Advanced Green Manufacturing Systems

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Lecture – 08
Modeling with continuous variable – Part 2

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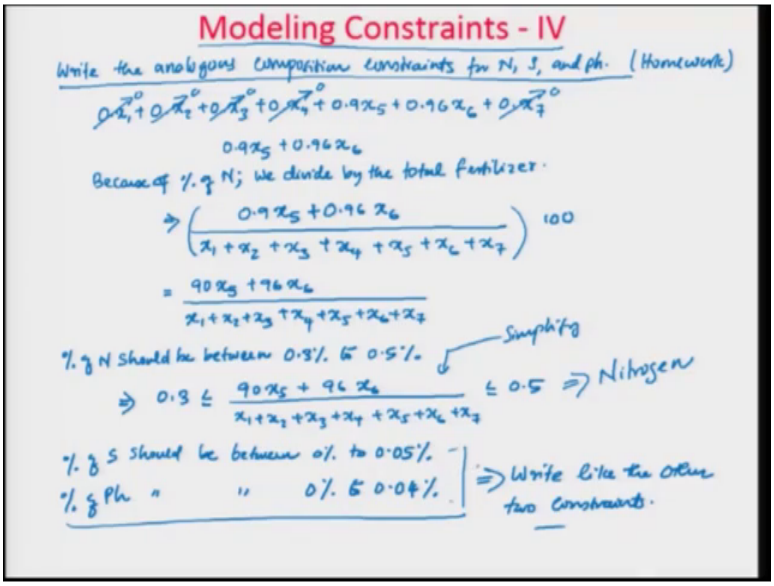

Continuing on what we were talking earlier, now let us try to model the other remaining constraints of the problem ok. So, now we will try to write the analogous composition constraints for nitrogen, sulphur, and phosphorus ok. Please do this as a homework, but I will start you to I will show you one more basically how to write the case of nitrogen.

So, if you go back in the previous table, we can see that the percentage of nitrogen is falls in this row ok. So, if we use this, we can write this constraint as follows ok, we will write it as same way 0 times x 1 plus 0 times x 2 plus 0 times x 3 plus 0 times x 4 ok. The first 4 are 0's if you can see this these first 4 are 0's, then you have a 90, 96 and a 0 ok, so then it is in percentages.

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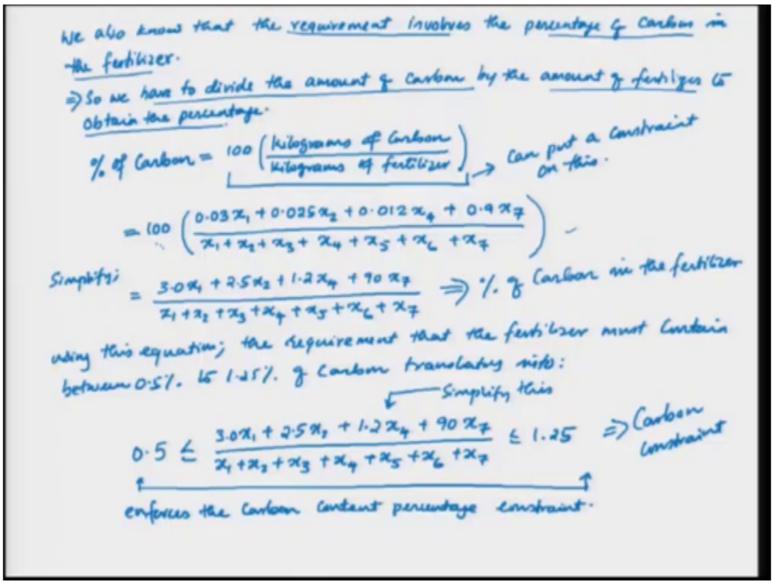

We are talking about is plus 0.9 times x 5 plus 0.96 times x 6 plus 0 times x 7 ok. You think about the previous case, these exactly how we went through the previous case.

