Advanced Green Manufacturing Systems
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Lecture – 04
Introduction to optimization

Good evening welcome to the Advanced Green Manufacturing Systems course.

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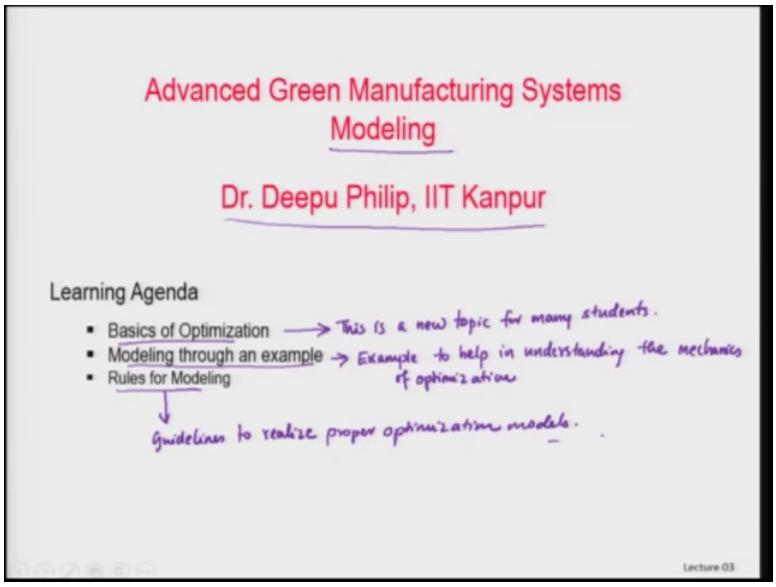

And today we are going to discuss the topic called Modeling and I am Dr. Deepu Philip from IIT Kanpur and today is lecture the learning agenda of today's class is we looked the basics of optimization and this remember this is important because this is a new topic for many students. And most of the green manufacturing courses does not covered this concept of optimization, because optimization is do is important for us and how to make realize green manufacturing through optimization. So, that aspect is taken care of by this part of basics of optimization.

Then we will work an example modeling through an example. So, example to help in understanding the mechanics of optimization and then a few rules of modeling which is there to us guidelines to realize proper optimization models already use modeling pitfalls ok. So, these 3 are the major aspects of today's lecture, we study the basics of

optimization we work out an example and then from there we divide the rules for modeling.

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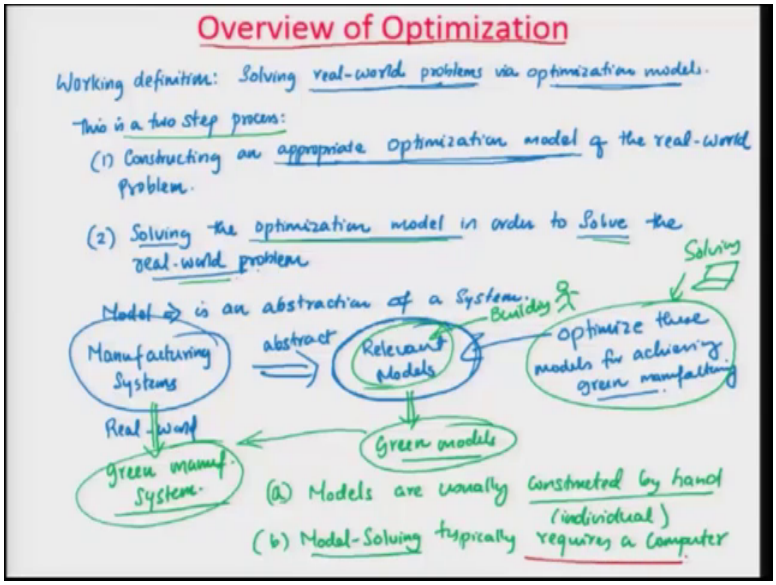

So, let us talk about the Overview of Optimization, what is optimization and what is the major aspects of optimization. So, the simple definition or we can call it as the Working definition, the working definition in this regard is this very simple solving real world problems via optimization models ok. So, optimization means solving real life problems solving real world problems using optimization models. And this is a 2 step process ok, this solving or the real life real world problems using optimization models is a 2 step process.

