Decision Support System for Managers
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Week – 12
Module – 04
Lecture – 58
Decision Support Systems for Operations Management (Contd.)

Hi, welcome to our 4th module on 'Decision Support Systems for Operations Management'!

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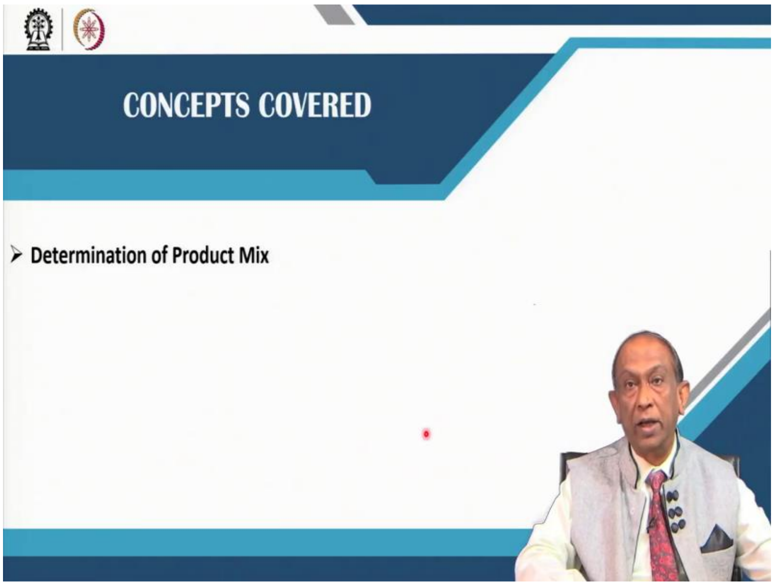

Today, we are going to deliberate upon a very simple topic but widely deployed and useful for industry people and that is determination of product mix.

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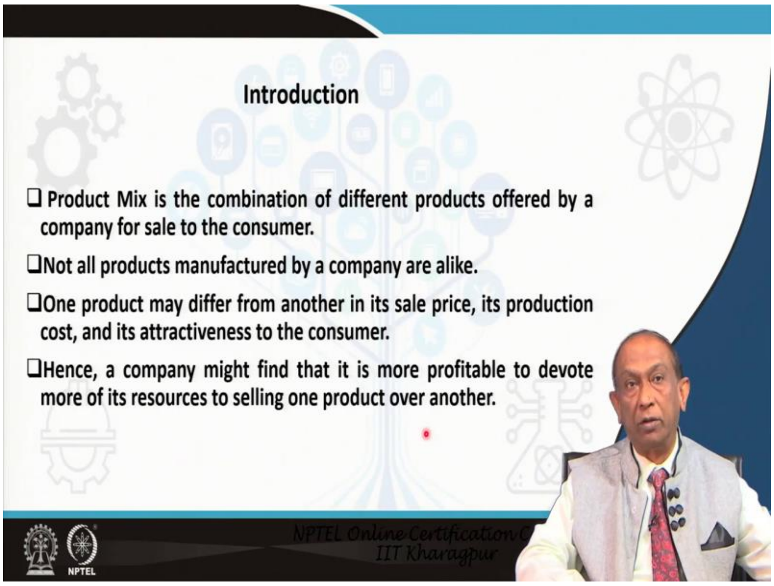

Now, what is product mix? Product mix is the combination of different products offered by a company for sale to the consumer. Now, not all products manufactured by a company are alike. One product may differ from another in it is sale price, its production cost and its attractiveness to the consumer. Hence, a company might find that it is more profitable to devote more of it is resources to selling one product over another.

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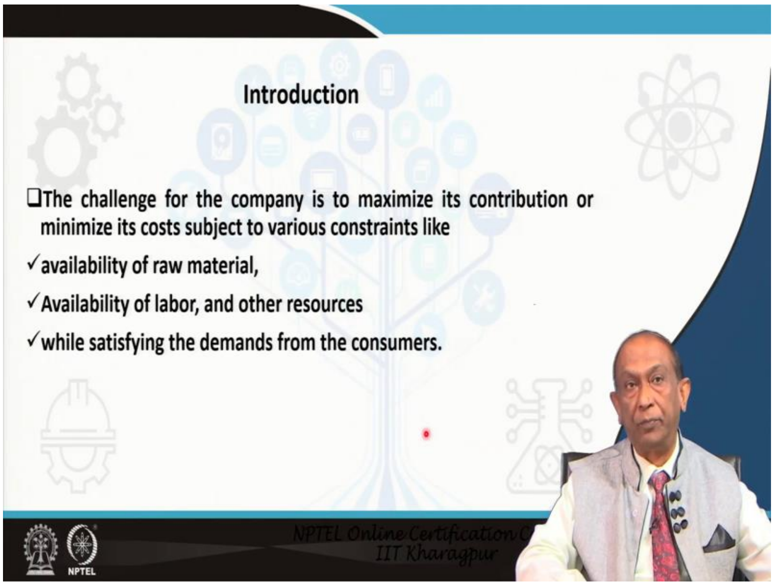

Therefore, the challenge for the operations manager, the marketing managers and the finance managers for a company is to maximize, its contribution or minimize its costs subject to various constraints like; availability of raw material, availability of labor and other resources, while satisfying the demands from the consumers.

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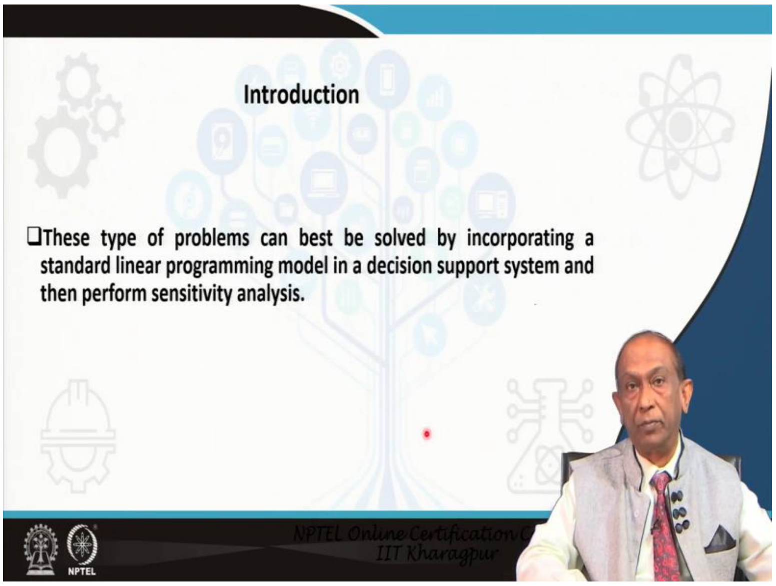

This type of problems can best be solved by incorporating a standard linear programming model in a decision support system and then perform sensitivity analysis.

