Business Analytics for Management Decision
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Lecture – 46
Prescriptive Analytics (Contd.)

Hello everybody, this is Rudra Pradhan here. Welcome to BMD lecture series, today we will continue with the prescriptive analytics and that to coverage on sensitivity analysis. We have already discussed couple of problems in this particular, you know unit that is the prescriptive analytics and that to we have dealt with lots of you know business problems, where we have objective functions may be maximization type, or minimization types subject to certain constants, may be constants are in a kind of normal set of, for instance with, with respect to maximization problems, the constants must be in the less than type and in the case of minimization problems, the constants are greater than type.

And also we have solves some of the problems, where corresponding to a particular objective function, whether maximization type or minimization type, the constants are you know both less than type and greater than type and also the kind of you know equality type, again we have also solved some of the problems, where you know some of the special issues. We have address like in feasibility of you know particular problems, the kind of you know unbounded solutions and the kind of you know multiple solution, you know degeneracy problems, redundant constraints so; that means, we have you know dealt with.

So, many business you know problems, business problems with you know different kind of you know nature and different kind of you know features so; that means, typically, you know in the prescriptive analytics structures. We must have objective function, subject to constants and condition and then we have solved you know the idea behind this particular, you know process is to find out the optimum values of the decision variables, through which we can address the business problem more effectively, more efficiently and come with a kind of you know management decision as per the particular, you know business requirement or the kind of you know management requirement in, in this particular you know unit, we like to address, you know some of the, you know

issues, where we can, you know address, this kind of you know problems in a more, you know attractive way.

For instance, you know the business is all together, you know very dynamic game and we, we will find, you know every moment, there is you know, kind of you know change. So, the topic a, that is the sensitivity analysis will be very helpful in this contest. So; that means, with respect to a particular, you know problems. So, we have objective functions may be maximization type or minimization type subject to you know constants, which may be in a normal kind of you know natures or the kind of no abnormality like less than type or greater than type and the kind of you know equality, but you know; obviously, with respect to a particular, you know situations at the particular, you know timeframes.

So, we have a kind of you know set up or we have a kind of you know problem structure, through which you can get the optimum solutions and that to the values of the decision variable, through which you can, you know address, the business problem, you know as per the particular, you know requirement, but now getting the optimum solutions or the values of the decision, problem to address this problem, you know you may have a kind of you know structure that you know some change may happen you know in futures, that may be with respect to the coefficients of the objective function.

The coefficients of the constants may be in the less than type, may be in the greater than type or we may have you know more number of you know constants or you know less number of constants. So, these are the following changes may happens so; that means, typically, we have already gone through predictive analytics, where we have a kind of you know information basket, where we have a data corresponding to a kind of you know problems and some kind of you know theory and the kind of you know structure corresponding to theory structure and objectives the requirements.

We like to connect all these data and come with a kind of you know models that really you know forecast or you know predict the future kind of you know business requirement. So, now, once the model is ready then we will find out some of the constants and conditions the kind of you know uncertainty, then again in the, in this kind of you know situation or in the, in this kind of you know, you know scenarios. So, we like to again have the optimum values of the decision variable subject to all the, you know changes like, you know the kind of, you know ah.

As per the particular, you know business requirement so; that means, you know what I like to you know address hers in the predictive kind of you know analytics, you know we have already, you know dealt with some of the problems like you know having data, having the kind of you know requirement, having the kind of you know you know conditionality. We may get a some kind of you know model that will address the future requirement and then we have lots of you know flexibility. So, changing the data structures, you know increasing this data size or decreasing the data size, increase the number of variables or decrease the number of variables, you know increase more number of you know equation or change the kind of you know functional form.

So, several ways we can, you know address the kind of you know problem, then we come with a kind of you know solution, which is actually more efficient and more effective and exactly the similar kind of you know framework. We can have in the case of you know prescriptive analytics structures, in this case with a given problems with you know; that means, with respect to a particular objective constant and conditions.

We may have optimum solution that is the values of the decision variable, which can you know address the problem, you know as per the requirement, but again we like to have some kind of you know kind of you know what I can say different kind of you know options or alternatives subject to change up these kind of you know requirements so; that means, say we, we are you know in this kind of, you know prescriptive analytics structures. So, the, the given situation is the kind of you know specification of the objective function and constant that to a the parameters that the coefficients of the objective function and constants are more or less, you know constant.