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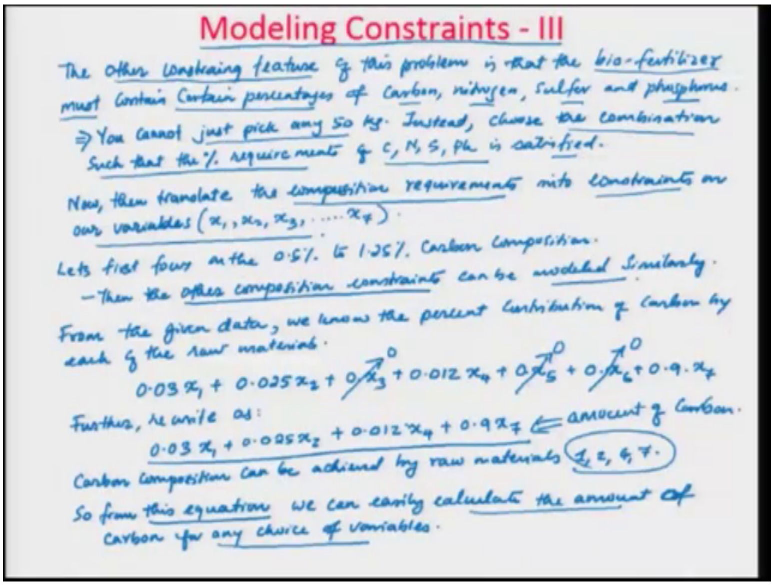

Remember this scenario, where we wrote the constraints for each one x 2, x 3, x 4, we wrote it in the same fashion ok. Now, we can see that this will go to 0, this will go to 0, this will go to 0, this will go to 0, and this will also go to 0. So, our constraint will be 0.9 x 5 plus 0.96 times x 6 that is our constraints ideally in this case ok.

Now, because of weight percentage because of percentage of nitrogen, we divide by the total fertilizer ok, so which implies 0.9 x 5 plus 0.96 x 6 divided by x 1 plus x 2 plus x 3 plus x 4 plus x 5 plus x 6 plus x 7 ok, whole thing multiplied by 100 ok.

So, remember this, the same fashion the same constraint is what we are trying to do this point, then we multiply this into the scenario which will give us 90 x 5 plus 96 x 6 divided by x 1 plus x 2 plus x 3 plus x 4 plus x 5 plus x 6 plus x 7. And we know that percentage of nitrogen should be between what is it 0.3 percentage to 0.5 percentage. So, this will give us 0.3 less than or equal to 90 x 5 plus 96 x 6 divided by x 1 plus x 2 plus x 3 plus x 4 plus x 5 plus x 6 plus x 7 less than or equal to 0.5 ok.

Similarly, we can do it for sulfur percentage of sulfur should be between 0 percentage to as per the question it should be 0.05 percentage. Percentage of phosphorous should be between 0 percentage to 0.04 percentage ok. So, these two can also be write like the other two constraints ok.

So, here we are going to so same here as we wrote the so this is the nitrogen constraint, and the one before that is the, this is our carbon constraint, and now we have to similarly right the sulfur constraint, and the phosphorus constraint ok. So, then we will have all the constraints on the composition of the writer.

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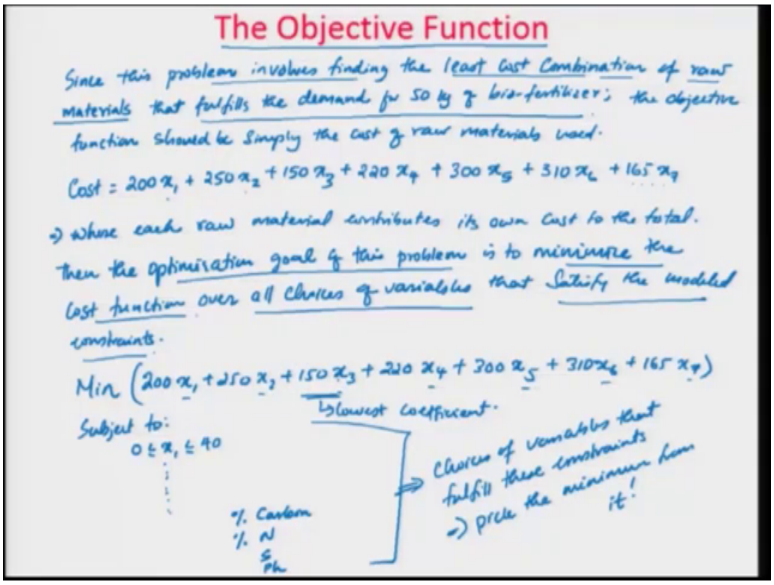

Now, with that the next aspect of us or the next thing we need to do is the modeling of the objective function ok, so because the constraints are all model now. Since, this problem involves of this problem involves finding the involves finding the least cost combination of raw materials; least cost combination of raw materials that meet the demand that fulfills the demand fulfills the demand for 50 kg of fertilizer of bio-fertilizer ok.

