Data Analysis and Decision Making-3
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Lecture 01
Management Control System and Responsibility Accounting I

A warm welcome to all my dear students and friends. A very good morning, good afternoon and good evening wherever you are in this part of the world and I coming after a long time with a new course.

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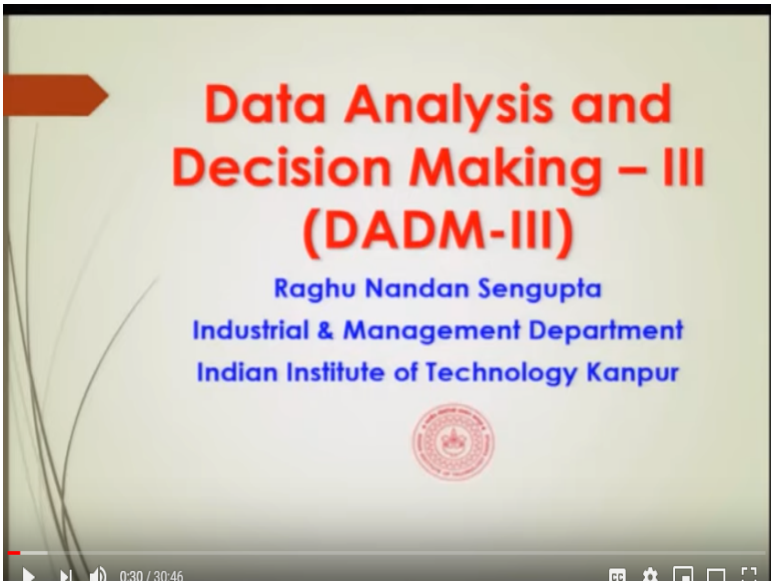

Which is DADM-3 which is as you can see is Data Analysis and Decision Making-3. Which you remember was basically a part and we have discussed that time and again during the part DADM-2 and DADM-1 which is a part of the series and in this course to give a very brief idea about the syllabus also it will be a 12 week course, total contact hours would be 30 spread over 60 lectures because you know each lecture would be for half an hour and each week we would basically have 5 lectures with an assignment after each week. Thus we will have 12 assignments and after the end of this course you will have a question paper, final question paper examination.

Now before I start of the class, based on few of the feedbacks which I could understand for DADM-2 specially, we will try to keep this course as logical and as practical as possible without

going to much details of theory because it would be more considering this total course as if you consider in the depth of the total course, it would basically be spilling over to almost two semesters in a year. A year course because it will have different components so I will keep it to the minimum to the basics, just consider the applications, their examples and no theorems would be discussed only the general crux of the concepts of the theorem, lemmas whatever. In the conceptual framework would be discussed and just mentioned accordingly.

Maybe as we are proceeding I would not be able to cover the whole gamut of the concepts but is basically trying to inculcate the interest and urge you, request you to read the different books, there are different E-copies of the books, different hard copies of the books, the net has different information and I am sure all these things would be helpful in order to make you understand and get yourself interested in this area of operation research and as you know my name is Raghu Nandan Sengupta from the IME department at IIT Kanpur in India.

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So this is DADM-3 lecture 1 which is for the first week. So before I start the course, obviously it will go on a little bit different pattern which respect to DADM-2 rather immediately going into the theory, I will slowly build up the storyline for DADM-3. So generally even though the syllabus looks huge I would again I am requesting that I will only keep to the basics. So will basically consider ok this, sorry we have to bear with me in this screen would be coming.