Number 1- the first step is constructing an appropriate optimization model an appropriate optimization model optimization model construct an appropriate optimization model of the real world problem. So, the first step is constructing an appropriate of optimization model, appropriate means the model that is relevant the appropriateness can also be think about is the relevance of the real world problem and then the second part of it is solving the optimization model solving the optimization model in order to solve in order to solve the real world problem.

So, the second step is you solve the optimization model which is the approximation of the real world problem and then once you solve this one you will result actually you will actually end up solving the real world problem and so that is what is called us an

optimization. So, optimization is optimization in a way is that you solve the real world the problem by solving the optimization model and what is an optimization model it is actually an approximation or an abstraction.

So, when somebody sees model I usually tell model is an abstraction of a system abstraction of a system for any system in that regard. In our case we have looking at manufacturing systems, so we will be building models. So, what we are actually trying to do is we look at in our current class it will be Manufacturing systems this is what the real world is real world and we abstract or the process of abstraction and we create Relevant models and then we optimize this optimize these models for achieving green manufacturing ok.

So, when you make these models green eh these relevant models when you convert them to green manufacturing models, so then what happens is when these models become green models ok. These green models this real system will become green manufacturing that is the idea here ok. So, by solving the model we will actually be able to do this and the question is also other thing that we need to understand these; a models are usually constructed by hand or what we call it as individual. The individual usually construct the model or builds the model.

The second part you need to think about is Model solving, model solving typically requires a computer. So, the solving of the model requires a computer. So, in this case when you abstract this portion this building of the model you require an individual, the optimization of this is the solving you require a computer in this regard.

So, that is idea in this regard and once you optimize this when you solve this then the green model will result in what we call as a green manufacturing system. So, the idea here is this how concept of this optimization is all about that is it is a 2 step process as I said you come certain appropriate optimization model or as I said earlier model is an abstraction of the system of the real world problem and then you optimize this model in order to solve the real world problem ok. So, that is the idea in this case and models are usually built by hand they construct the model by hand and the models solving is typically done with the help of a computer all right.

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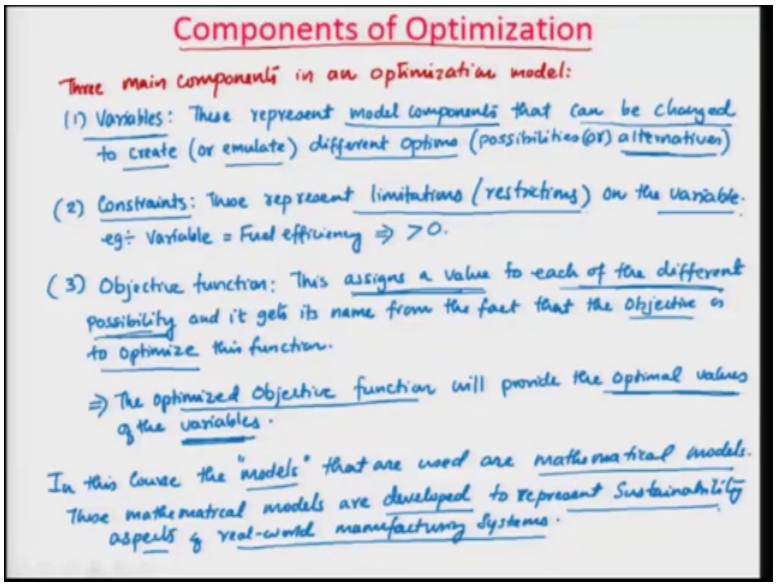

So, then let us talk about the major components of the optimization or major aspects of components of optimization. So, there are 3 main components of an 3 main components in an optimization model optimization model there are 3 major components in an optimization model.

So, the first component includes so the first one we call it as Variables ok. Variables of the first component of the optimization models and variables these represent these represent model components or components of the model, model components that can be changed to create or emulate create or emulate different options or what we call us possibilities or a better term for as alternatives. So, the first part of this whole thing is what we call us variables.