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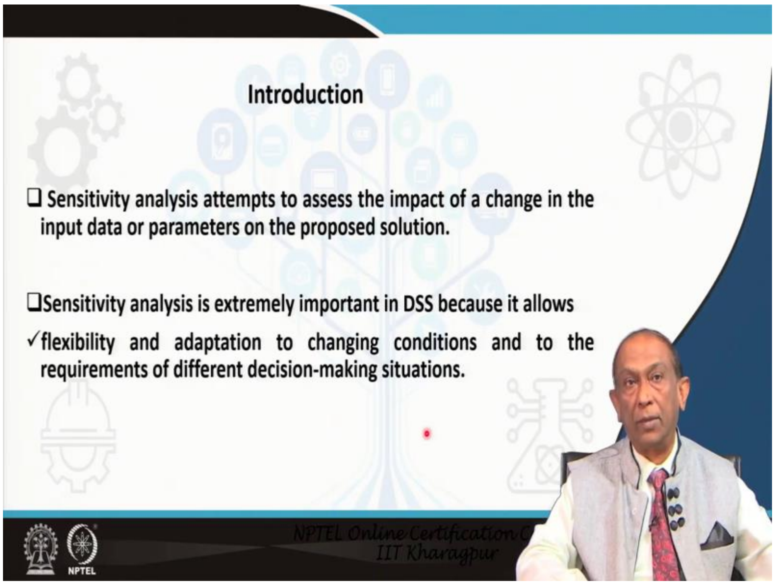

Now, what is the sensitivity analysis? Sensitivity analysis attempts to find out the effect of a change in the input data or parameters on the proposed solution. That means, if the managers, they change the values of say 1 input parameter, what will be the effect on say revenue, or price, or cost, depending on whether the problem is of the type maximization or minimization.

Sensitivity analysis is extremely important in decision support system; because it allows flexibility and adaptation to changing conditions and to the requirements of different decision making situations.

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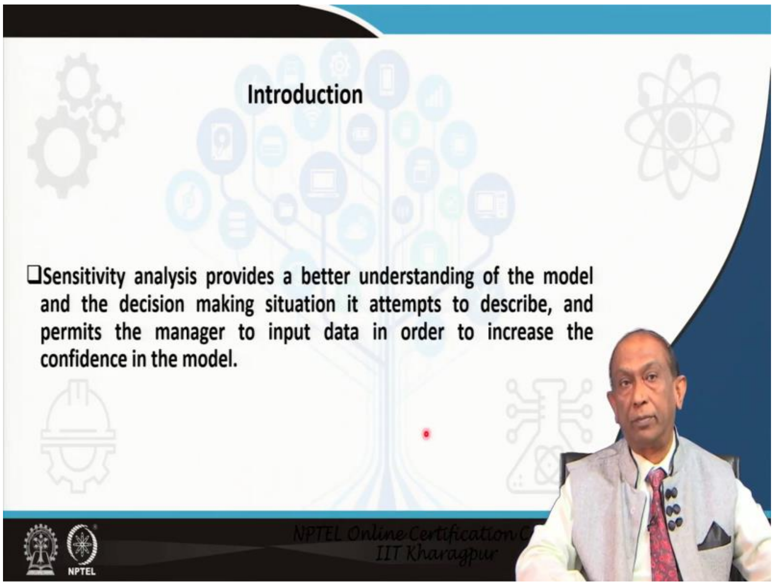

Sensitivity analysis therefore, provides a better understanding of the model and the decision making situation, and thereby it permits the manager to input data in a way that might increase his confidence in using that model.

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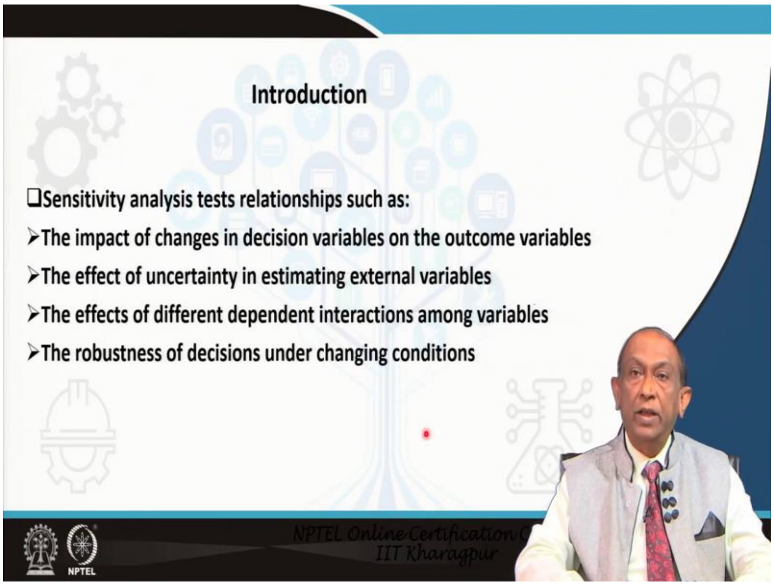

Sensitivity analysis tests relationships such as, the impact of changes in decision variables on the outcome variables. It also allows us to test the effect of uncertainty in estimating external variables. Sensitivity analysis also helps us to find out the effect of different dependent interactions among the variables; and thereby also find out the robustness of the decisions under changing conditions.

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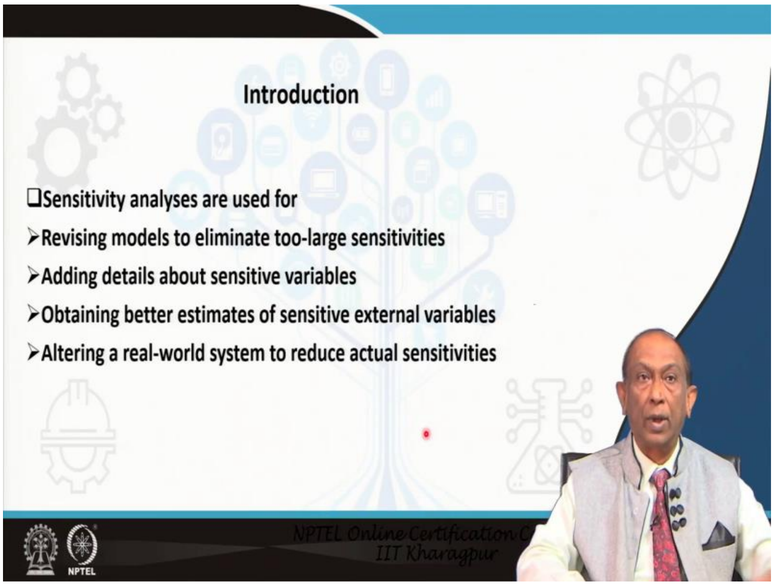

Sensitivity analysis are used for revising models to eliminate too large sensitivities. This model is used for adding details about sensitive variables. This technique also helps the managers to obtain better estimates of sensitive external variables and also to alter a real world system to reduce the actual sensitivities.