Then we like to you, know solve the kind of you know model you know that is what the linear programming model, which you have discussed and then we come with a kind of you know optimum solution. Now, there may be high chance that you know the coefficients of the objective function may change as per the future business requirement or the kind of you know, you know change of the business environment or with respect to competitive kind of you know scenario.

So; that means, technically we are addressing a particular, you know business problems, but that business problems may be you know connected with the similar kind of you know business problems may be connected with you know different competitors or

different sectoral problems or different kind of you know specification of the business so; that means, technically there may be high chance that you know the coefficients of the objective functions or the coefficient of the constants, may change again. There may be high chance that you know some of the additional constants may be coming into the picture and some of the constants we may a drop, if there is no necessity in, in the kind of you know future kind of you know requirement or the kind of you know business requirement.

So; that means, the, the item which you like to address here, today is like this that you know, we have a you know given problems, where we have objective function constants and conditions and then we like to predict the, predict the kind of you know structure, where if any change happen with respect to objective functions or coefficients of the, a, a constants may be left hand side, may be right hand side and the change of the numbers of you know constants, then what will happen to the optimality that, that is the values of the decision variables.

So, there is a high chance that you know if the problem is very perfect and very consistence, any change you can do with, you know coefficients of the objective function or the coefficient of the constant that to in the left hand side or in the right hand side and then change of the constants may not drastically or may not change at all the values of the decision variable or the kind of you know optimality.

So, . In fact, in reality and if any change happen with respect to objective functions or the you know the coefficients of the constants or you know change of the number of constants, there may be, there may be chance that you know the, a, the optimality structure will change; that means, the values of the decision variable may change or else the value of the objective functions may not change, but the structure of the you know optimality a, may change.

For instance in the; in the first instance you know, you we may have a kind of you know three variables problems, where a particular variables X 1 is not coming and; that means, the value of X 2 is coming 0, where the value of a, you know X 2 and the value of X 3 may be is something positive and now, any change with respect to constants and the kind of you know coefficients of the either objective function or constants or both.

So the, the optimality structure will remain constant; that means, still you know X 1 is not coming into the picture, X 2 is a still there and X, you know X 2 is still there, but the values of the decision variable will change, if the values of the decision variable will change and the typical structure is a constant then by default the value of the objective function will changed so; that means, what I like to say with respect to dynamics of business, there can be anything. So, so, so; obviously, it is a kind of you know challenge for us and now, with the help of you know LP a linear programming and the kind of you know softwares and the kind of you know programming. So, we like to predict the possible changes ah.

As you know for the future requirement or the kind of you know business requirement then with a, if with a present conditions we, we try to extract the optimality and the optimum structure, then with respect to prediction of you know future requirement, then we like to, we like to predict again, what should be the optimality of you know futures, with respect to the change, a change of the particular, you know business, you know setups that is with respect to change up the coefficients of the objective function, the coefficient of the constraints and the kind of you know number of constants corresponding to a particular problem.

Sometimes you know, we can, put the condition of, of the decision variable. For instance; you know the if typical optimality will change, if we will put, you know like you know, let us say the, the values of the decision variable may be integer types, then the problem will be you know, we can be solved with a different kind of you know structure. For instance; we, we first try for optimal, optimal solution and if it is not coming to the integer type kind of you know solution, then again we have to restructure the problem t and continue with the kind of you know operation.

Till we get the, the you know optimality or the values of the decision variable, which will exactly follow the kind of you know integer type as per the particular, you know requirement and these are the you know various dynamics and that is the particular requirement as per the given kind of you know situation or the dynamics of you know business or the, change of the business you know environment. So, now, . So, this kind of means this, this, this topic you know will address, you know all these issues and the kind of you know challenges and then give you the kind of you know exposure that you know, if you know what should be the kind of you know, solution for the existing

problems and then what will be the kind of you know solution with respect to different, you know change situations. Now, we have a two different kind of you know understanding, first understanding is that.

So, what should be the possible changes with respect to the a, with respect to the given problems that to you know, if you are changing the coefficients of the objective function or coefficient of the constant or the you know number of constants. So, that definitely there is a kind of you know, of you know proper planning or the kind of you know strategy, through which you can change the particular, you know structure or the kind of you know, you know requirement then after that we will look for the optimality or the optimum solution as per the particular you know requirement.

