Decision Making With Spreadsheet
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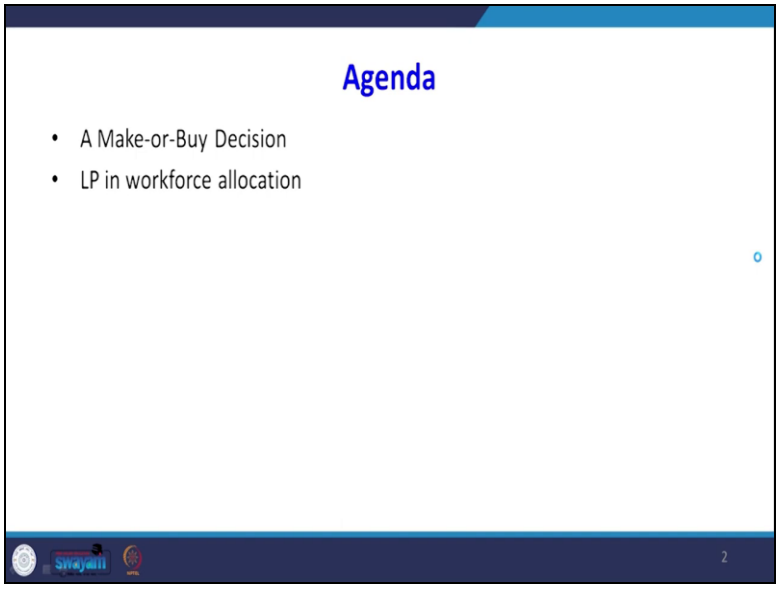
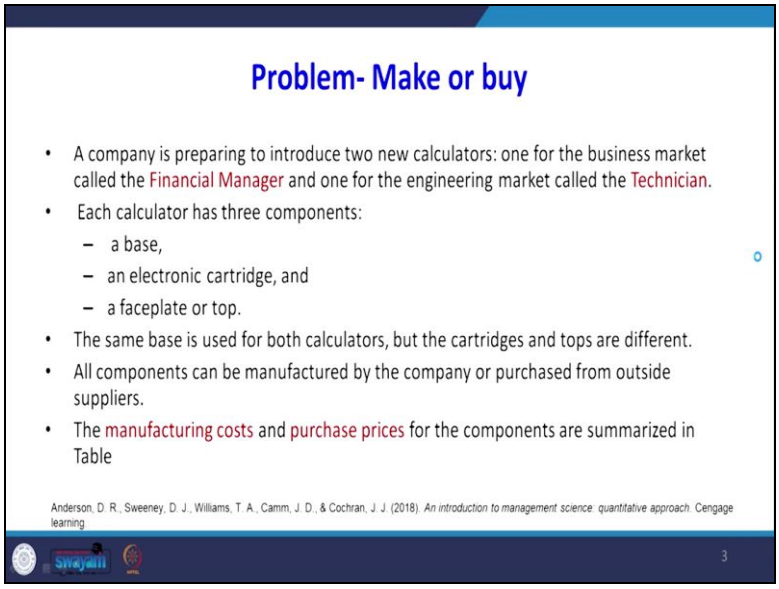
Lecture-11
LPP Applications in Operations - 2

In the previous lecture, I started the application of linear programming problems in operations. We have taken one problem on production scheduling, and then we solved it in this lecture also. I am going to formulate another problem in the area of operations I am going to formulate it and solve it.

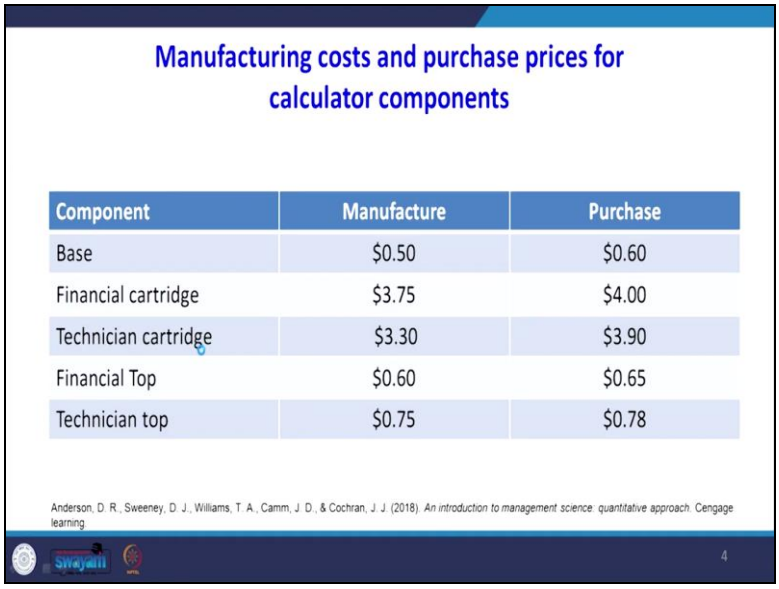


So, the agenda for this lecture is I am going to take one problem on the make or by the decision because in the operations area, this is a very, very common problem whether we have to make the component in-house or we have to buy it from outside the vendor from the suppliers. Another example is workforce allocations. These are the two examples that I am going to cover in this lecture.