So, variables are the components of the model or model components that can be changed or you could change the value of them that can be changed the values of that can be changed to create or emulate different options or different alternatives. So, when you want to so the variables are the ones that you can actually model define or change them to create different alternatives that can be evaluated, so that is the first part of an optimization model.

Second one is what we call us constraints, constraints are these represent constraints these represent limitations on the variable limitations or restrictions on the variable. So,

one example of this is so when you say limitations or restrictions to an example I will give you a simple example so it makes sense to you.

If the variable is variable is fuel efficiency, so then which implies value should be greater than 0 at least the value should be greater than 0, you cannot have a negative fuel efficiency hardly speaking right. Maybe you know the way you look into it, but the idea is that the best way you can think about is very close to 0 right. So, that is one example. Third case is third what aspects of the constraints is they are the limitations on the variable, so what are the values the variable can take what is the maximum value the variable can take those kinds of things are all part of the constraints.

Then the last part is the objective function many of you might have heard about this term objective function objective function like this. The objective function what it does is this assigns the objective function assigns a value to each of the different each of the different possibility each. So, it assigns a value to each of the different possibility and possibility and it gets it is name from the fact that the objective is to optimize this function.

So, the idea is that what objective function does is it assigns a value to each of the different possibilities. So, by the combination of this different values of the variables and constraints you assign a value to each of the different possibility of the model whatever we talked about and the it is called objective function is that this function which assigns it is value the idea is to have optimize this function. So, the objective function is something that you optimize.

So, that the so these variables so that way the Optimized Objective Function will provide the optimal values of the variables of the variable or the variables. So, the variables once you optimize the objective function, then the resulting values the resulting the assigned values of the option that have a possibility that you picked up or the alternative that you picked up then whatever the variables that resulted in the dogmatic that settings will be the optimal values of that variable.

So, in this course the models that we use ok, the models that are used are mathematical ones or mathematical models ok. We are not really talking about building a physical model yeah.

So, then these mathematical models these mathematical models ok, these mathematical models are constructed or developed let us call this developed we develop these models to represent to represent sustainability aspects of real world manufacturing systems.

So, what we are saying is that in this course the models we refer to our mathematical models and these mathematical models are developed or we develop them to represent the sustainability aspect or what we are trying to model is the sustainability aspects of the real world manufacturing system.

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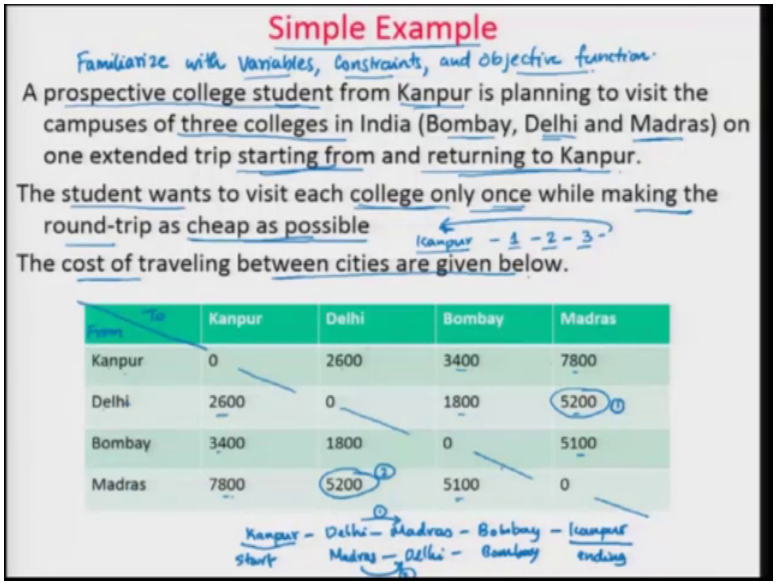

So, now with this, what we will do is with this understanding of the components of optimization. Let us get into a simple example of this problem and what am trying to well let us think about a scenario where a student perspective college student from Kanpur this city of Kanpur is planning to visit campus of 3 colleges in India Bombay Delhi and Madras, let us assume that a student from Kanpur is going to visit IIT Bombay IIT Delhi, IIT Madras on an extended trip on one extended trip starting from and returning to Kanpur. So, you are starting and returning to Kanpur.