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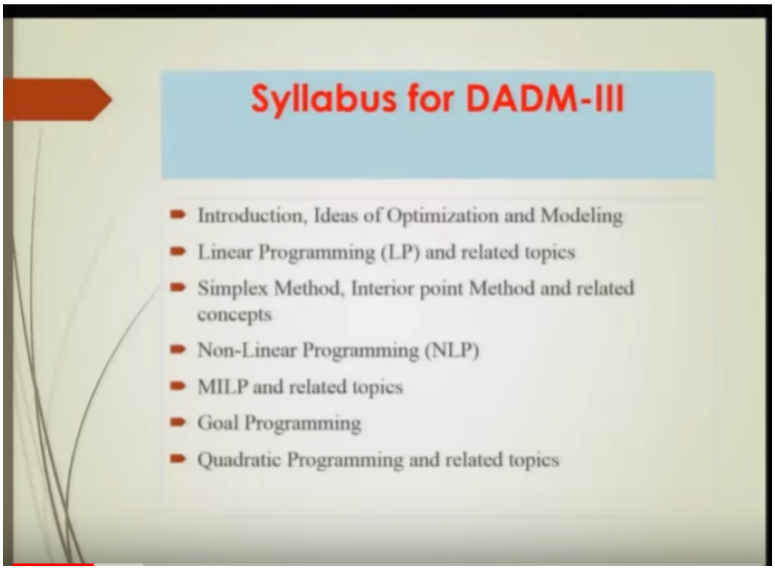

So we will consider the introduction basic ideas of introduction, what we mean by optimization, what we mean by linear programming, what we mean by non-linear programming, 01-programming we will discuss about that, mention it very briefly, their general essence and we will basically consider that what we mean by modeling? So modeling is more of a conceptual part rather than a mathematical part.

So we will basically discuss about the mathematical tools more here, while the conceptual tools how you build up would basically come through your experience, how you gather the information, how you process the information, all will be utilized. Will consider the concept of linear programming and related topics. Related topics would be in the simple concept of network flows, would be in the concept of Northwest Corner method, in the very simple concept of how you solve an optimization in the linear framework and why we solve as it is given?

Will consider the concept of what is a dual problem? What is duality? What is actual simplex problem, linear concept of linear programming? Why we need the slacks? What are the shadow prices? Those would be mentioned as we proceed and obviously very simple problems would be considered, both in the two-dimension one and then higher dimension for the higher dimension the problems would be given as stated.

Will consider this as I mentioned the simplex method, the interior point method and the related concepts which I mentioned and then obviously this point first, second and third bullet points are huge in scope so we will keep it to the minimum as required. Will consider the non-linear programming concept, so will consider very simply the quadratic programming and what we mean by non-linear programming with respect to the linear programming, so obviously the word non-linear and linear gives you an idea that there is some non-linear equations or non-linear concepts in the non-linear programming which is not there in the linear programming.

Will consider the mixed-integer linear programming, so it would be a combination of integers in linear programming for solving, I will give you the idea, the solutions would be discussed very simply. Will consider the goal programming, where how goal programming is used, (what are the) what we mean by the concept of goals, how the goals are basically conceptualized in the models. Will consider as I said in the non- linear programming thing, one is the quadratic programming and related ideas.

So what we mean by quadratic programming? What are the properties of the quadratic programming? So will consider the simple concepts of gradient descent search, how the concept of maximum (minimum) will be utilized in a very simplistic sense to arrive at the solution and get the whole depth how the problem solutions can be tackled.

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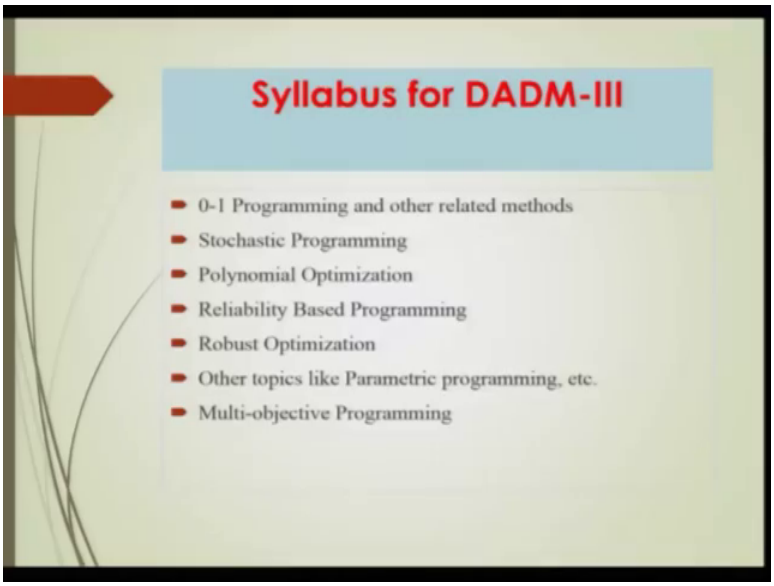