So, what we are saying is that the problem involves finding the least cost of combination, how can we combine the raw materials in the least cost fashion, so that we can fulfill the demand of the 50 kilogram fertilizer. Because of this the objective function should be simply the cost of raw materials used excuse me the cost of raw materials used ok.

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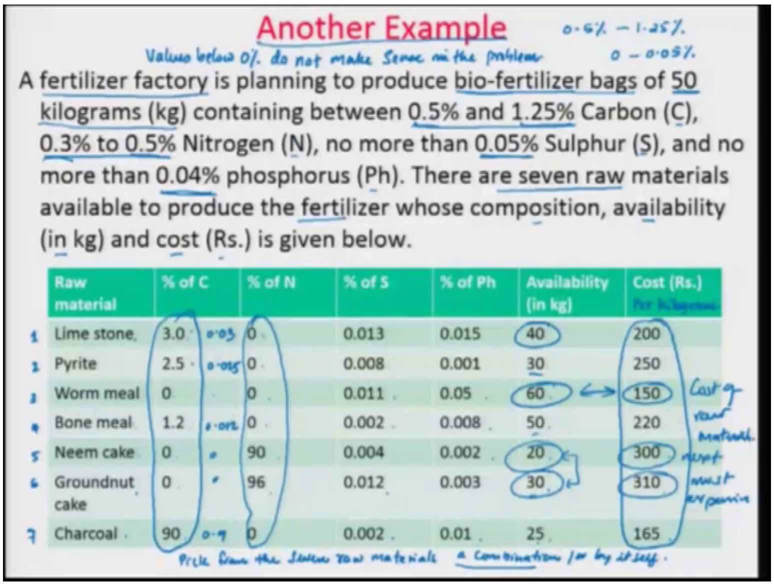

So, how can we write the cost of raw materials, where do we get the cost of raw materials? The cost of the raw materials per kilo gram is given right here this is the cost of raw materials ok, so that is the case how do we write that then we have again x 1, x 2, x 3 are the same way.

So, your cost is equal to if you look in the table, it is the first one is 200, so is like 200 x 1 plus 250 x 2 plus 150 x 3 plus 220 x 4 plus 300 x 5, then plus 310 x 6 plus 165 x 7 ok. So, this is the cost of the raw materials. So, depending upon a the quantity that you are using which are given by x 1, x 2, x 3, x 4, etcetera the quantity that you are using ok.

So, which implies where each raw material each raw material contributes its own cost to the total its own cost to the total. So, what we are saying is if we use 10 units of x 7, then the cost will be 165 times 10 ok. So, you will get to see that this factor will put into this ok.

The then the optimization goal of this problem is to minimize the objective of minimize the cost function over all choices of variables that satisfy the modeled constraints modeled constraints. So, what we are saying is that our optimization goal is to minimize the cost function, where the choice of variables the values of x 1, x 2, x 3, etcetera that we choose should satisfy the model constraints.

So, then we can write it as minimize 200 x 1 plus 250 x 2 plus 150 x 3 plus 220 x 4 plus 300 x 5 plus 310 x 6 plus 165 x 7 trying to minimize this subject subjected to you are subjecting to our constraints, where we will say that 0 less than or equal to x 1 less than or equal to I do not remember what their quantity was, but the quantity was I think it was.

So, if we go back, it will be 40 ok, so we will write it as 40. And like this all our constraints will be written here. And finally, we will have the then you will have a percentage carbon constraint, then you will have the percentage nitrogen constraint, percentage sulfur and percentage phosphorus constraints all of these. So, all of these the choices of variables that fulfill these constraints, then pick the minimum from it that is idea ok. I hope you guys understand the how the objective function has been modeled in this case alright.

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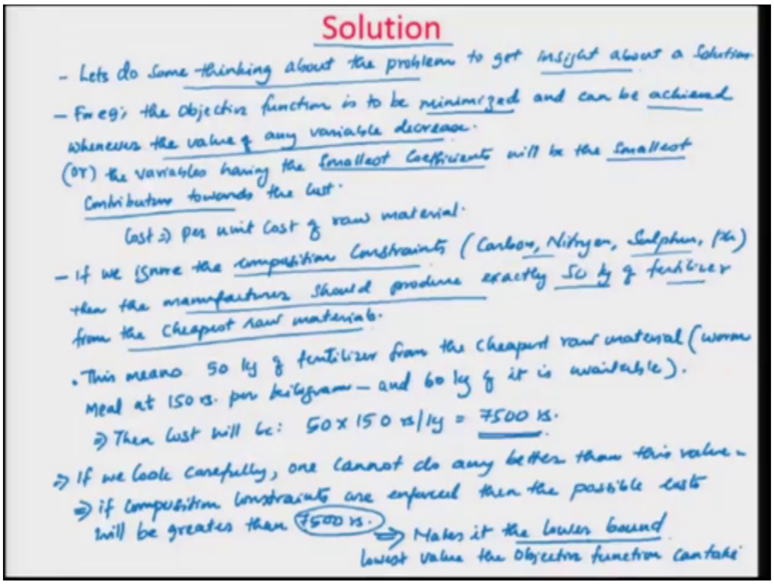