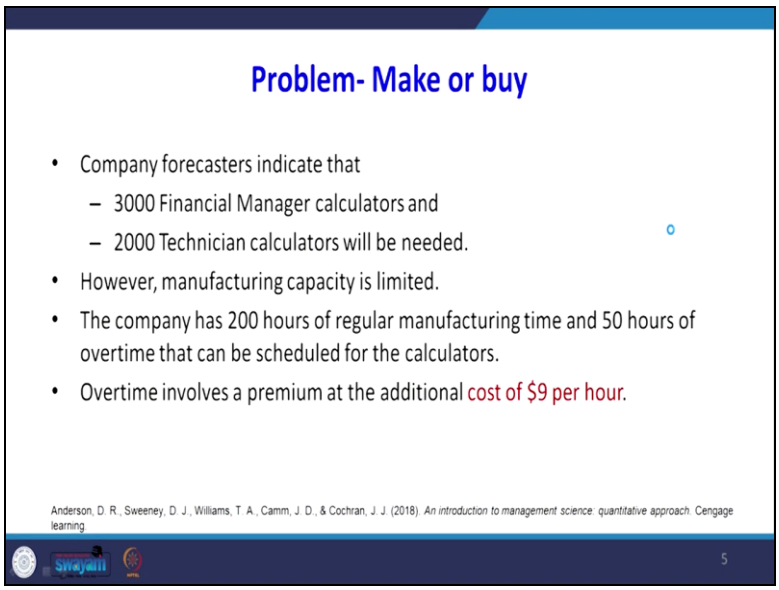
The problem is like this problem is taken from Anderson et al. A company is preparing to introduce two new calculators, one for the business market called the financial manager and one for the engineering market called the technician. Each calculator has three components: a base electronic cartridge and a face plate or top. The same base is used for both calculators, but the cartridges and tops are different. This base is common for both types of laptops, whether it is a financial manager or technician.

All components that can be manufactured by the company are purchased from outside the suppliers. So, we are going to suggest which components have to be manufactured in-house or which components need to be purchased from outside. The manufacturing costs and purchasing prices for components are summarized in the table, which is given here.

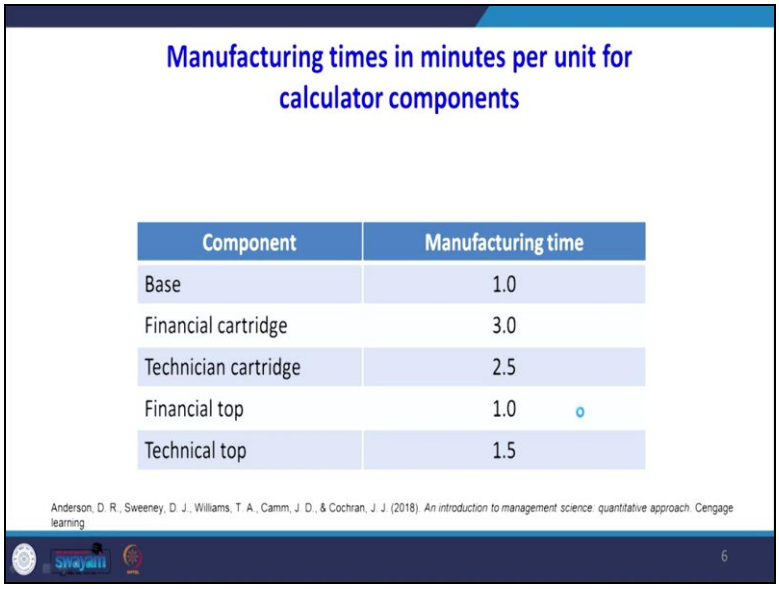


This table shows the components for the price, the manufacturing cost, and the purchasing price. For example, this base component you can manufacture it is the manufacturing cost, and you can buy it from outside; also, this is a purchasing cost. You see that the purchasing cost is always higher than the manufacturing cost of manufacturing in-house. So, this problem is the make-or-buy decisions between these five components.