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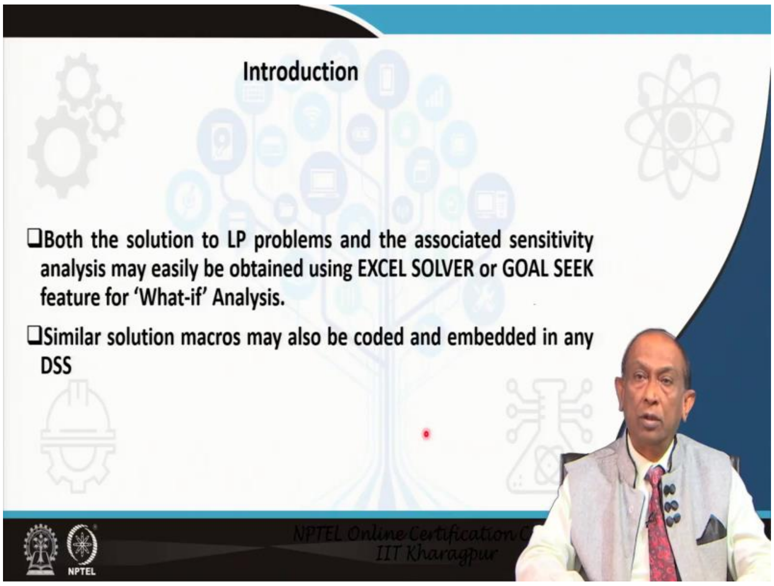

Both the solution to the linear programming problems and the associated sensitivity analysis may easily be obtained using EXCEL SOLVER or the GOAL SEEK feature of excel to do 'What-if' kind of analysis.

What will happen to the output variable? If, one of the input variable is changed by some amount. This kind of analysis you are very familiar with excel is now very commonly deployed software and it has a goal seek feature, which allows you to find out answers to this kind of problems. Similar solution macros may also be coded and embedded in any Decision Support System.

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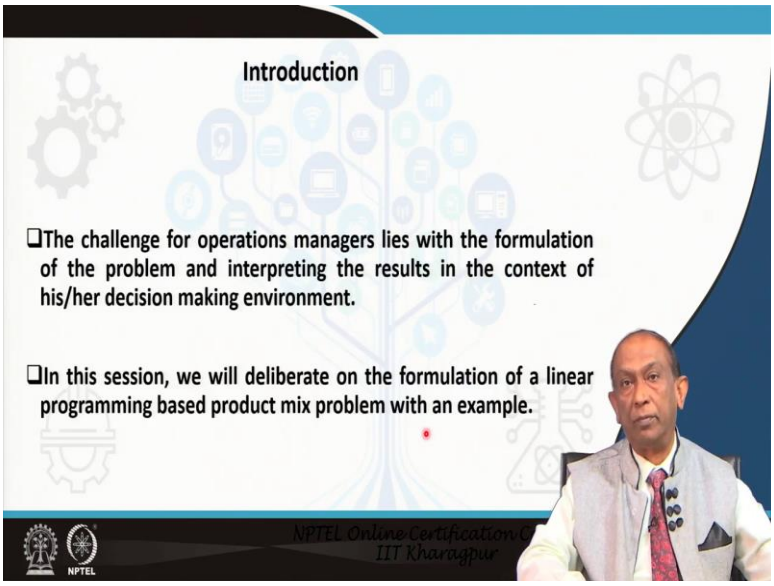

The challenge for operations managers therefore, lie with the formulation of the problem and interpret the results in the context of his or her decision making environment. In this session, we will deliberate on the formulation of a linear programming based product mix problem with an example. What is the problem? ABC Corporation manufactures special-purpose computers.

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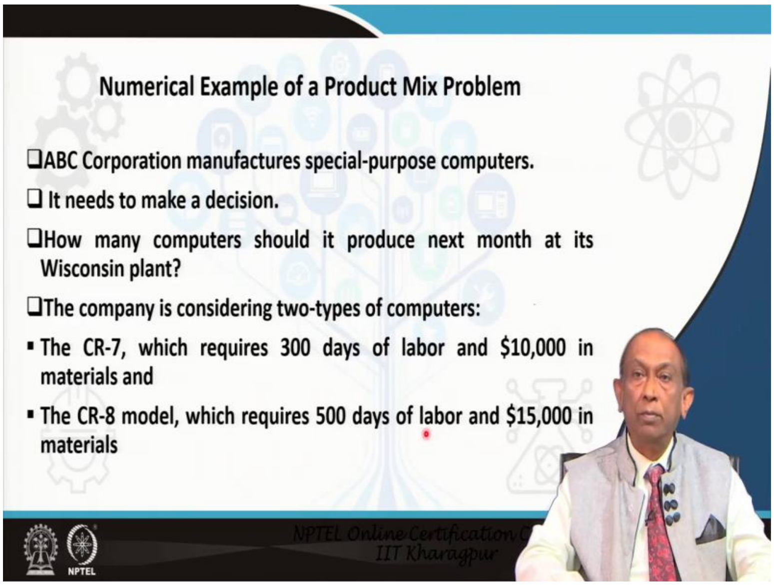

Now, the operations managers of that company, they have to take a decision and their plant is based in Wisconsin in US. The first question is how many computers should the company produce next month at it is Wisconsin plant? The company is considering two types of computers. The first model which is designated as CR-7 requires 300 days of labor and 10,000 dollars in materials. And, the second model that is CR-8 requires 500 days of labor and 15,000 dollars, worth of materials.