So, now about the solution ok? And we are not going to sit and spend time on solving the problem, but we are going to have some thought process on how to this problem is to be solved ok. So, let us think about the problem, let us do some thinking about the problem to get insight about a solution. So, let us think about the problem, let us do some thinking so that we can get some insight about the problem ok.

For example, the objective function is to be minimized, and can be achieved whenever the value of any variable decreases ok. So, the one way to get to the minimal value can minimize this objective function, if we can minimize the value of the variable.

So, what we are saying here is when any of these values of these variables these x 1, x 2, x 3, x 4, etcetera when these values can be reduced ok, then you can also you can achieve the minimization of the objective function or in another way to think about it is or the smallest the smallest coefficients or let us say or the variables having the smallest coefficients will be the smallest contributors towards the cost.

So, what we are saying is that the variable that is the smallest coefficients will also be the smallest contributors to the cost ok. And the cost is cost implies per unit cost of raw material ok. So, if you look into the function, you can see that whoever has the lowest coefficient of the whichever variable has the lowest coefficient, it will be the lowest contributor to this ok.

So, for objective function if you write it down, then we can see that in this the lowest this is the lowest coefficient ok, so then that means the any value of x 3, you put it in will result in the lowest contribution towards the cost right. So, if then if we ignore the composition constraints for the time being composition constraints, they are the carbon, nitrogen, sulfur, phosphorous ok.

If you ignore this composition constraints ok, if you are not working into that, then the manufacturer then the manufacturer should produce should produce exactly 50 kilogram of fertilizer from the cheapest raw material from the cheapest raw materials.

So, if the composition constraint is not there, if you not worried about the carbon, nitrogen, sulfur, phosphorus, etcetera, then what the manufacturer should do should produce exactly 50 kilograms of the fertilizer from the cheapest raw material ok. And this means this means 50 kilograms of fertilizer from the cheapest raw material which is worm meal worm meal at 150 rupees per kilogram gram and 60 kg of it is available, how do I know that ok.

You go back to the table, you will see that the price of it is 150 rupees, and there is 60 kilograms of it available. So, I can easily make 50 kilograms of fertilizer from that ok. So, what are we trying to say is that then the cost will be 50 kilograms multiplied by 150 rupees per kilogram which will be the cost of the worm meal, so that will be equal to 7500 rupees. So, this is the cheapest, I can make this 50 kilograms of this fertilizer ok.

If we look carefully or if you think carefully, one cannot do any better than this value ok, you cannot produce than this value which means you cannot produce any fertilizer any fertilizer any 50 kilograms of this fertilizer at a cheaper price than this, it is that way value.

This also implies that if composition constraints are enforced if composition constraints are enforced constraints are enforced, then the possible cost value cost will be greater than 7500 rupees ok, which means, you cannot do any lower than the 7500 rupees makes it the lower bound ok.

So, lower bound is that value for which you cannot do any lower any cheaper than this particular or you cannot have a solution to this problem any lower the any below this value or this is the lowest value sorry lowest value the objective function can take ok, so that is what we are talking about the lower bound. So, when somebody says a lower bound to the objective function, this is what we talk about as a lower bond.

The lowest possible value the objective function can take for a given set of values for the problem, and these values only feasible this approach is only feasible, if we do not enforce the composition constraints. So, if you enforce the composition constraints if the composition constraints are enforced, then you cannot do any better than this 7500. So, the lowest possible thing that you should be able to aim at least 7500 rupees per kilogram bag of the fertilizer ok.