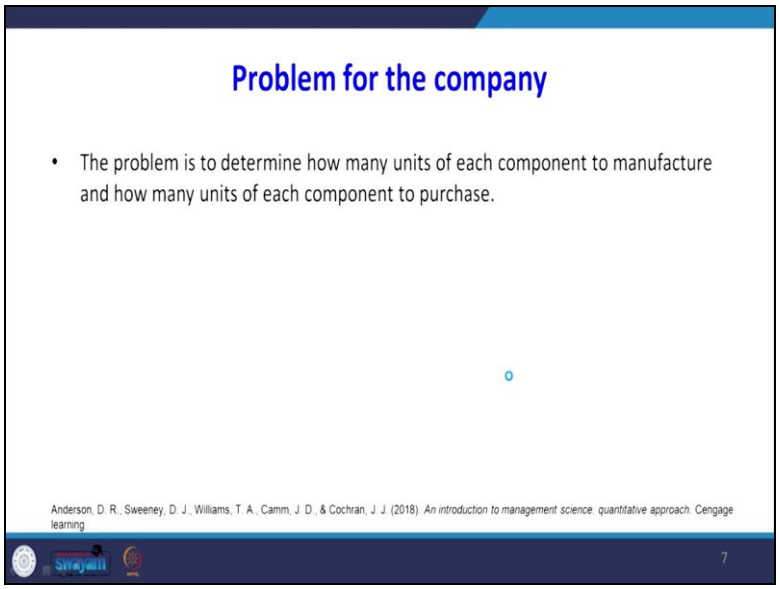
So, we are going to suggest out of these five, how many quantities in each category of the component are we going to do it ourselves, or are we going to buy from outside? That is the make or by decision.



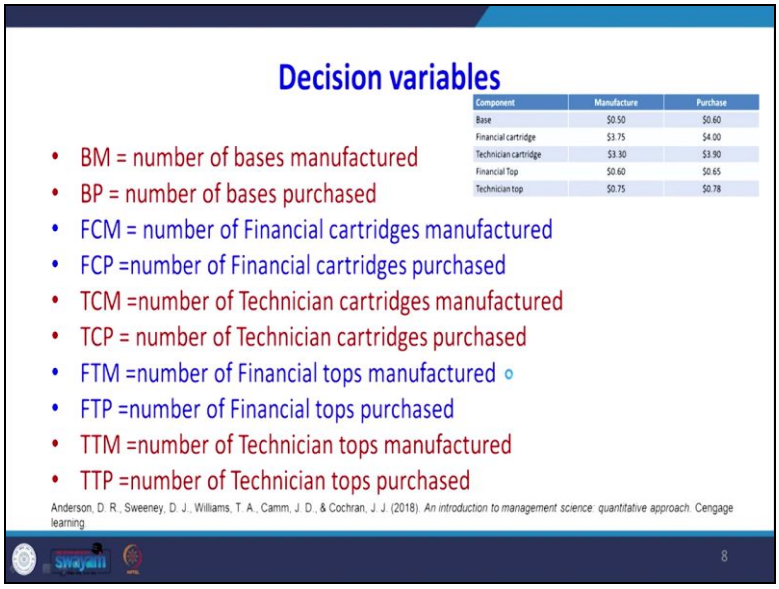
The company forecast indicates that 3000 financial manager calculators and 2000 technician calculators will be needed, but the problem is the manufacturing capacity is limited. Apart from manufacturing capacity, the company has 200 hours of regular manufacturing time and 50 hours of overtime. There is a possibility apart from regular manufacturing time to go for overtime. So, the available overtime is 50 hours, but when you go for overtime, that involves a premium at the additional cost of 9 dollars per hour.



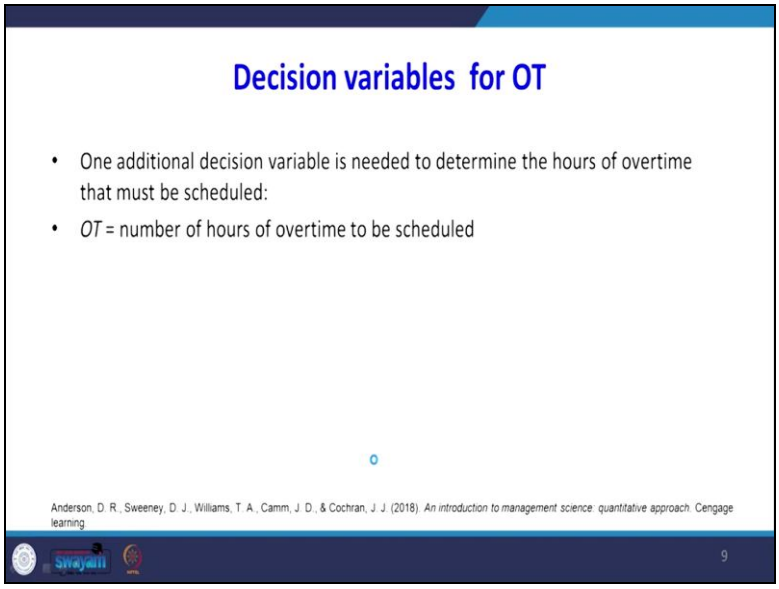
This table shows the manufacturing time for each component. So, if it is the base, is this in terms of minutes? This is minutes financial cartridge 3 minutes technician cartridge 2.5 minutes financial top 1 minute. So, if you manufacture this is the time taken for manufacturing for each component.