So; that means, we have addressed lots of problems and now, we like to you know solve some of these issues and then we like to check how we? How these are all coming in, in the kind of you know real life scenario or the kind of you know business scenario. So, so I start with a simple problem and the way we have solved you know in the last couple of lectures and now, I like to first connect with a particular problem and use the software's that is the solver package and let you know, how these program, you know the particular problem can be you know quickly you know get the optimum solution through the solver package.

Then I will connect with the sensitivity structure and then give you the kind of you know understanding and the kind of you know clue, how you have to address the you know optimal problem or LP problems with respect to changing, you know business environment or the change of you know business dynamics ok. So, let us see here is. So, how is the kind of you know structure.

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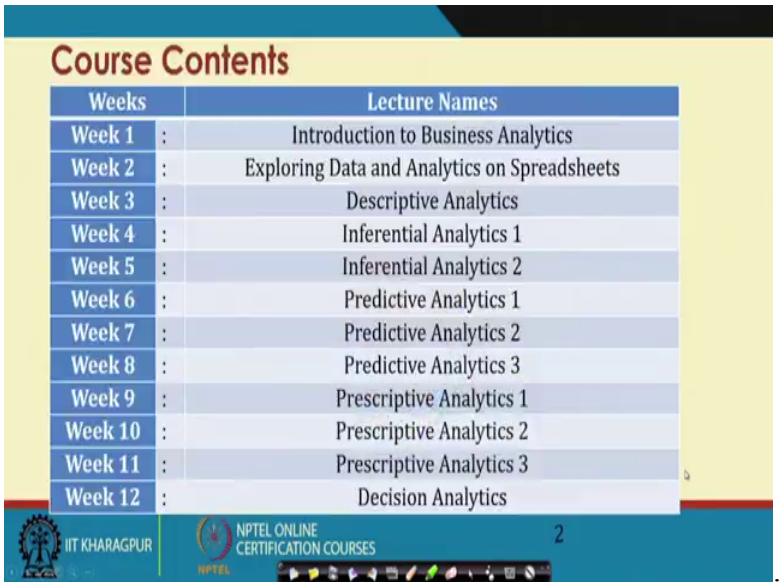

So, ah.

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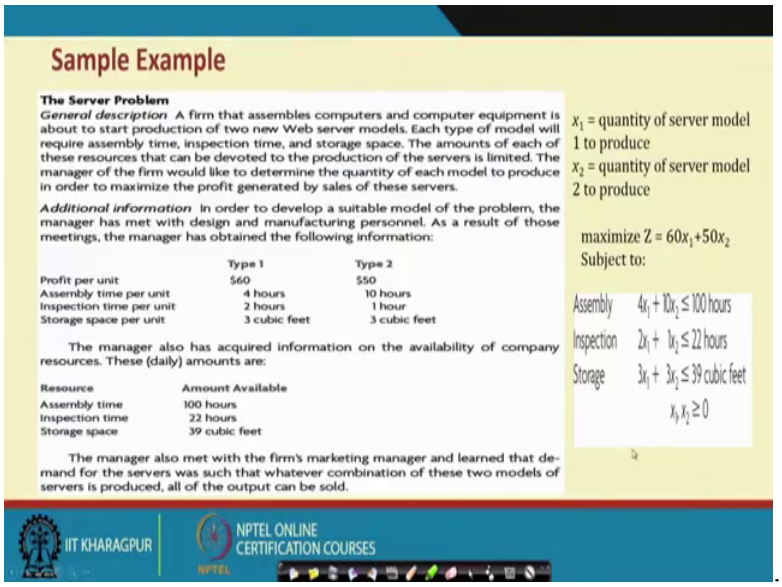

Let us say, you know consider this particular you know problem. So, we have already solved this problem and now, we like to you know, you know solve this problem through the kind of you know solvers; that means, technically this is a server problems and that to it is a maximization problems with respect to two variables and with respect to three constraints and then we are you know trying to even say solve the problems to look for the values of the decision variable and in this context, we have already solved this

problem by graphical, you know structure by simplex structure and again we take this problem and then we like to you know, you know or we, we like to know the kind of you know solution, through you know solver. So, for that.