Later on will come to the 01-programming and the related concepts, so the 01-programming to give a very simple concept that you have to build a factory not to build a factory, (you will) basically higher or not higher. So obviously the outcomes of these variables what we mean by these variables are the decision variables I will come to that. They will be considered as having either the values of 0 and 1.

Now in all these concepts which we discussed this quadratic programming, linear programming, goal programming, MILP, there are other variance also I will go as we proceed, discuss. So we will consider very simplistically the general input which you are getting from the external sources and the decision variables are deterministic in nature that means they do not have any underlying distributions and we will try to basically solve the problems accordingly. But when we come to the concept of stochastic programming, we will consider that the concepts of the decision variables either the all the inputs or the different type of parameter which we are considering have some underlying distribution that means they are non-deterministic, they are stochastic, they are probabilistic.

So how we would solve the stochastic programming? We will consider very simply, it is a huge topic but will just keep it minimum as possible. We will consider the polynomial optimization concept also. How the polynomial, so when you have a polynomial equations we know that there

are x has different powers, so how we consider this polynomial optimization concept in very simple areas of applications will consider that.

Then we go into add-on from the stochastic optimization would be the reliability based programming and robust programming. So how reliable your results are based on the input? How reliable your results are with respect to decision variable? Will consider the concept of reliability, optimization and how different concepts of change of variables, how different concepts of optimization and stochastic would be utilized for reliability program will be considered.

Later on to add to the flavor, to add to this inertia of consideration of different topic will consider the robust optimization, so will consider how robust our results are with respect to the perturbations. So, if perturbations can be with respect to the input data, perturbations with respect can be due to decision variables. Like say for example, you are designing a car. So there would be vents, switch would basically have an effect on the car movement on the speed, they can see for example the condition of the roads, the materials, so how we basically consider that, considering there are different variables which are changing and how robust the results are with respect to the perturbations.

Other topics like parametric optimization, where the parametrization is possible, not possible we consider in a very simple way and later on we will just wrap it off with multi-objective programming in a simple sense that how they can be attempted and if you remember that we had discussed few topics in multi-objective optimization, where different type of heuristic method were used. Even though we are not able to cover everything but we did try to basically stress on colony optimization, on artificial immune system, genetic algorithm and colony optimization, particle some optimization, so all these things can be utilized if straightforward solutions for multi-objective optimization are not possible.

Because you want to basically reach a paraoptimum solutions as that, by trying to basically make a compromise with the x bundle of goods and y bundle of goods considering there are only two products you can get the best solutions. So you can change x, obviously the y component would also change but the combination of x, y should be such that you would get the benefit (right now) when you are trying to optimize, you will get the benefit that is required and if you increase it to the higher dimension, obviously there would be a bundle of goods for x, for y, for z or if it is

more than 3 dimension it will be x1, x2, x3, x4 and these can be combined in such a way that you get the maximum benefits. So benefit or try to basically reduce your total loss because in optimization you are already considering that you want to either maximize or minimize some objective functions. So how it is to be done, we will see that in details.

Now this reference in list which I have given and it was already there in the net for the NPTEL course, they are not the best one, best one in the sense they are not the only one which is existing in market, so there are a lot of books on optimization, as in statistics, the research work has been going on and statistics is such a popular subject so is operation research and mathematics is such a popular subject, many classical books have come into the market. So maybe I am not been able to deal with the all the classical books as and when proceed you proceed and if there are any queries which is coming in, the forum we will try to answer that.

But in general if you pick up a good textbook, you will find all the classical references are there which you definitely refer to. These classical books I am giving you just for interest not to basically make an extra reading because considering the depth of the course obviously the classical books if you pick up one, it will basically going to a direction where you will basically spend hours and hours to study that and understand the concept.