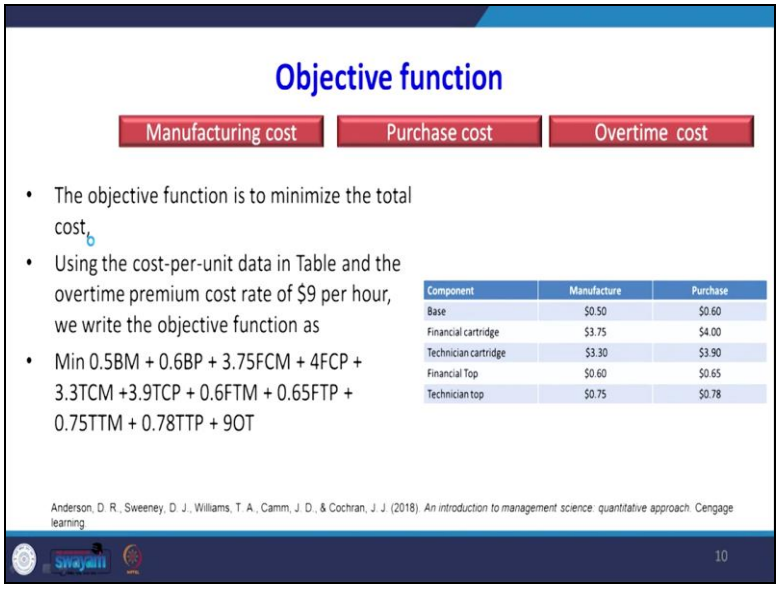
Now, the problem is to determine how many units of each component to manufacture and how many units of each component to purchase that is make or buy.



Now we will discuss the decision variables because for each decision variable if it is manufacturing, there will be one decision variable. If it is purchasing, there will be another decision variable. For example, when you say BM base manufactured, BP base purchased, FC financial cartridge, M means manufactured, M represents manufacturing, and P represents purchasing from outside FCP. So, like there are five components, there are two possibilities we can make, or we can purchase. So, there will be 10 decision variables 1, 2, 3, 4, 5, 6, 7, 8, 9, 10.

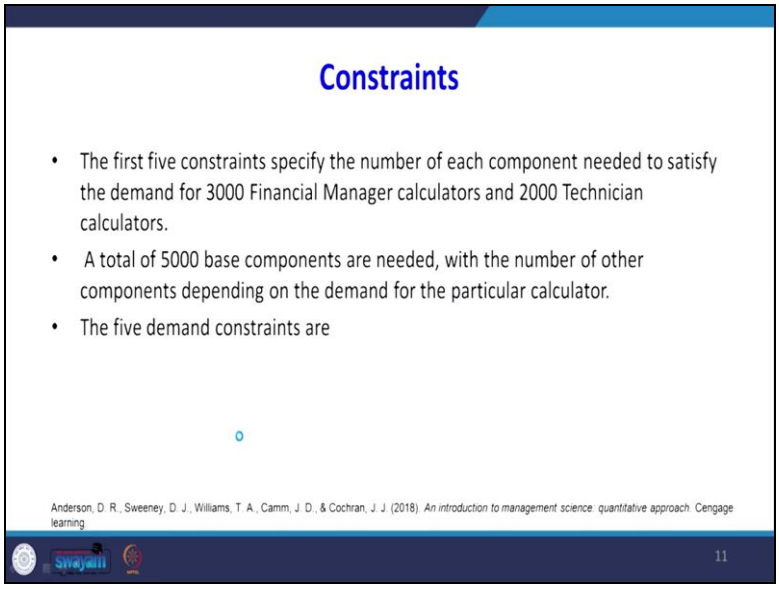


Apart from the decision variables, we have to introduce one more decision variable over time. So, one additional decision variable is needed to determine the hours of overtime that must be scheduled. So, the decision variable for that is the number of overtime hours to be scheduled.