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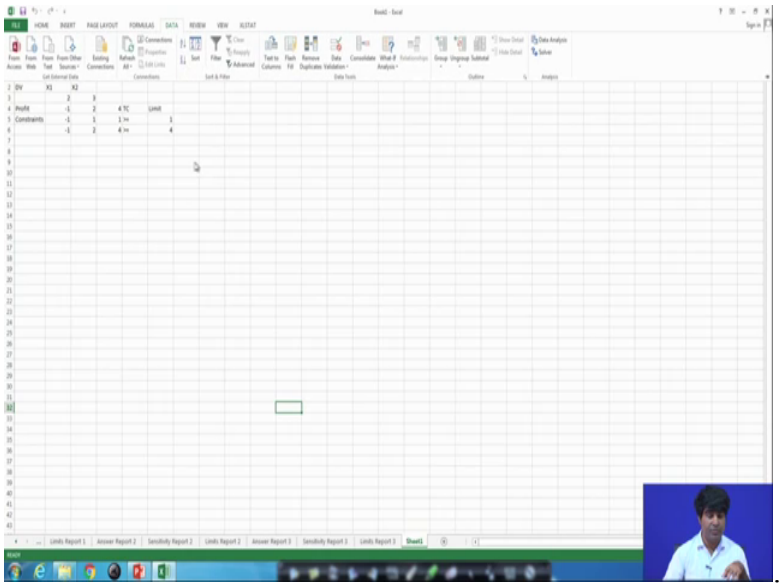

So, we can go to the, you know excels as you know, solvers. So, here the kind of you know structure is like this and. In fact, we like to start with a new problem and for that ah. So, let me take you to the new excel sheet.

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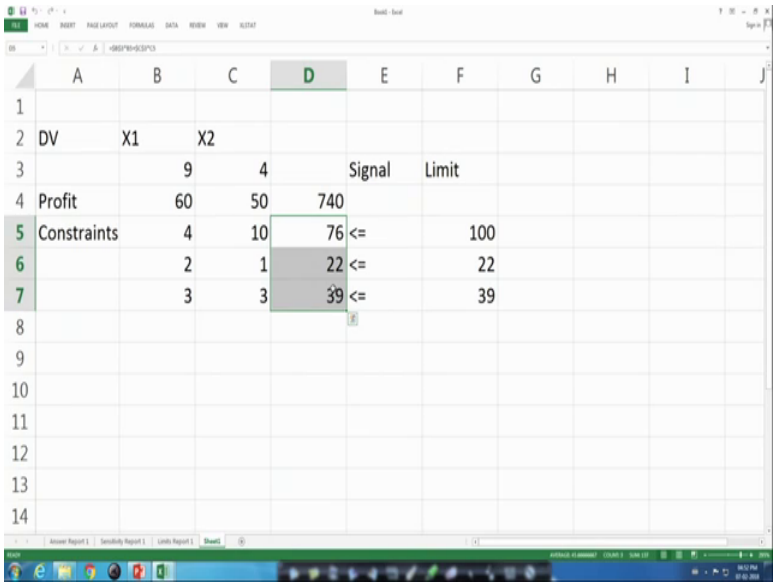

And then you know we start with a simple problem, which you have already here. So, this is what the problem and then we like to you know solve through the kind of you know solver package. So, what will it do? So, we like to start with here kind of you know structure like this, let us see here. So, how we can actually solve this, this type of you know problem in a kind of you know simple framework. So, we start with the structure like this. In the first structures, we will put you know DV that is called as you know decision variables and then we will have a, like you know objective function that is you know profit type and again. So, we have the kind of you know constraints, we have the kind of you know constraints and. So, also the, these are the typical you know structures ah.

So, we have a, you know our, you know requirement is the values of the decision variable subject to availability of profit functions that is the objective functions and the kind you know constraints and then the kind of you know conditions. So, assuming that it is a kind of you know, you know positive values of the decision variables, kind of you know requirement. So, this problem is you, with respect to you know two variable case that is the bivariate case. So, as a result.

So, will you put, you know X 1 here is and we will put here X 2. So, this is how the kind of you know indication and then ah. So, we first start with the a coefficients of the objective function. Since, there are two variables; the objective function structure will be a maximizing Z equal to C 1 X 1 C 2 X 2. So, C 1 is already given here that is actually 660, a 660 and then for X 2. So, this is actually 50 so; that means, the simple understanding of this problem is you know.

So, we are hoping at least, you know 60, you know U S D a will be for X 1s and 50 USD for X 2 and then we like to know what is the exact profit then you know for that, you know we look the a X 1 you know I, you know quantity and X 2 quantity and for that we need to have a first, the kind of you know exact problems, then we look for the kind of you know solutions.