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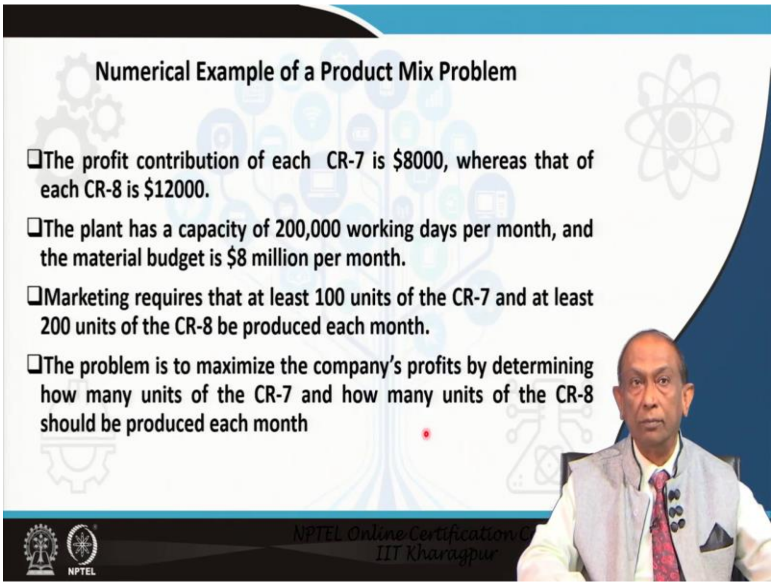

The profit contribution of each CR-7 model is dollar 8000, whereas, the contribution of 1 unit of CR-8 is 12,000 dollars. The plant has a capacity of 200,000 working days per month, and the material budget that is available to the managers is dollar 8 million per month.

The marketing managers have informed that they require at least 100 units of the CR-7 and at least 200 units of the model CR-8 to be produced each month. Now, the problem is to maximize the company's profits by determining how many units of CR-7 and how many units of the model CR-8 be produced each month.

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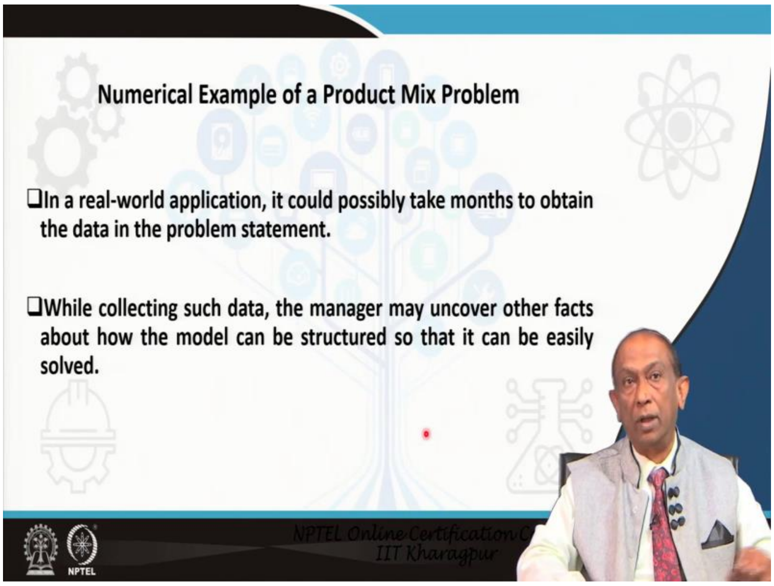

So, that is the given problem. In a real-world application, it could possibly take months to obtain the data that is stated in this problem. And, while collecting such data, the concerned managers may uncover other facts about how the model can be structured. So, that it can be easily solved.

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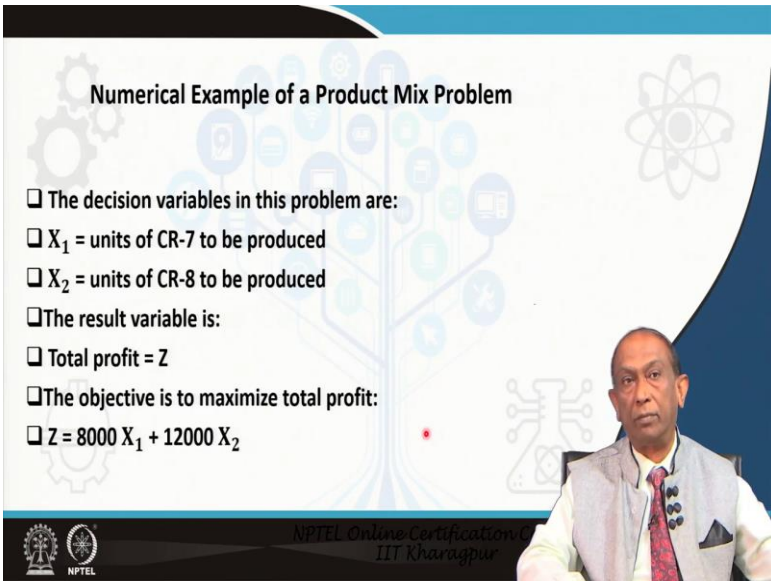

So, now let us get into the formulation of the problem, which is extremely simple, the decision variables related to this problem are say, X 1 representing the units of the model CR-7 to be produced and X 2 is the number of units of CR-8 model to be produced. So, the result variable in this problem is the total profit, which is designated by Z. The objective is to maximize total profit. Therefore, the profit equation Z or contribution rather, total contribution Z equal to 8000 X 1 plus 12000 X 2.

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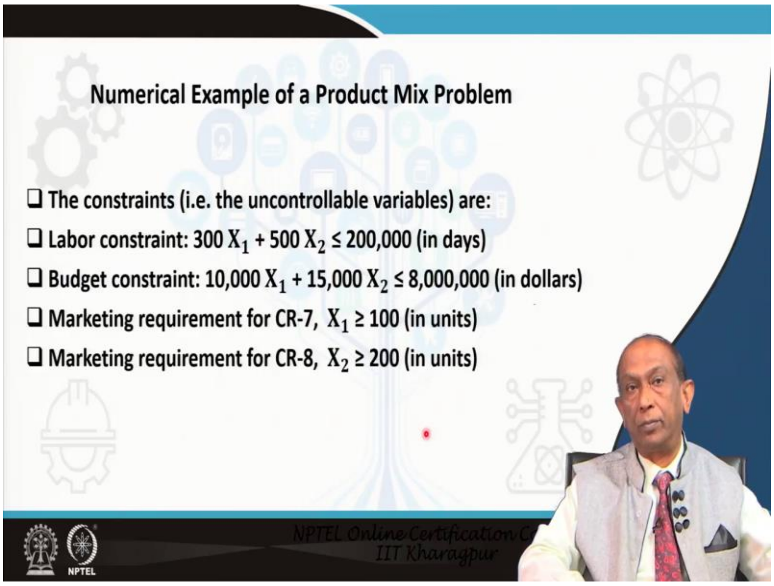

The constraints for this problem are number 1 labor constraint that can be written in terms of 300 X 1 plus 500 X 2, less than equal to 200 1000 in terms of days. So, this is given in the problem. The budget constraint similarly can be written as 10,000 X 1 plus 15,000 X 2, less than equal to 8 million dollars.