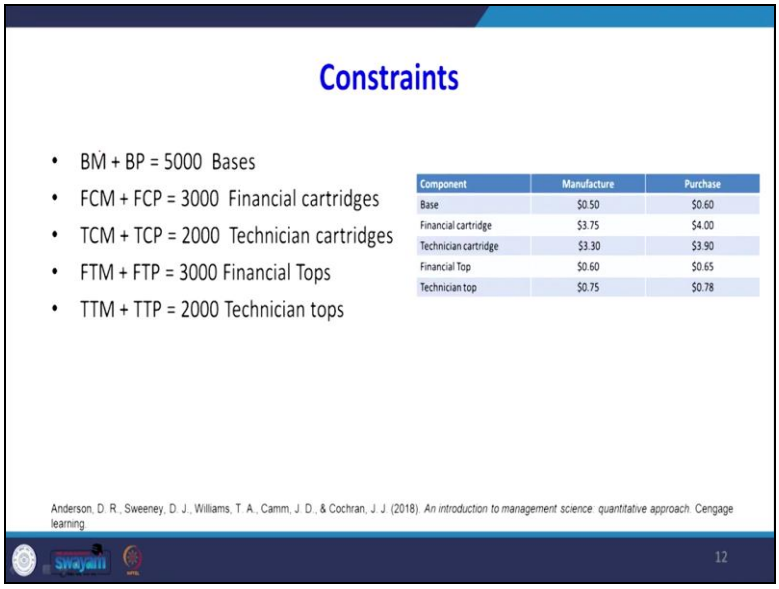
So, now, this objective function that I am going to formulate will have three components: there will be a manufacturing cost, there will be a purchasing cost, and there will be overtime cost. So, we have to add all these costs that have to be minimized if you want to minimize how much component has to be done in-house, how much component has to be purchased from outside, and how much over time we should utilize because there is a cost for overtime also.

So, the objective function is to minimize the total cost. Using cost per unit data, this table, the overtime premium cost rate of nine dollars per hour, which I have mentioned in the previous slide, we can write the objective function. So, 0.5 BM, 0.6 BP base for manufacturing base for purchasing similarly FCM for manufacturing then FCP for purchasing. So, TCM for manufacturing, TC for purchasing, FT for manufacturing, FT for FT is financial top for purchasing, TTM manufacturing technician top TTP that is purchasing then 9 OT because there is a 9 dollar for each overtime hour.



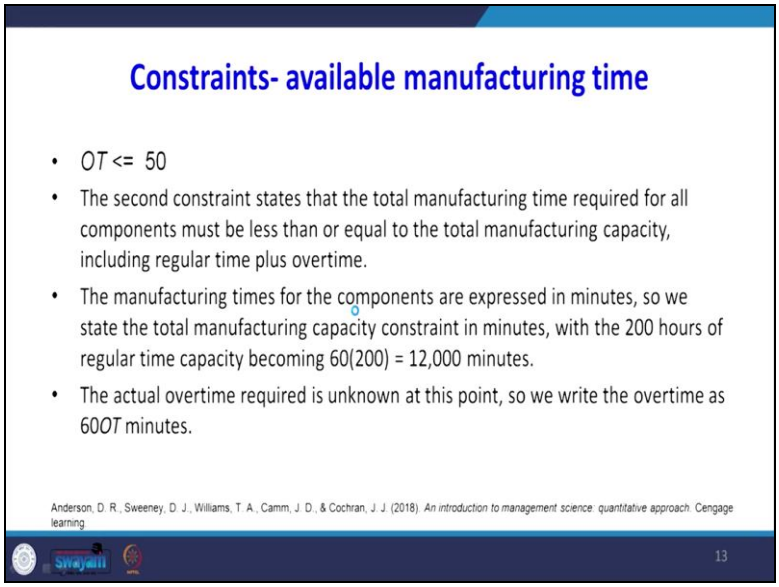
Now, we will write about the constraint. The first five constraints specify the number of each component needed to satisfy the demand for 3000 financial manager calculators and 2000 technical calculators. Why are there five constraints? Because there are five components? A total of 5000 base components are needed, with the number of other components depending on the demand for a particular calculator because the same base can be used for both types of calculators.

So, the total number of bases required is 3000 + 2000. So, the five demand constraints are given in this way.



So, for each variable, when you add B manufacturing and P purchasing, the total should be 5000. Okay for the second one, financial cartridge, we can manufacture and purchase that

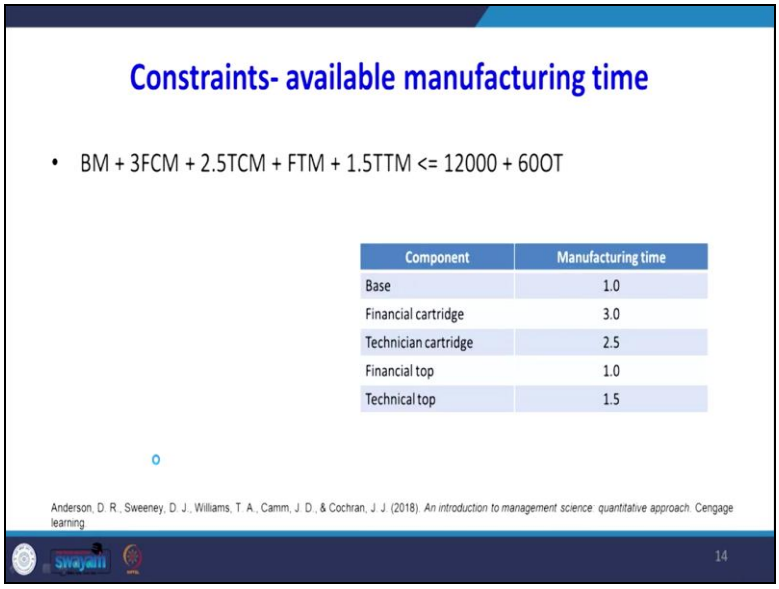
should be 3000 cartridge technicians that can be manufactured or purchased 3000. So, these constraints are given.