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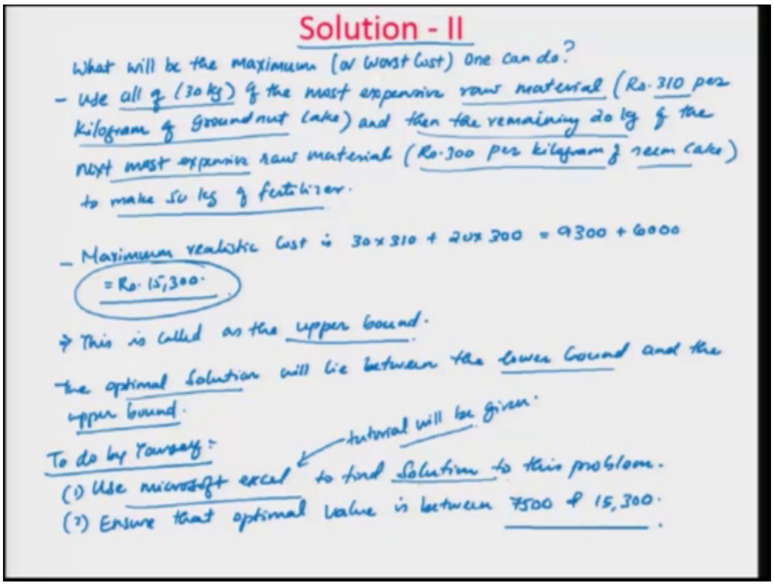

Now, let us take the look at the other side of the problem ok. What will be the worst you can do, what will be the maximum what will be the maximum or worst cost one can do. So, now we so what is the minimum or the best cost we can do. Now, let us look at what is the worst cost we can do ok?

So, if you look into this, we have to go back to the data again. If you see this the most expensive of this is the most expensive ok, and there is 30 kilograms of it and then the next most expensive the next most expensive and this 20 kilogram of it. We combine both of these, you can get the most expensive one without why we why violating the composition constraints.

So, we can say that use all off which is 30 kilograms of the most expensive most expensive raw material that is what is the most expensive raw material we have, the most expensive raw material is groundnut cake followed by neem cake raw material rupees 310 per kilogram of groundnut cake the use all 30 kilograms of the most expensive raw material, and then the remaining 20 kilograms 20 kilograms of the next most next most expensive raw material expensive raw material no expensive raw material that is rupees 300 per kilogram of groundnut of neem cake to make to make 50 kilograms of fertilizer ok.

So, what we are saying here is if you combine that all of the 30 kilograms are the most expensive raw material, because you only have 30 kilo grams of it which is the ground nut cake. And then the remaining 20 kilo grams of the next most expensive raw material, which is 300 per kilogram of neem cake, it will give you the 50 kilograms of fertilizer.

This means, the maximum cost maximum realistic cost is thirty multiplied by 310 plus 20 multiplied by 300, which is equal to 9300 plus 6000, which is equal to rupees 15,300 ok. So, this amount it is the maximum realistic cost you can think about making this fertilizer, this is called as the as the upper bound ok.

So, ideally speaking the optimal solution the optimal solution will lie between the lower bound and the upper bound ok. The optimal solution always will lie between the lower bound and the upper bound, we seen what is an upper bound, and we seen what is a lower bound ok.

Then to do by yourself ok, then use number-1 use Microsoft excel to find solution to this problem ok. And ensure that optimal value is between 7500, and 15,300 ok. If you do all of this by yourself, so you have to use Microsoft excel there will be a tutorial will be given in this regard ok, you can use this tutorial to find out how to use Microsoft excel to solve this problem, because excel how solvers we on which you can actually feed this kind of scenarios, and it will solve it for you. And then ensure that the optimal values between 7500 and 15, 300 ok.

So, we now know what is say lower bound, and what is an upper bound to the problem. And we have also seeing how to model a optimization problem using in which the variable variables are having continuous values rather than the discrete 0, 1 values, we did in the first example.

And you are seeing that we have also fulfilled most of the constraints, please make sure that these constraints that we are talking about these conversation constraints should be converted into a simple so simplify this ok. You can simplify this by basically multiplying it dividing it throughout so it is easy to make it, and or you can move it into one side ok, and then do the simplification aspects of it.

So, please go ahead and do that, and make this simplify this constraints same way you also have to think about is simplify this constraint ok. Remember among the four laws one is make it lean, make it clean and simplify can make a linear, so that is what we are trying to do here. So, simplify these aspects.

And with that then try to solve them using the excel solver, you will can find those way to use excel to solve this problem, made available on many parts of the internet. So, please goead and solve this problem. And if you have any questions on this, please let us learn the discussion forum, so that we can help you with this regard. And continue learning, continue practicing the only one way you can do the modeling, and of the optimization problems is by just keep on doing it and practice and practice and practice, and that is the only one way where you can actually make this actually happen.

So, thank you very much for your patient listening, continue reading, and hope to see you soon in the coming aspects of this course.

Thank you very much.