So, in these problems we have a two constraint sorry, three constraints; assembly constraints, inspection constraint, and storage constraint. So, so; that means, we go to again excel sheet and then put the constraints. So, again the all the constraints are with respect to both X 1 and X 2 so; obviously, the first constraint that the assembly constraint

is with respect to 4 X 1 plus 10 X 2 less than equal to 100 hours so; obviously,. So, so 4 X 1.

So, it will be 4 and then for X 2, it is, it is it 10 and then this is first constraints and then the, a limit, a maximum limit is 100 here's. So, this is 100. So, this is what we can put here, the kind of you know limit, you know limit that is the resource availability and, and then the, the ok. So, we can put here limit and then this is what the we can put the kind of you know or the kind of you knows, a signal, signal ok. So, this is, this is the case, you know signal means, it is the kind of you know, you know indication about the kind of you know constraints; that means, the constraints may be less than type may be greater than type may be equality type.

So, this will give you the kind of you know signal and the limit is here, actually 100. So, that is the availability, the minimum availability or the kind of you know maximum availability, depending upon the, a kind of you know signal structure, if it is the less than type, then this is the, this limit will give you that, you know that is the maximum limit, through which you can you know reallocate the resource or allocate the research to get the optimum solution, if we will put greater than by default the indication is that you know it is the minimum requirement of this particular, you know resource allocations then come to the second constraint that is the inspection constraints, and for that 2 units of X 1s and then 1 units of X 2 and again the constraint is you know less than type.

The constraint is again less than type and the limit is a 21 and this is inspection constraint then the third constraint is a three storage constraint that is 3 X 1, 3 X 2; obviously, 3 for X 1s and again 3 for X 2. So, this is like you know input arrange, you know a matrix arrangement and; obviously, this constraint is also less than type. So, again you put here the kind of you know less than type of you know situation and then. So, the limit is here again 39 and so, you put here 39 ok. So, now, the a is you know the entries ready to operate. So, the first and operation is like this, we put here's then we, we like to define the objective function, which is nothing, but actually C 1 X 1 plus C 2 X 2 and then we are looking for the values of the decision variables.

So; obviously,. So, the X 1 value, which we can have here is like this. So, multiplied by profit coefficients, then plus again X 2 values, values X 2 value and then multiply the corresponding, you know coefficient and again, we can actually block this ones and for

that we can put through the kind of you know restrictions and ok, this is for B 3, this is for V 3 and again. So, we can block this ones for C 3. So, we can block this one for C 3 and ok, this is again blocking C 3. So, now, this is, this is ready to operate ok. So, now, just you know this is for profit function and you can scroll down for you know rest of the constraints.

So, now, this is how the a you know. Now, on the operation is ready to operate. So, then you go to the data you know analysis package like you know we have already solved some of the problems inferential analytics problems and the relative analytics problems. So, here we have used the data analysis package now. So, just data analysis package in the excel you know software.

So, we have a solver package just to click here is then you will find this screen will appear like this and here. So, we have actually three different structures that is the objective function structures and the kind of you know changing variables cells and then the constraints box. So, first and requirement is setting the objective functions that is, that is what actually you know this value ok. So, first of all we go for, you know reset, close this one ok.

So, now ok. So, now, we can go to the data solver all right. So, this is what the first and choice is the a kind of you know objective functions and that is actually we are putting the indication about to the D 4, then again you go to the second option that is the changing variable of options that is with respect to X 1 and X 2 again, you click here and then we set up the constraint sides and in the constraint sides, we in the box, we will go a add ons, one after another. So, this is the first constraints and the corresponding a, you know constraint indication is the less than type then the constraint limit is actually less than type you know less than equal to 100.

So, we can indicate less than 100, then this is the entry of the first constraints then we can add on the second constraint for that again, we go to this particular you know second constraint 2 X 1 plus X 2. So, which is here again the, the signal is less than type and the constraint limit means the resource availability is this much. So, we can again freeze this ones, then again you, we can go for you know add on third constraints that is actually A 3, X 1 plus 3 X 2 and again the signal is here again less than type and again the

constraint, availability and say that is B 3. So, which is nothing, but you know 39 ok. So, now, this is what ready. So, now, we can put ok.