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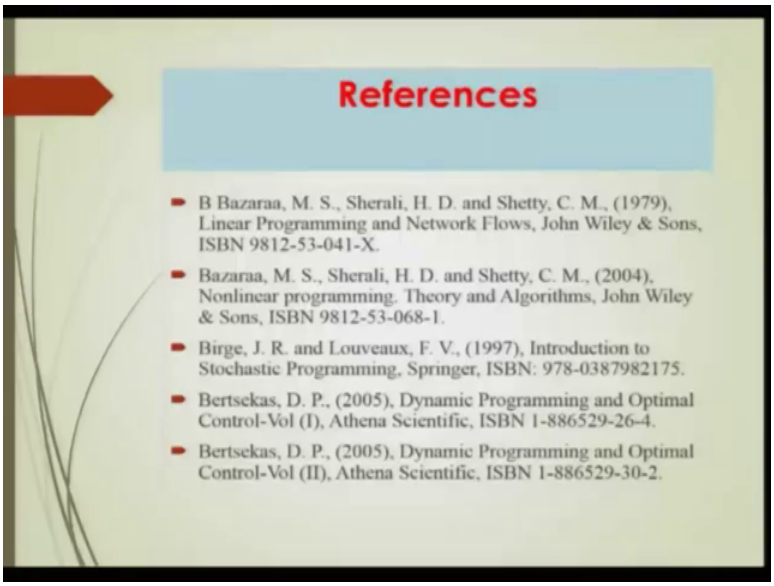

So I am just giving them as a nodal point based on which you can basically search, get your interest, find out who the authors were, what type of work they are doing and where are the different type of universities, different types of companies which are working and so on and so forth. So few of the good books are basically by Bazaraa, Sherali, and Shetty, by Birge, by Bertsekas. So these are in the area, last two names are in the, and books are in the area of dynamics programming, Bazaraa, Shetty are in the actual non-linear and linear programming which is good.

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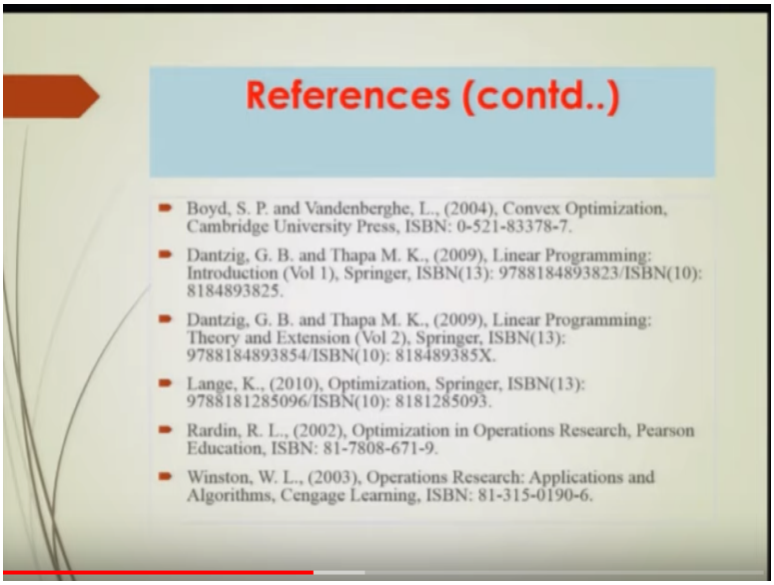

So you have Boyd, you have Dantzig so I will come to the word of Dantzig later on. You have Lange, Rardin which is a good book in the optimization. It is a general good book with all the problems, your good old very classical books is basically by Winston. So what I have mentioned here, I am again mentioning these are not the end of the list. These I thought are good starting points, you can basically check the book, find out, you need not buy these books, you can find out where they are available and just check flip to the pages if you have time and understand what are the different ideas which we will try to cover.

Now before I start of the linear programming, there would be a storyline, so because discussing any concept (would) basically we have a history so I may not be possible to deal with all the historical perspective of linear programming but I will try to basically go through the topics as and when it occurs.

