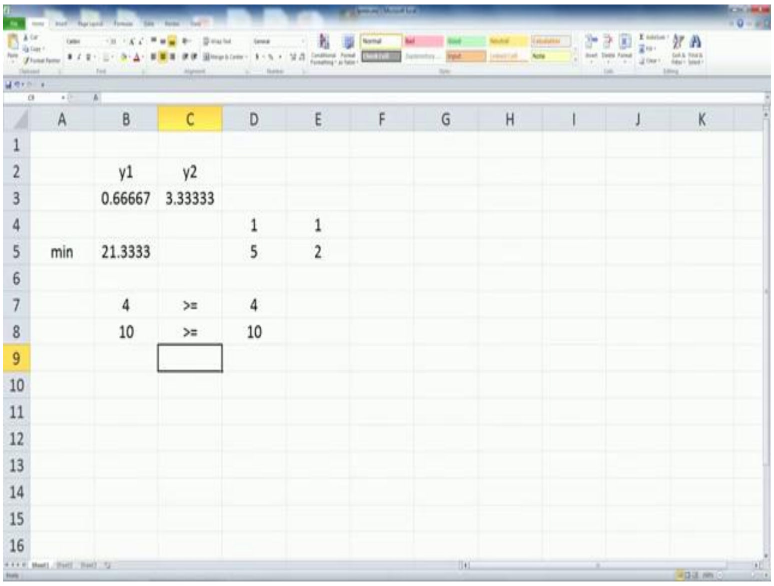

So, this is the problem that we have been solving, I will zoom it for you. So, the minimization problem that we solve minimizes.

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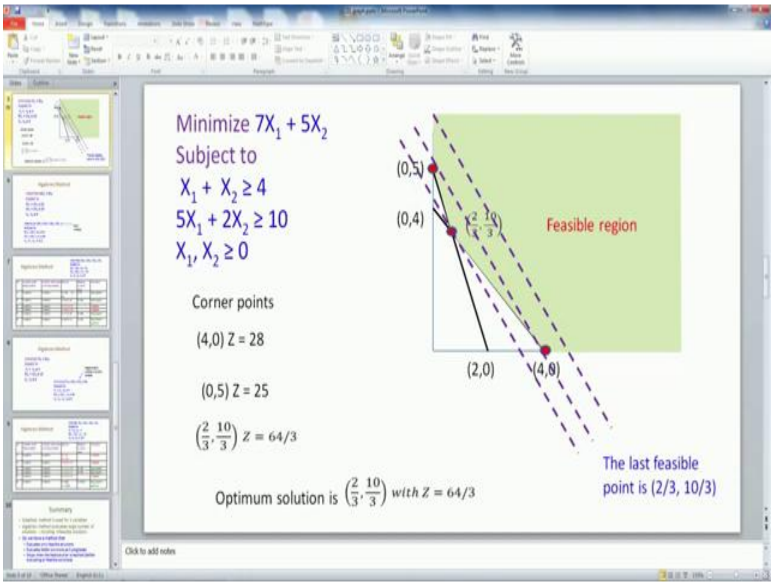

It minimizes 7 X 1 plus 5 X 2, subject to X 1 plus X 2 greater than or equal to 4, 5 X 1 plus 2 X 2 greater than or equal to 10, X 1, X 2 greater than or equal to 0. So, we now create the sheet for this problem. Now, we define two variables, I have just defined them as Y 1 and Y 2, we could use X 1 and X 2 also, there is no problem there. ((Refer Time:

18:21)) We can just give some arbitrary values, we can give some value here, let us say 3 and we can give another value here let us say 5.

Now, I have given some two arbitrary values, the two constraints are, the first constraint we minimize the objective. So, the objective of a function is 7 into X 1 plus 5 into X 2, which I have written here, you can see 7 into the position B 3 plus 5 into the position C 3. The positions B 3 and C 3 are the given values of Y 1 and Y 2, which are the variables. So, the present objective function is 46.

In a similar manner, I have written the two constraints, the first constraint is X 1 plus X 2 greater than or equal to 4, I have written. When, I use this X 1 plus X 2, it is actually the position B 3 into 1 plus 5 into 1 X 1 plus X 2, 1 into X 1 plus 1 into X 2 is this 8, this 25 is 5 into 3 plus 2 into 5 is 25. So, the second constraint is 5 X 1 plus 2 X 2, which is greater than or equal to 10.

So, now I am calling the solver for this problem, I go to data and I call the solver, I have already done everything here. So, the objective function is set at this position, which is B 5, the variable cell positions are B 3 and C 3, which are here. The two constraints are already added and they are greater than or equal to constraint. So, now, I have given some arbitrary values 3 and 5, now I solve it to get Y 1 is 0.666, Y 2 is 3.333, the actual values are 2 by 3 and 10 by 3 and this is 64 by 3.

So, 14 by 3 plus 50 by 3 is 64 by 3 and now, you realize that, both the constraints are satisfied as equations and the optimal solution is Y 1 is equal to 2 by 3, Y 2 is equal to 10 by 3 and the value is 64 by 3. So, this is how you solve a minimization problem. So, whether you have a maximization problem or a minimization problem, you can set up the problem as it is here.

The first part is writing the problem on the sheet. So, you define the variables, important thing is to give some arbitrary values, then write the objective function in terms of the values that you have given to the variables, write the constraints. Then, call the solver, and then set the position for the object of function, which happens to be the position B 5, set the position for the variables which happened to be B 3 and C 3.

And then write the constraints in the solver use the correct inequality from the solver position and use this, and then once you call the solver and the solver ask it to solve, you will get this solution. So, this is how we solve linear programming problem. And in the next class, we will see more examples of solving these programming problems. We will also try and solve some of the problems that we formulated at the very beginning of the course to understand, how the solutions to those problems look like.