So, starting from Kanpur then they all visiting Bombay Delhi and Madras and you are visiting the college campuses. So, you are visiting 3 cities starting from Kanpur and the student what he wants to do he wants to visit each college only once. So, you have to visit the city only once while making the round trip. So, round trip means you start from Kanpur then he visits city 1 then city 2, city 3 and then you come back to Kanpur. This is

the idea and the aim is you want to make it as cheap as possible, make it the cost the how much are the costs associated with doing this starting from Kanpur traveling to 3 different cities Bombay Delhi and Madras and come back to Kanpur in the cheap as possible the cost of it should be cheap as possible.

The traveling cost the cost of traveling between the cities are given below, so what does it say is you can think about this as a matrix, you can think about it as something like this is from and to.

So, when we say this we can say this is Kanpur to Kanpur the cost is 0 that means you ideally you do not want to transfer between Kanpur to Kanpur and even though we joke about this on Kanpur. This 2600 rupees whatever it is you want rupees you know dollars yen does not matters, this is the cost of traveling from Kanpur to Delhi this 3400 is a cost of traveling from Kanpur to Bombay.

So, and there is an 7800 is a cost of traveling from Kanpur to Madras. So, this 7800 is true when you see here this is the cost of travelling coming back to Kanpur from madras 7800. So, if it takes one same amount that way so these values are exactly the mirror. So, this mirror this matrix if you think about it you know, you can actually think about this cost is brutally mirrored in this side.

When you say 3400 that means, it is a cost of coming back from coming back to Kanpur from Mumbai, 2600is the cost of coming back from Delhi to Kanpur like that. So, this 1800 percent of costs are traveling from Delhi to Bombay 5200 is a cost of traveling from Delhi to Madras and 5100 is a cost of traveling from Bombay to Madras and the similar cost this 5100 is the cost of traveling from Madras to Bombay the reverse of it right.

Because you can visit the cities in any different order we are not really said which order you want to visit. So, this is the study of the problem and this is an optimization problem, so we are trying to work this numerical example in such a way that you will understand and you will understand the different aspects of what are the variables what are the constraints and what is the objective function.

So, this aim of this example once again is to demonstrate is to familiarize that variables, constraints and objective function and objective function. These 3 aspects of the

optimization we want to I want you guys to familiarize with, for this we are using a simple example of a perspective college student from Kanpur visiting 3 other college campuses in India where which are in Bombay Delhi and madras and it the trip starts from Kanpur and it has to end back at Kanpur ok. So, rounded and the student wants to visit each college only ones, so the main aim is to visit the city only ones not multiple times while making the round trip as cheap as possible.

So, you want to reduce the cost of travel as much as possible and the cost of travel between the cities is given in a matrix where I said that it is from 2 matrix. So, since it is a upper part of the matrix actually tells the cost of traveling from different one city to another and the lower part of the matrix will tell you the costs of traveling from the other cities the riverside. So, since it is a round trip. So, you can have an example of we can travel 1 would be Kanpur to Delhi to Madras to Bombay to Kanpur. So, this is what we call as a round trip the trip should start in Kanpur and then that is Kanpur.

So, this is the starting point of the trip this is the ending part of the trip. So, once and like for another option on this can be Kanpur it can be madras and Delhi and Bombay; this is also another option right. So, in this case the Delhi Madras we would use Delhi Madras this as the price for this case. So, we call this one and this madras Delhi we can think about yes this is madras Delhi you can call this as 2 and the 2 will be used as the cost there. In this case these costs are exactly the same, but there could be scenarios where this cost could also be different.

So, the traveling to from 1 city to another city it can be much more cheaper than in one direction or other. But since you are none of you have an exposure to the optimization aspects of the problem, it is better that we start with such a simple problem to begin with and then proceed step by step to going through the 3 aspects the variables the constraints and the objective function of the optimization model and thank you for your patient listening good luck.