Marketing requirement for the model CR-7 is expressed in terms of X 1 being greater than equal to 100 numbers and marketing requirement for the model CR-8 can be expressed, in terms of X 2 being greater than equal to 200 numbers.

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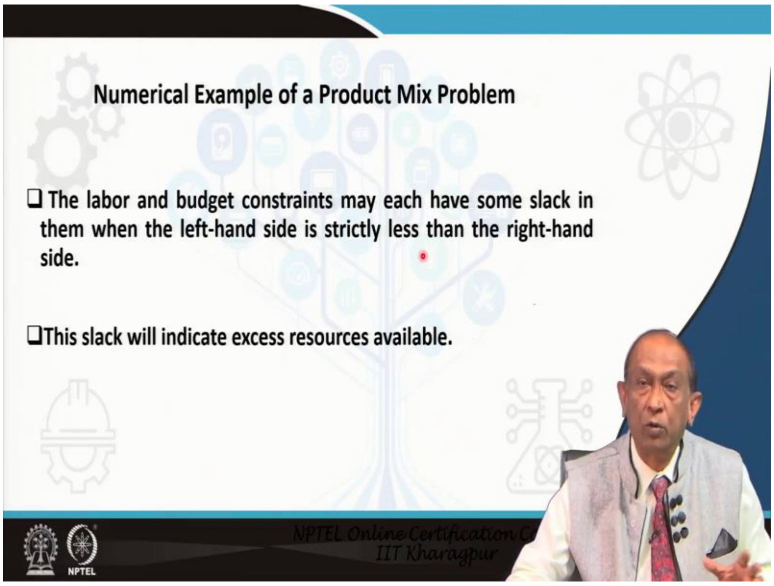

Now, you see the labor and the budget constraints each one of them may have some slack in them when the left-hand side is strictly less than the right-hand side. Because, if you look at the problem structure you see 300 X 1 plus 500 X 2 is strictly less than equal to 200 1,000; that means, 300 X 1 plus 500 X 2 plus some slack variable say S 1 will make it equal to 200 100 1000, that S 1 is the slack variable.

Similarly, for this 10,000 X 1 plus 15,000 X 2 plus something S 2 is the slack variable associated with this constraint that becomes equal to 8 million dollars. So, that means, if the constraint is of the type strictly less than, then you can associate a slack variable with that and this slack will indicate the excess resources that are available.

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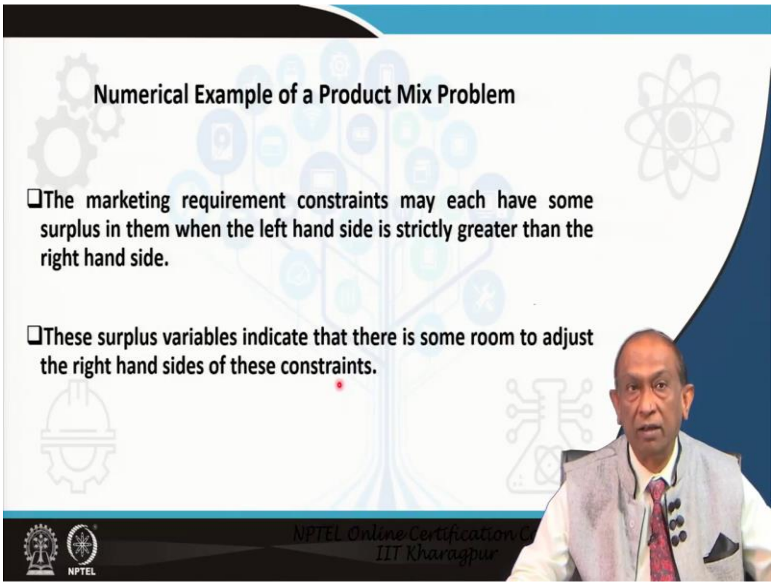

On the other hand the marketing requirement constraints may each have some surplus in them, whereby the left hand side is strictly greater than the right hand side. That means, you see here X 1 is strictly greater than equal to this; that means, X 1 minus something say S 3 equals 100. Similarly, X 2 minus S 4 equal to 200. So, this S 3 and S 4 in this context are known as surplus variables.

These surplus variables indicate that there is some room to adjust the right hand side values of this constraints; that means, the marketing requirements can be adjusted accordingly.

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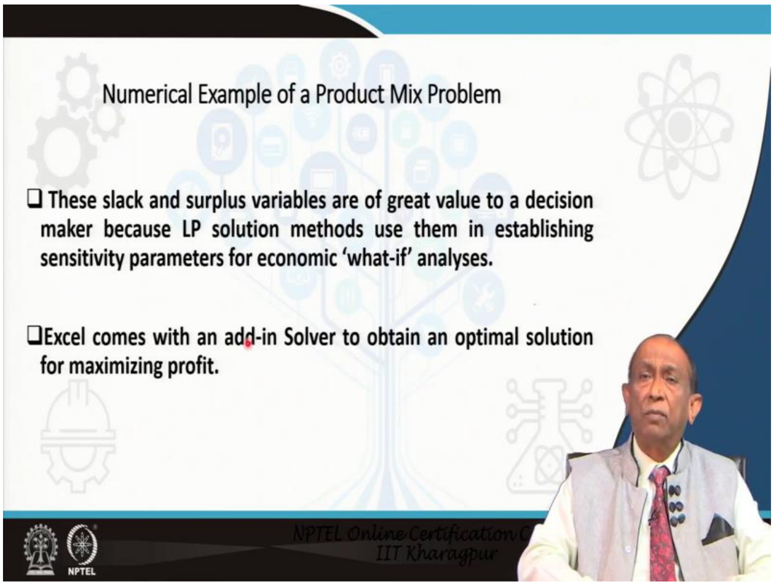

These slack and surplus variables are of great value to a decision maker, because Linear Programming solution methods use them in establishing sensitivity parameters for economic 'what-if' analysis.

Excel comes in with an add-in and that is the solver to obtain an optimal solution for maximizing profit or minimization of cost, basically solver add in basically helps you to solve various types of optimization problems.