Now, as I told you overtime cannot exceed 50 hours. So, there are five constraints for each component, and there is an overtime constraint. Now, we have to introduce another set of constraints. So, the second constraint states that the total manufacturing time required for all components must be less than or equal to the manufacturing capacity, including regular time and overtime. This constraint says that the total manufacturing time should not exceed your total manufacturing capacity, including your overtime.

So, the manufacturing time for components is expressed in minutes. You should be very careful with the table that I have shown previously because the values of manufacturing times are expressed in minutes. So, when you write the constraints, you have to make sure that both sides have the same unit. So, we state the total manufacturing capacity constraint in minutes because we know there are 200 hours of regular time capacity.

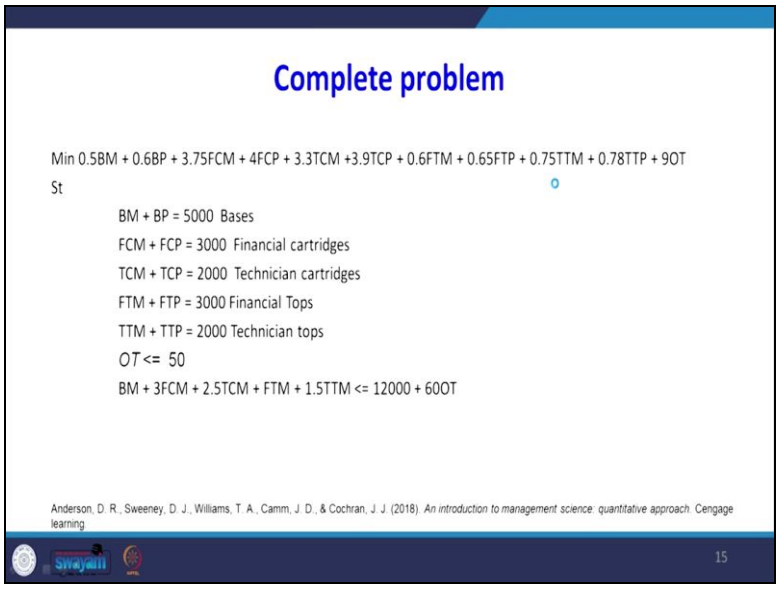
So, when you convert into minutes. So, 60 multiplied by 200, there will be 12000 minutes. The actual overtime required is unknown at this point. So, we write the overtime as 60 overtime minutes because we are writing over time also in terms of minutes. That is why 60 OT.



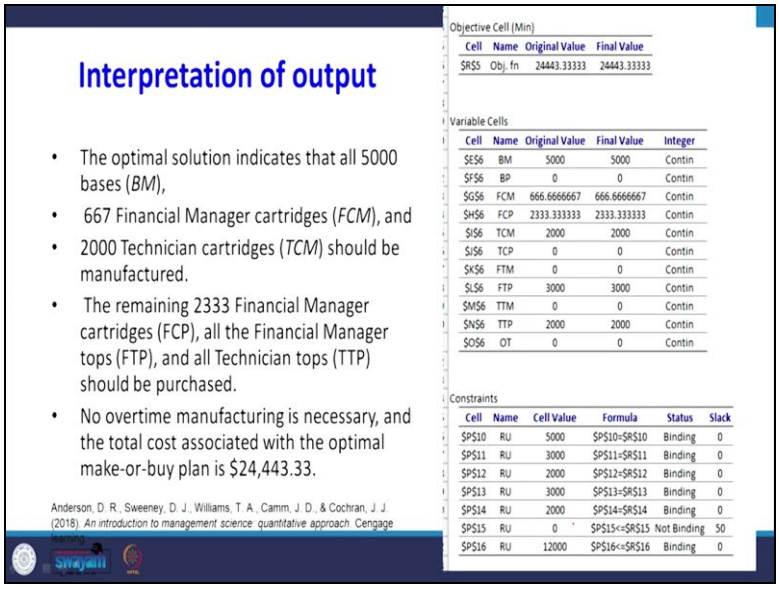
Now, when you bring this one, you see that the base will consume one unit. This is minutes, and the time is in minutes, ok?