So, now this is what the operations and corresponding to this problem. So, we have objective functions, we have the kind of you know, changing variable cells that is with respect to both X 1 and X 2 and the you know input of you know three constraints and again we have lots of you know, you know options here. So, if there are more constraints then, you can add on, you know continuously till you, you know close this particular, you know problem and again there is a change option, we can change as per the particular requirement that is how the sensitive analysis will work there and now, with the given situation, we look for the kind of you know optimum solution. Now, in the solving methods, we have a here, you know GRG non-linear and simplex LP.

So, now, here, we are actually discussing the problem LP and that to we have already discussed graphical structure and simplex structure and now, we are putting the simplest structure and then we give the option of you know solve . So, now,. So, this is how these solve options. Now, this is, this is now operative ah. So, now, it is ready for the solutions. So, now, here there are three options, answer sensitivity and limits and then we are giving option to three occurs the sensitive part. We will discuss after this particular you know solution. So, let us see, how is the kind of you know solutions. Now, this is what the operation is ready now. So, initially the these two are you know a blank. So, now, it is, it has the entry so; that means, the entry is 9 for X 1s and 4 for X 2.

So; that means, now the optimum solution is like that you know the value of X 1s, the distant variable X 1 is a 9s and the value of X 2 that is the decision variable 2 is 4 and as a result. So, your profit function will be 60 into 9 and 50 into 4 that will give you 740 and then, these are the kind of you know you know constraint kind of you know optimality. So, here is if you compare with you know you know resource kind of you know use this is, this is what actually the, you know optimality problem, where the measure, you know kind of you know structure is he how to allocate the resource, you know effectively.

So, that you know the objective function, we will reach at the highest level so; that means, typically it is in a kind of you know resource allocation process and there are three constraints, here and the maximum ability of research resources are there.

So, now we are you know optimizing and you know changing the structure as per the particular requirement so; that means, for the first constraint the maximum limit is 100, the second constraint, the maximum limit is 22 and third constraint, the maximum limit is a 39.

So, now, after the solutions; that means, we have already gone through simplex procedures and simplex procedure idea is that you know, we have a we, we have you know the idea of you know moving from you know first steps to last; that means, it is, it typically you know in the iterative process moving from you know a particular corner point to optimum corner points, you know every stage, the value of the objective function will be in a kind of you know increasing, increasing signal ah; that means, technically in this kind of you know situations. So, we like to check, where is the kind of you know optimality.

So, in the solvers, it will not give you the you know stepwise is kind of you know indications so; that means, technically what are the possible corner points, but it will give you the exactly, the final solutions that is the optimal solution, but if you go manually then you will start with you know first, you know a, you know optimum solution, then first improve basic feasible solution, second improve basic feasible solution, then finally, the final optimum solutions. So, now, in the solver package or ultimately it will give you the last step of the particular process, where you know the value of the objective function is the optimum and that to at the highest levels. So, now, after getting the optimum solution we like to check the kind of you know constraints. So, far as a first constraint is they are you know.

So, the maximum limit is 100, but the utilization is 76 second constraint, 22 and the availability is also 22, third constraint we have reached 39 and maximum availability also 39 so; that means, we have discussed the concept called as you know binding and non binding. So, the second and third constraints are you know binding and the first constraint is not, you know binding so; that means, still some resources are left, you know even after the optimality so; that means, we have a kind of you know resource pool. So, there is a high chance that you know all the resources may not be fully utilized, while you know having the kind of you know optimum solutions, but whatever we will change and you know, you know structure it.

So, ultimately will have optimum value corresponding to these, you know, you know, you know kind of you know availability only. So, now, in this kind of in this kind of you know situations, we have already highlighted, the particular you know requirement.

So, now on the basis of you know solutions. So, the maximum profit which you have reached here is 740 and that to the values of the X 1 is 9 and value of you know X 2 is the 4 and as a result the particular, you know business for a teacher to you know profit of you know 740 so; that means, the values of the decision variables for X 1 is 9 and for X 2 4 and that to value of the objective function Z equal to 740 and it satisfied all the constraints as per the particular, you know signals that is the less than type.

So, now, this is the original solution and that too fast and optimum solution and of course, we have reached the optimum solution with respect to or you know, you know, you know touching all these corner points and out of all these corner points, we, we, we have targeted the kind of you know optimal one . Now, coming to the sensitivity part. So, now, the process will start from here is. So, now, with respect to whatever optimum solution, we have reached.