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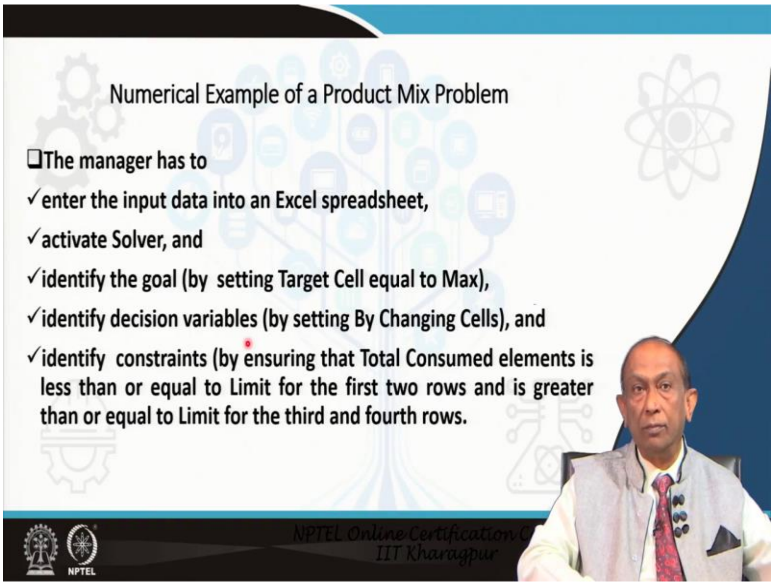

And, when you get the add-in that is the solver, the manager has to enter the input data in an excel spreadsheet. Activate the solver, identify the goal by setting the target Cell equal to Max. The manager has to identify decision variables by setting By Changing Cells and identify constraints by ensuring that total consumed elements is less than or equal to the limit for the first two rows and is greater than or equal to limit for the third and fourth rows.

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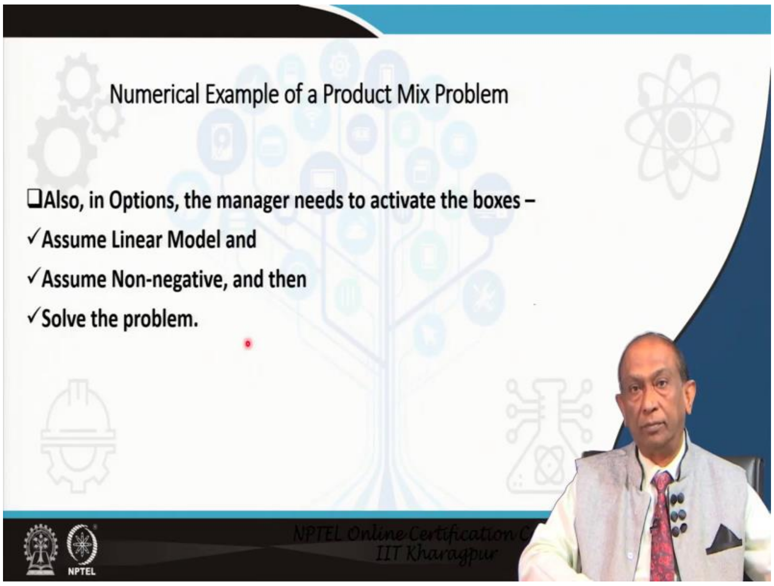

We will basically show you, how the data has been entered, also after entering the data the manager needs to activate two boxes, wherein they have to basically tick, against the first one is assumption of a linear model and also they have to tick the non-negativity restriction and then solve the problem.

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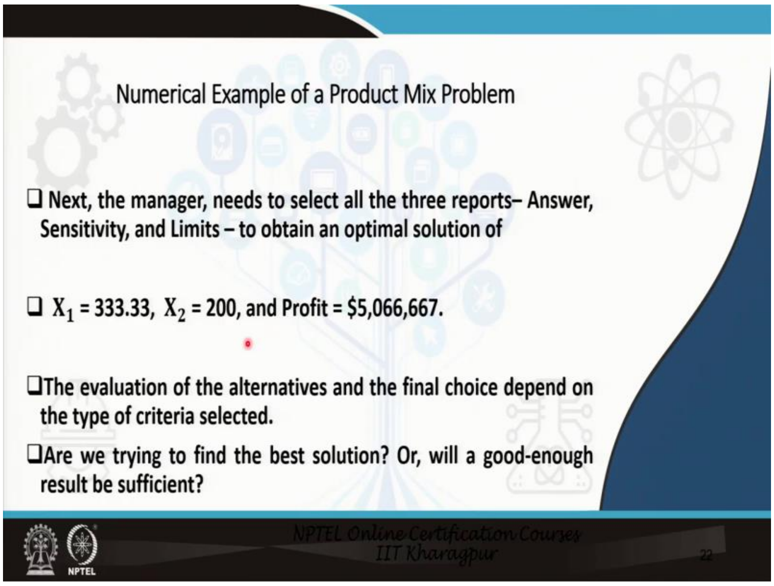

And, thereafter the manager needs to select all the three reports, that are generated by the solver and the three reports are the answer sensitivity and the limits. And, in this case the optimal solution comprises of X 1 equal to 333.33, X 2 equals 200, and profit is given all of you can try this problem in the solver and see whether you get this result or not.

Instead of the linear model, if you opt for an integer solution, then you will get an integer output corresponding to X 1. The evaluation of the alternatives and the final choice will depend on the type of criteria selected; that means, it will depend upon what the manager wants.

Are we trying to find out the best solution? Or, will an effective solution a good-enough result will be sufficient? That will depend upon what the operations group, they feel like or they want.