So, 1 BM + 3 FCM + 2.5 TCM + 1 FTM + 1.5 TTM <= 12000+ 60 OT

should be less than or equal to your manufacturing time capacity plus over time because we are talking about only the manufacturing there will not be any P vary the variable which has P because P represents purchasing. We are not bothered about purchasing.



Now, this is our complete problem. What are the complete problems we have to minimize the objective function? So, objective function takes care of manufacturing cost, purchasing cost, manufacturing time, and overtime. So, this constraint is for demand, this constraint is for our OT, and this constraint is for total available manufacturing time, including over time. So, when I solve this, this is the output that I got it.

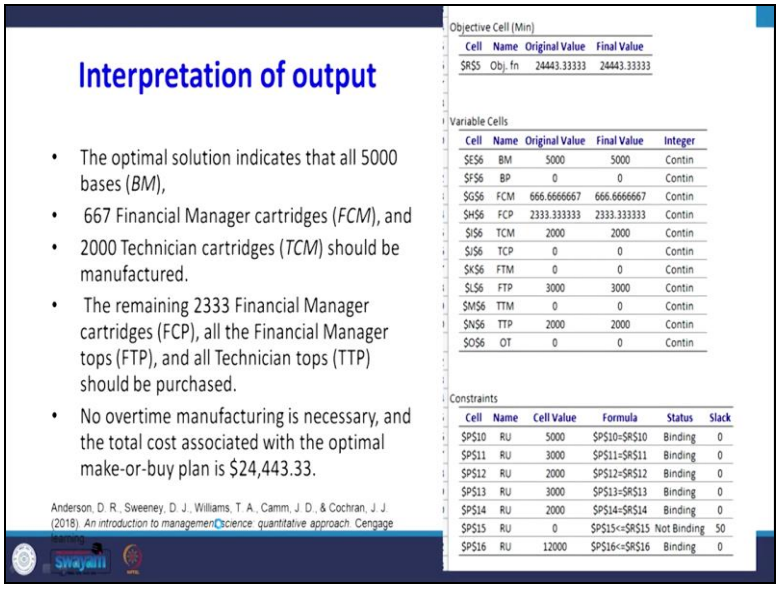


So, now, with the help of a solver, I will run this solver in Excel, and then I will come back to interpreting these answers.

I have formulated an Excel solver. So, this is the place where we are going to get the answer. I have entered all the constraints. So, my objective function is here objective function is in your R5. So, I go to the solver where the data solver sees. Remember, this is a minimization type because we have to minimize the cost. So, when I solve it. So, this is the value of the objective function. Suppose I want to see the output, I will go back solo again after solving, Please select answer sensitivity limits.

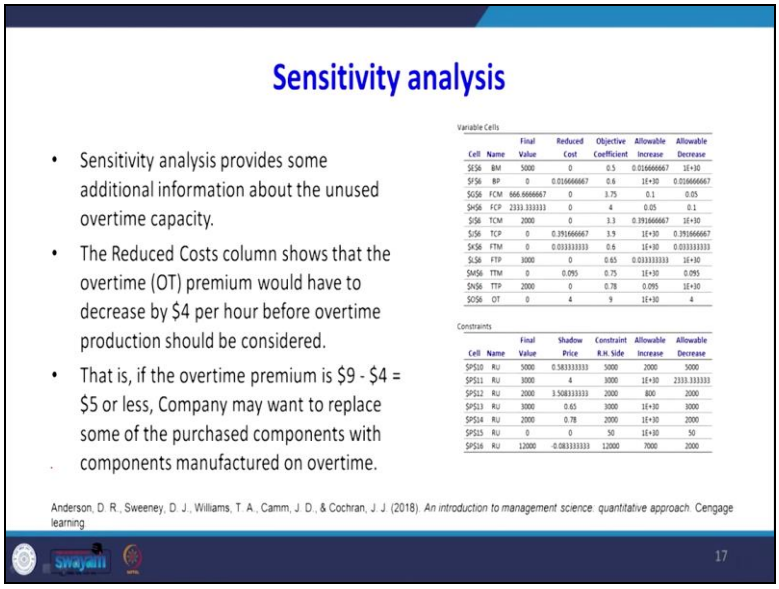
So, now here we have the answer report. This can be formulated like this: yes. So, we are getting here to answer the BM base that has to be manufactured 5000. Base nothing need not buy from outside this solution suggest we need not buy from outside. So, financial cartridges have to be manufactured; some quantities have to be manufactured, and financial categories and some quantities have to be purchased.