So, we like to change some kind of you know you know requirement means some kind of you know structuring that may be with respect to objective function that may be with respect to constraint. So, for instance, here the a constraints you know inputs are 4 2 3 10 1 3 in that 2 for X 2 and X 1 respectively and then the coefficient of an objective function 60 and 50 and the limit of the constraints are you know 120 to 39; that means, if we apply sensitivity analysis.

So; that means, the change can happen with respect to either 60 you know or 50 that is the, with respect to objective function and the, a coefficient of the constraint so; that means, the input can change actually instead of 4, you can put 4 5 or you may put, you know 3 2 like this. So, any change, we can put here is and again in the right hand side, you can put any change then again after you know after allowing the particular, you know change again,.

You allow this solver to you know run the model and then again, we check the optimum solutions, there is a high, there is a possibility that you know the, you know optimum solution, after the change will remain constant as per the original one or there may be actually changed with respect to the original one. So, whatever may be the situation. So,

it is a kind of you know again iterative process and that too with respect to you know all changes then finally, we come with your kind of you know solutions, which can be a very effective as per the particular, you know requirement. So, with this actually we have addressed the particular, you know business problem and that too.

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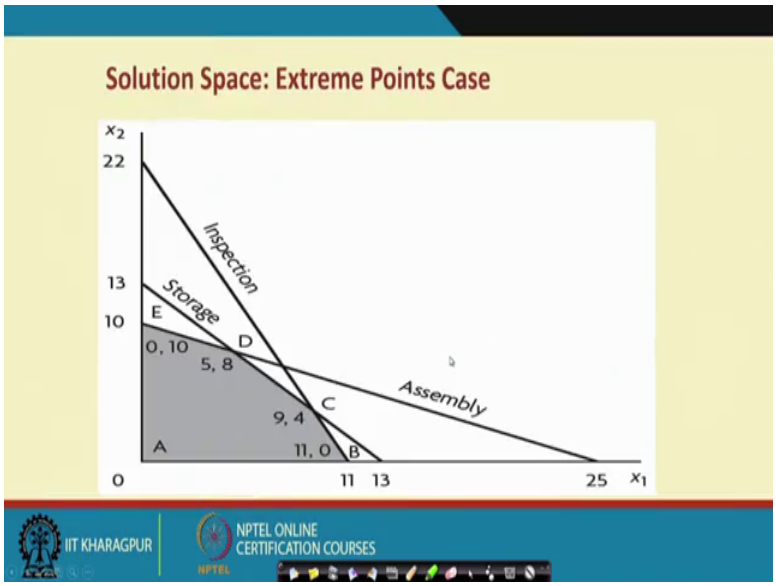

We have already discussed the graphic, you know solution in the graph .

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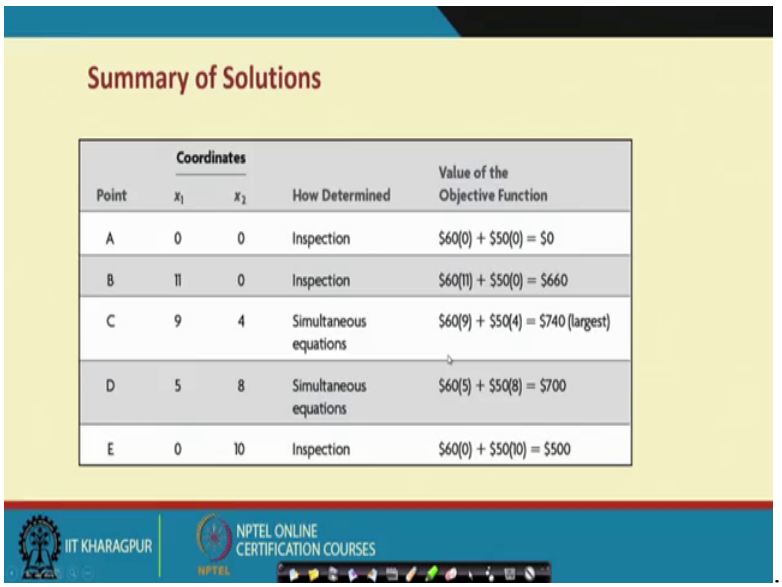

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So, in these problems corresponding to this objective functions graphical methods and again you know the summary of the solution is a like this.