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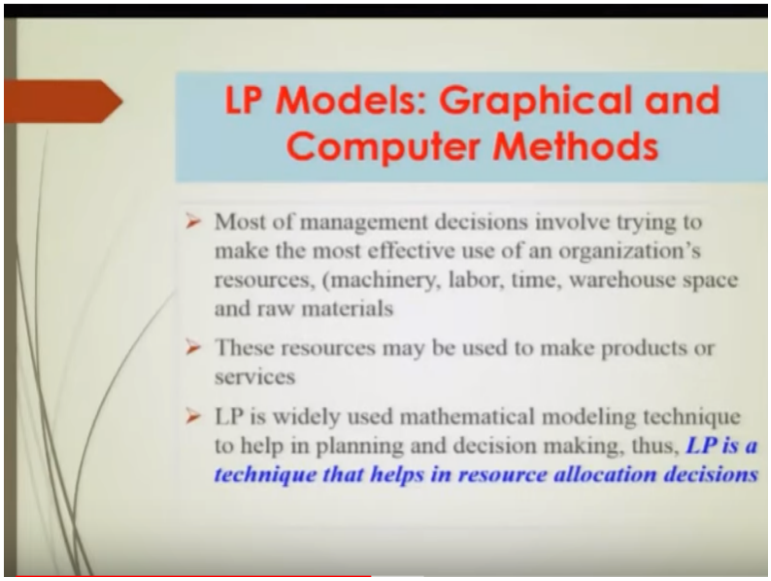

So most of the management decision involved, trying to make out the most efficient and effective utilization of resources. So, what are these resources? Resources can be say for example water, it can be say for example natural resources, it can be coal, it can be sources can be machine utilization, it can be man-hour whatever it is. So there are some resources which have to be utilized and we have to utilize effectively.

So by the word effective I mean or we generally mean that we have to utilize them in such a way that the utilization per unit time or the utilization per unit value is basically be is at the maximum level provided we are getting some profit or some benefit out of it. So it is not that I am going to utilize some resource and I get a negative benefit, it is not that. So will try to basically utilize that it in such a way that we get the maximum possible benefit.

So if I read this point it says that most of the management decisions involve trying to make the most effective use of an organization resources, resources can, as I said, can be machinery, can be labor, can be time, can be warehouse space, can be raw materials and raw materials can be of any type. Now what is our main concern? Our main concern, our main objective is that these resources may be used to make products or services.

So products can be I am trying to make the car, I am trying to make a chair, or I am trying to make a table, I may be able to make some paints, or I want to transfer some goods from warehouse to the distributor, services so services can be I am trying to basically give the maximum through port when I am trying to basically utilize the tele-machine at the counter for bank or maybe say for example I have different base and processing products which are coming in the top floor, I am trying to basically give the maximum services or it can be say for example at the airport people are coming to check in book their tickets, board the flight, or I would basically increase my services and basically increase my throughput. So it can be both product wise which is tangible and services which are intangible.

So linear programming, so the words are LP which is linear programming. So, linear programming is widely used mathematical modeling technique to help in planning and decision making, so we want to basically plan our resources utilization, plan our resources utilization for different point of time, so as that we are able to utilize them in the best possible manner. So if I read it, it means that LP is a technique that helps in resource allocation decision to basically make the optimum use in order to achieve some objectives, some goals. So what is that goal, what is that objective? It can be single objective, it can be multi-objective will come to that later as I discussed in the general outline of the syllabus.

Now obviously when you are trying to solve the problem, you will basically have different of practical implications. So trying to basically implement all the practical implementation in the theoretical sense when you are trying to solve may not be possible. So you have to basically make some assumptions. So what are the assumptions and how practical the assumptions are possible? We will also consider that either through some examples or through some pictorial diagrams so such that you will be able to appreciate that what is the actual difference between the practicality and the theoretical viewpoint which on based on which we will try to basically solve our problem or trying to consider the problem as it is given in the textbook.