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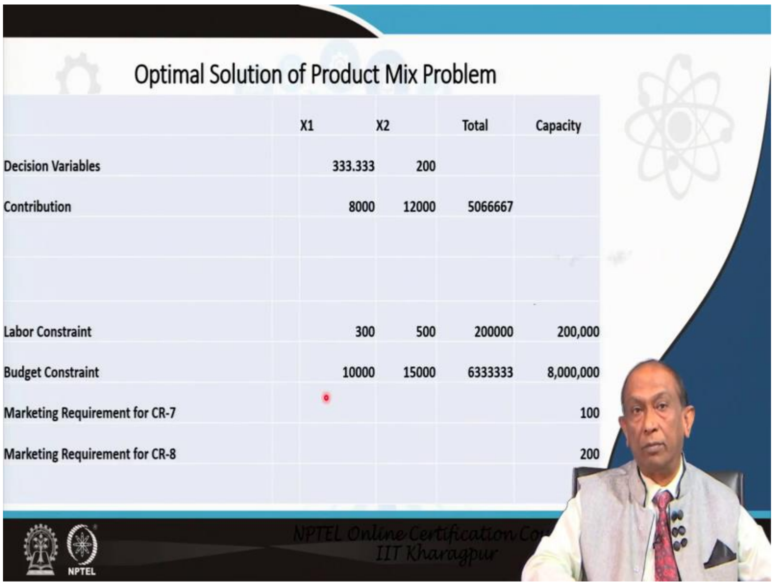

So, you see in your excel output initially to start with you have to basically supply the input values, for the labor constraint, that is 300 500 for against X 2 and the available capacity is mentioned in this cell, the budget constraints are written in this cell available is 8 million dollars. So, the constraints are entered the marketing requirements also need to be entered and the coefficient of the variable X 1 and X 2 in the objective function are entered in here.

Initially, you will supply some values to X 1 and X 2 and against those values of X 1 and X 2, this particular cell will give you, the total profit that will get generated against those X 1 and X 2 values. And, this cell in these two columns will give you the actual amount of resources that have been used.

Since, this particular excel spreadsheet is related to the optimum solution, we can see that the optimum profit value is this much, the corresponding optimal values of X 1 and X 2s are given as 333.333 and X 2 equal to 200. And, under the optimal condition, this much amount of resources related to the labor constraint has been utilized.

That means, whatever is available at the capacity, the entire available capacity with respect to the labor has been utilized. With respect to budget, what we find that even though the allocated budget or the available budget is 8 million dollars, we have utilized something like 6.33 million dollars. So, we have not able to utilize the full amount of budget; ok.

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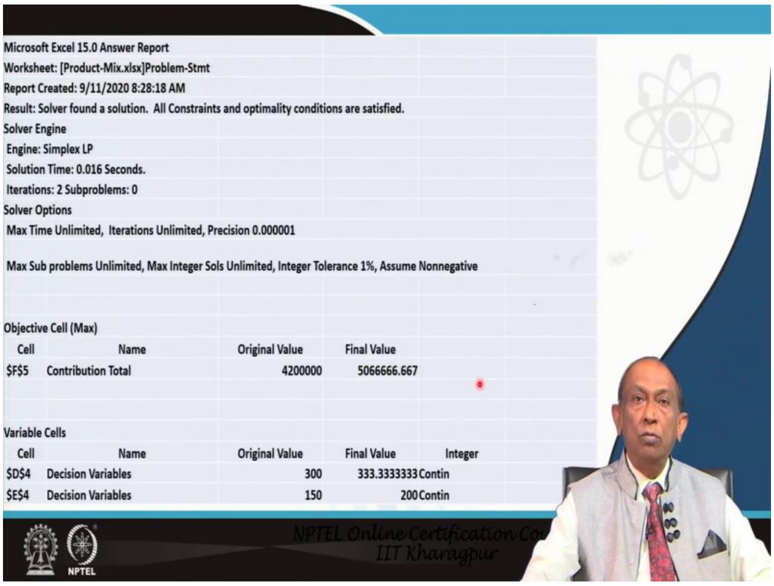

Now, when you look into the excel output, it will come into this particular format. This is the optimal value and I started with some initial solution corresponding to that, that value was this much with iterations successive iterations total iterations have been 2. So, with successive iterations by changing the cells, the final optimal value is this much.

And, the optimal values of the decision variables X 1 and X 2 are given here. We had started the solution by giving X 1 equal to 300, X 2 equal to this much corresponding to that we got a total profit value of this much, but in the optimal solution we are getting this final values.

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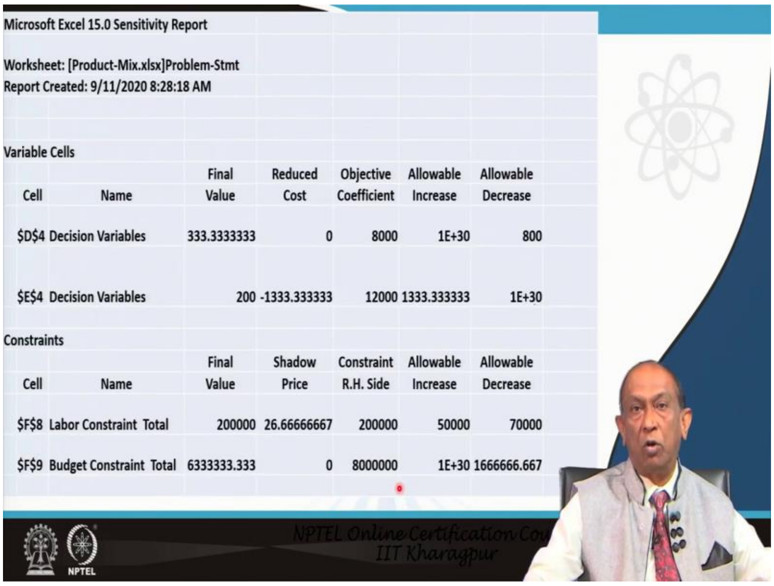

Microsoft Excel 15.0 Sensitivity Report

Worksheet: [Product-Mix.xlsx]Problem-Stmt
Report Created: 9/11/2020 8:28:18 AM

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
D4	Decision Variables	333.3333333	0	8000	1E+30	800
E4	Decision Variables	200	-1333.333333	12000	1333.333333	1E+30

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
F8	Labor Constraint Total	200000	26.66666667	200000	50000	70000
F9	Budget Constraint Total	6333333.333	0	8000000	1E+30	1666666.667

Next the important portion is the sensitivity analysis report. You see in this sensitivity analysis report also, you get the final values of the decision variables and then in this constraints related area corresponding to the labor constraints you get a shadow price of 26 point something.

What is the implication of this shadow price? What is the meaning of this shadow price? The shadow price basically means, you see the available or the constraint value on the right hand side of the labor constraint is this much. You see, if you increase the available resource related to this particular constraint by 1 unit, your total profit will go up by this much the shadow price.

So, shadow price basically means that, if you increase 1 unit of the available resource, then the impact on the objective function in terms of increased profit is by the amount 26.66. If, you increase this value by 2 more units, then the profit will go up by 26.666 multiplied by 2. You need not again have to run the model to get this answer, but this is valid within a range; that means, to what extent you can increase the value of this right hand side, allowable increase is this much.