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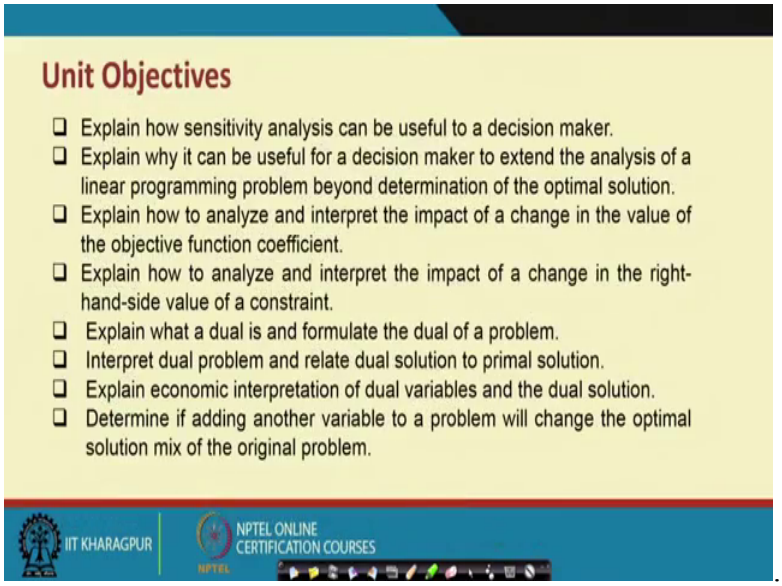

So, here the kind of you know structure is a you know 740 that is the you know highest optimum, Z value subject to other corner points that to you know in the first end point a 0, second 660, then 700, then 500. So; that means, if you go by simplex method. So, it, it will start with you know first the value Z Z equal to 0 then Z equal to 500 then Z equal to 660, then 700 then finally, 740. So; that means, simplex method is a very-very fantastic, you know structure, it will be an arrange, you know systematically, starting with you know on the lowest value of Z, to the highest value of Z.

So, where we have to freeze the optimum solutions. So, now, solver will ultimately give you the final, you know step and that to declare the, the optimum values of the decision variable and the optimum value of Zs and that to the kind of you know original kind of, you know, you know scenario so; that means, with respect to objective function and the kind of you know conditions with respect to all these, you know iterations finally, we reach the optimum solution. Now, after getting the optimum solutions then we look for the change scenario. So, that is what the sensitivity analysis all together.

So, now we look for the sensitivity structure and. So, far as the sensitivity structure is concerned, we have the following objectives. So, the . So, the objectives and the kind of you know understanding is the; so, we like to highlight, how sensitive analysis can be

used to, where decision you know makers or decision making process, explain why it can be useful for a decision maker to extend the analysis of a linear programming problem, beyond determination of the optimum solution and again explain how to analyze and interpret? The impact of the change in the value of the objective function coefficient again, we like to address how to analyze and interpret the impact of change in the right hand side value of the constant.

Again we like to interpret, what a dual is and formulate the dual of a problem and again interpret dual problem related to dual solution to primer solutions and explaining economic interpretation of the primal problems and the dual problem and again a examining the kind of you know situations, if adding another variable to a problem and the, whether the optimum value will change or optimum solution will change, again whether adding one particular constraints the, whether I means the kind of you know optimality remain constant or there is he, a kind of you know change so; that means, we have a different kind of you know, options.

Now, that is how the prescriptive analytics is a very interesting, you know we have the kind of, you know original structure and that to first and we need to find out the optimum solution corresponding to the, you know original problem provided the problem must be very consistent as per the particular, you know requirement or the kind of you know business setup and then we like to first predict the change you know situations with respect to objective functions constraints and the kind of you know condition.

And again we go the, go, you know we go on, on the stepwise process or we follow the kind of iterative process, till we get again you know the another optimum solution corresponding to the change scenario and again we like to compare the optimum solution with respect to the original structure and again optimal solution with respect to changing structures, then we, we like to, you know address how is the kind of you know business, you know business structures or the kind of you know business problem and then we come with a kind of you know management decision, you know as per the particular, you know requirement.

So; that means, it will give you lots of you know extra flexibility to address the problem more effectively and then you can, you know take the management decision more efficiently, you know as per the need and the kind of you know requirement againt. So,

with this, we will stop here's and we will continue, continue this particular, you know discussion in the next class.

Thank you very much have a nice day.