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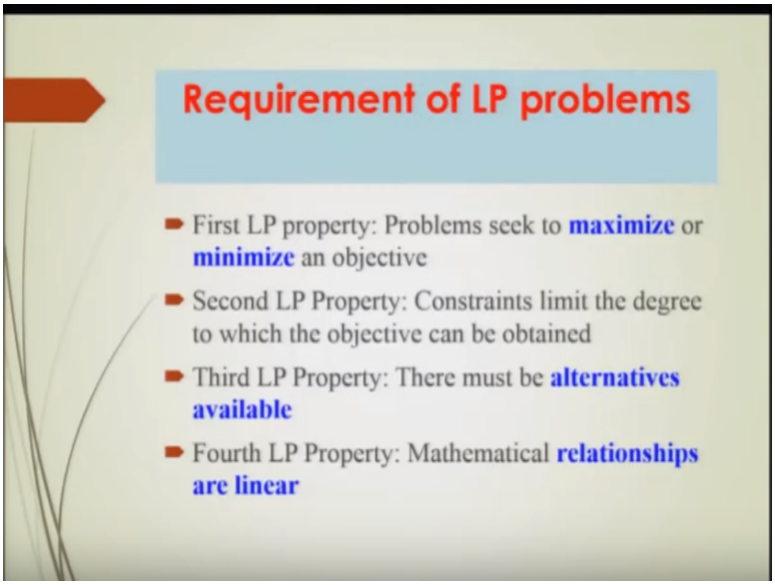

So the first linear property is, linear programming property is the problem is basically to maximize or minimize some objective function. So objective function may be profit, so you want to basically maximize the profit. Objective function may be loss, so you want to basically minimize the loss. Objective function maybe say for example distance travel, so you basically want to minimize the distance travel, objective function maybe say for example the capacity of the lorries, consider that you are basically utilizing lorries to transport goods from the distributor to the retailer. So objective, if it is capacity of the lorries we will try to basically maximize the capacity of the lorries.

Another case can be say for example we have a two-dimension aluminum sheet or a two dimensional some wood and you want to cut different shapes and sizes from the piece of aluminum or from the piece of wood, so your objective maybe say for example you want to minimize the wastage. In that in case it is the minimization of the overall loss or say for example you are trying to basically produce some paint or some fluid which are to be used in the chemical reaction and you want to basically produce the maximum amount without thinking of the profit because the maximum amount of fluid which you produce will be utilized for the production.

So in that case your throughput would be to maximize the total output or say for example in the service sector your actual objective would be number of people who are being processed, so you will try to basically increase the number of throughput considering the number of people who are being processed per unit time.

Another case may be say for example in the same sense that you have a tailor machine, you have a basically counter in the bank and you want to basically minimize the waiting, average waiting time for which each and every passenger which or every customer is there in the line. So your main objective would be to basically to minimize the average waiting time for each of the customer. So obviously what you want to optimize whether you want to maximize or minimize I try to find out the different combination obviously will come out as the practical situation demands or how the problem has been formulated.

The second linear programming concept would be the property would be what are the constraints? So obviously the constraints can be if I have say for example 8 hours working for any human being in the factory, obviously I cannot utilize him or her for more than 8 hours or say for example the capacity of the raw materials which I purchased is basically say for example only 240 liters per week. So obviously I cannot manufacture any product for which the utilization of that product is more than 240 liters or say for example consider on the other sense I am trying to basically optimize the throughput of the products and I have the inventory where I will keep the products.

And if the inventory capacity is say for example in the whole space is 100 cubic feet and if I have to store goods in that warehouse so obviously my total (weight) the total volume of the products which I am going to put in the warehouse cannot exceed 100 cubic feet. So in that case, it is less than equal to 100 cubic feet.

Other case can be say for example I am trying to basically produce the good and sell them in the market and the demand in the market is say for example for that product may be computer, maybe car, maybe say for example chair, maybe table, maybe anything and the demand in the market is there has to be met from my side because I am the producer, I have taken say for example the contract to produce goods and supply in the market and the demand is minimum

500. So in that case my production capacity should be such forget about the optimization concept whatever is to be there.