So; that means, you can go up to this value plus this 50,000. If, you do that the corresponding profit will go by this shadow price multiplied by the amount by which you have increased this right hand side values. Allowable decrease similarly, if you decrease then the by for 1 unit decrease in the value of right hand side, the profit will go down by the amount that is stated in the shadow price.

That means, you can use this particular relationship without running the problem within a range of this, this is the implication of this allowable increase and this allowable decrease values. See this budget constraint the shadow price is 0 means, what?

If, you increase the available budget it will not have any effect on the total profit and as such you have already seen, that we have not been able to utilize the full budget. Let us look at this reduced cost column in this sensitivity report. Now, the reduced cost corresponding to the first decision variable that was X 1 is 0.

What does it imply; reduced cost 0 means: that now even if you start another one more unit of production for the variable X 1, it will not add to the profit. And, the objective coefficient, the coefficient of the variable X 1 in the objective function is 8000. This allowable increase and allowable decrease basically specify a range, over which the current optimal condition still holds good; ok.

If, the objective coefficient or the coefficient, of the variable X 1 in the objective function is changed within this range, the current optimality condition will not be violated. The reduced cost value corresponding to the variable X 2 is minus negative minus 1333.333 something.

What is the implication of this negative value here? Basically, it means that, if we increase the production of the variable X 2 by 1 more unit, the objective function will be reduced by this amount; that means, we will incur a loss. And, hence production of additional unit of X 2 is not recommended.

So, from the reduced cost, we can also find out that to what extent? See, in this case both the variables have appeared in the objective function. In case some variable would not have appeared in the objective function. This reduced cost column would have given us the idea that, what should be the objective coefficient for that variable and to what extent it can be manipulated such that, that variable can enter the objective function.

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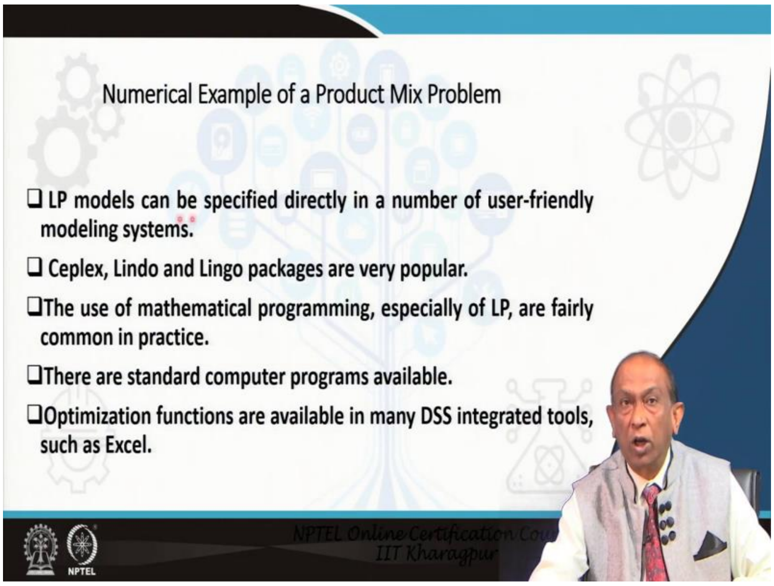

So, LP models can be specified directly in a number of user friendly modeling systems: CPLEX, LINDO, and LINGO packages are very popular. The use of mathematical programming, especially of LP, are fairly common in practice. There are standard computer programs available; optimization functions are available in many DSS integrated tools such as excel.

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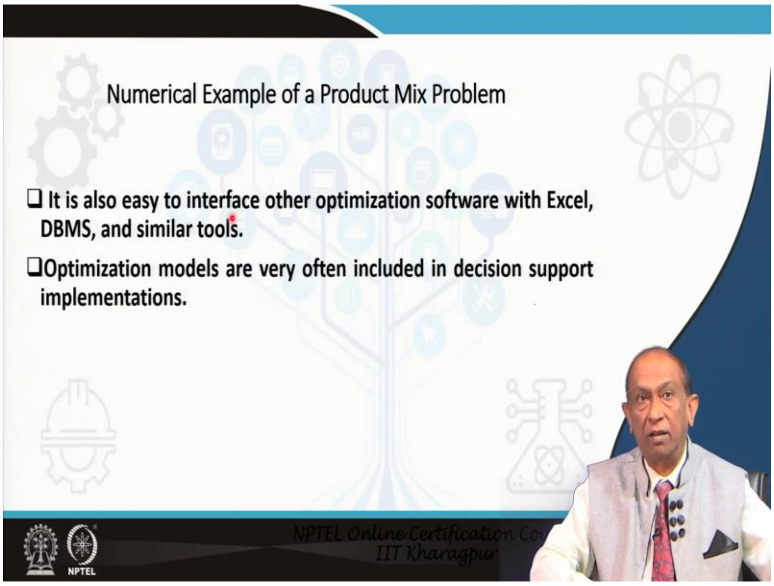

And it is also easy to interface other optimization software with Excel, DBMS, and similar tools. Optimization models are very often included in decision support implementations. And hence, this kind of deployment of software packages inside a decision support system is widely acceptable.

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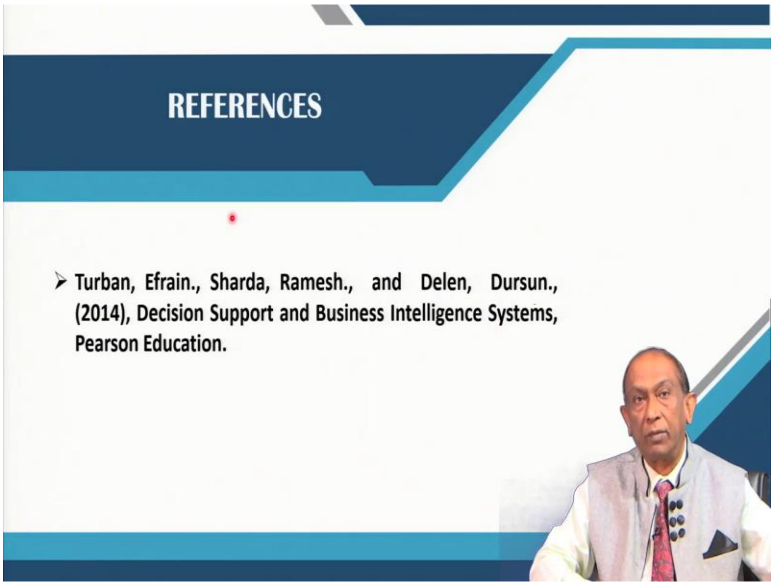

These are the references that have been used for preparing this lecture.

Thank you all!