The constraint would be such that it has to be the combination of the products which I am going to sell in the market has to be greater than equal to 500 or it can be say for example I am trying to invest in the market, some amount of money I am trying to buy and sell different stocks and they are stipulated by either the external constraints by the financial institution or due to my own financial constraint that I have to basically invest minimum 10 percent of the amount of money in x-stock and I cannot basically invest more than 90 percent of my money for that x-stock.

So obviously, the total amount of money which I can invest for this extra would be bounded between 0.1 and 0.9 considering the total amount of money which I have, 0.1 and 0.9 means out of the total amount of money which I have. So there can be different constraints based on which it can be less than type it can be greater than type, it can be unbounded between greater than and less than type. So all these constraints would be coming up depending upon what are the practical situations we are going to face.

The third linear programming property would be there must be different alternatives available. So if I am talking about trying to optimize, so obviously alternatives would be different combinations of the goods I can produce. So different combinations of the goods which I am going to produce. So if I am trying to produce different quantum of combination of paints and consider I am using two different paints, one of red color of some property, property means depending upon what type of paint which is to be utilized, it can be industrial paint, it can be used for the household one, so obviously they would have the properties like the least corrosive one, they are able to withstand the change in the temperature, withstand the weather, so on and so forth.

So, if I am utilizing two different paints, so they can be utilized or produced in the market depending on what my goal is in different quantum. So producing different paints in different quantum would give me a different concepts of output and if I consider those output my optimum value whether we were are trying to maximize your profit or whether you are going to minimize your profit would change and in that case you alternatives would be laid in front of you based on the problem formulation which you have such that you can basically find out which is

the optimum one considering what is your actual objective ways, whether you want to maximize or minimize the overall profit or try to basically minimize the overall loss.

Because if you are producing it may be possible that we are producing paint there would be some pollutants. So these pollutants which has to be, which have to be discarded so you want to minimize the total pollutants which are being thrown away in the environment. So in that case the problem would be minimization of the total pollutants which are going to produce. In the other case, say for example if you are trying to produce the total number of paints such that you want to increase your profit, so in that case it will maximization of the total output of the two different paints such that two different paints I am considering for this example such that you increase your profit.

In other case, say for example if you remember I did mention about the multi-objective problem, it may be possible that the researcher want or the actual practical person wants that you basically produce paints in such a way that you optimize your profit but at the same time try to minimize the total pollutants. So it will be basically a combination of two objective functions wherein the first objective is you are trying basically to maximize the profit and the second objective function is trying to basically to minimize the pollutants. So obviously you have to make a the balance between these x-bundle and y-bundle of products which you are going to produce. X-bundle means the number of amount of paints you are going to produce and y would be the amount of pollutants which will be a throughput or an output for the production process.

The fourth linear programming would be the mathematical relationship would be linear. So whenever I am talking about the mathematical relationship it is a linear, it would basically mean that the relationship which is there between the objective function, the objective function and the constraint which are there and separately the constraints would be there, they would be linear because the world linear programming actually means that we are trying to utilize the concept of linear programming in order to optimize the overall scenario whatever we are facing.

So obviously when we come to the non-linear part when we come to the mixed-integer linear part, when we come to the quadratic programming, when we come to the robust optimization part, obviously the programs, the objective functions and the constraints can be linear or non-linear depending on the flavor of the problem but basically for the initial part linear

programming it would be a huge emphasis would be paid or we would lay a huge emphasis on these properties where the fourth property about the relationship being linear would be harped upon time after time in order to basically see to the fact that the problem formulation is linear and we are able to utilize the linear programming concept or simplex method to solve the problems.

Now whenever you are trying to solve a linear programming there would be 2 sets of properties or say for example 2 sets of ideas which should be conveyed to you or you should understand it.

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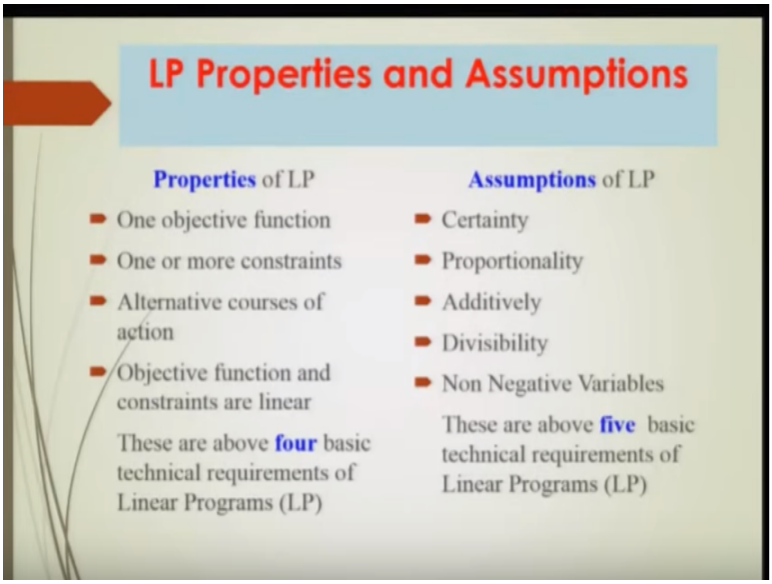

The first is basically, what are the properties of the linear programming? Properties means, what are the characteristics, which you cannot basically forcefully put into the system. These are already there in the system or already there in the problem formulation and based on the properties, based on the external information which you have, we have to basically synthesize and take some assumptions such that you are able to utilize the existing mathematical models given the historical mathematical tools which are there such that the assumptions can be utilized in order to solve the problem.

It may not give you the practically the best results but the theoretical best results would be such, that such that they can be utilized in order to understand that what practicality would mean in case the theoretical results are utilized in order to make some sense.

To give a simple example, I think I have given that in DADM-2 or in DADM-1 is if you are utilizing the example of a car, or a body traveling on a surface and we want to basically find out that what distance the car would travel. We technically in order to assume or if you utilize Newton's law of motion or you try to find out what is the time period of oscillations of a simple pendulum, we consider there is no friction. So there is no air friction or there is no loss of energy due to heat, there is no loss of energy due to radiation of whatever these are.

And will consider those problems and based on that we are able to solve the problems in a simplistic and in a nice manner such that the theoretical results which we give, give us a good idea that what in a practical situation they would be. So in the same sense, we will consider some assumptions in the theoretical sense such that when we try to utilize them in the practical sense they give us some idea that how the problems would be.

So do not let us come out to, to the case what are the properties and what are the assumptions of the linear programming. So in the linear programming as I said will always consider there is only one objective function. So one objective function would be that means we are not going into the realm just wait, so we are not going into the realm of multi-objective, will only consider one objective function and that one objective function may have different decision variables. What we mean by decision variables, I am going to come to that later on.

So will consider only one objective function with many decision variables. We will also consider in the linear programming they for the simplistic case there would be one constraint and as you go higher up in the and trying to solve the problem, the constraints may be say for example more than one. So when I am trying to give an example of the constraint remember one thing, based on the number of constraints which we have, if we too many constraints but if the decision variables are 2 in number it would be easy for us or for discussion or for me to basically to give an idea how the problem can be formulated in a linear programming concept, in a graphical method.

So will come to that later even though the constraints on the decision variables are two different ideas but I still wanted to mention that. So will consider the alternative for course of action which would be there, will also consider the objective functions or the constraints which are there, so what is a objective function? As I said there is only one objective function and based on

that we will have a linear objective function and linear constraint based on which we will try to solve the problems.

So these are the four basic technical requirements of the linear programming. Number one is there is only one objective function, number two is there would be one or more constraints, decision variables I am not going to consider now it can be 2, 3, 4, 5, 6, however decision variables you have. There would be alternative course of action based on which we can find out the different solutions to the same problem and will basically try to basically pick up which is the best and based on these four basic technique requirement will basically solve the linear programming.

The assumptions on the linear programming 1, I will just consider in the next class because this is 30 minutes basically has been covered for the first lecture and in the second lecture we will consider these assumptions as required. Thank you very much for your attention and have a nice day.