See this one? This has to be manufactured by a technician. The second one, zero, need not be purchased. So, FT zero but FT this has to be purchased. Then, when you go to sensitivity analysis here, we can see the reduced cost and the dual value. So, there is a reduced cost, and there is a dual value under the column of shadow price. Now, I have taken a screenshot of this answer so that I can explain how to interpret these values.



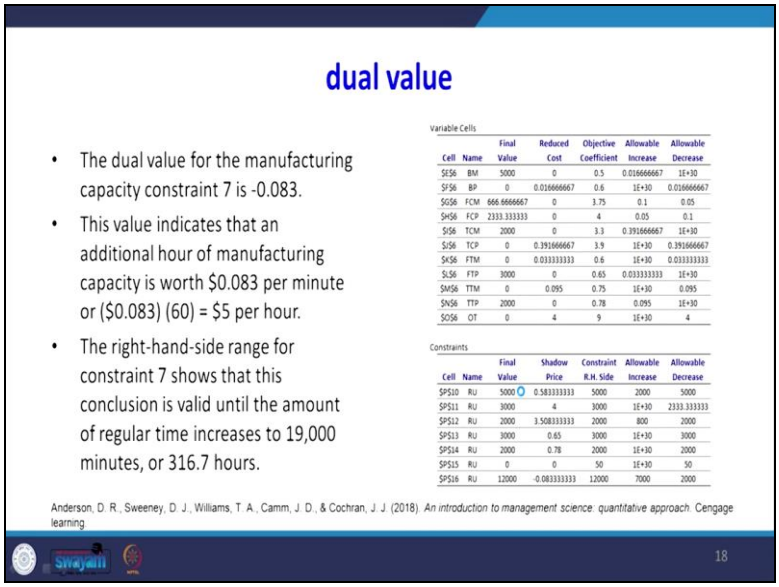
Now, we will interpret the output of our solver. So, what we are in for from here, is that our final objective function value is 24443. So, the other thing is, you see, the BM is 5000. So, this is the optimal solution that indicates that all 5000 bases and 667 this one, approximately 667 financial manager cartridges and 2000 technician cartridges, sorry 2000 technician cartridges here should be manufactured.

So, there are three elements, 1, 2, and 3, that have to be manufactured in-house. Other things remaining are 2333 financial manager cartridges and FTP and TTP. Ok, this has to be purchased from outside. Now we are getting the final answer: how much has to be manufactured in-house and how much has to be purchased from outside? No overtime manufacturing is necessary; see that the value for overtime is zero. The total cost associated with the optimal maker by the plan is this much: 24443.



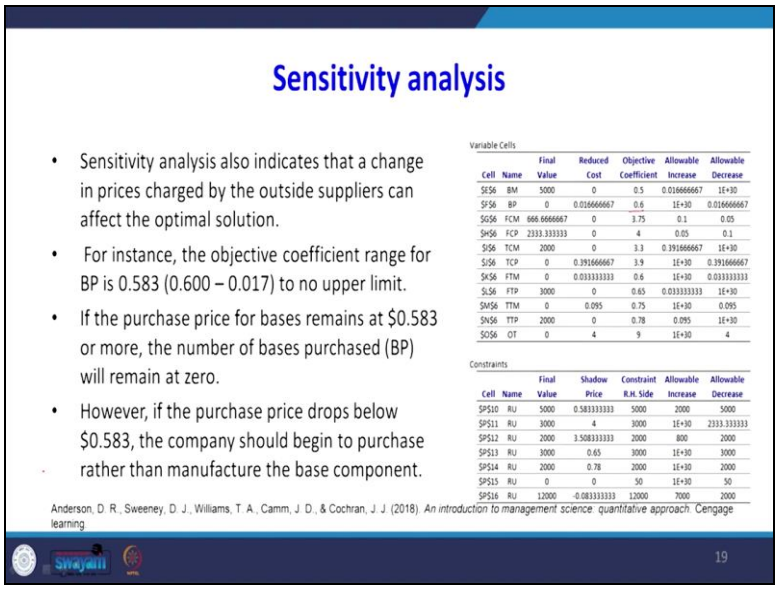
Now we will interpret the sensitivity analysis report. The sensitivity analysis provide some additional information about the unused overtime capacity. Here, when you look at the final, we are not getting, we are not using any overtime value, but the reduced cost is zero, and the reduced cost is 4. So, what it says that the coefficient of our over time in our objective function is 9 OT. So, if the cost of overtime is decreased by 4 more units, then we will get a positive value for the OT.

So, what it implies is that if the overtime premium is 9 - 4, that is 5 or 5 dollars or less, the company may want to replace some of the purchased components with components manufactured over time. So, what it says is that if it is 5 OT, what will happen? There will be a possibility we will be forced to use OT because that will be beneficial for you. Ok, that is the interpretation of this reduced cost.



Then, we will interpret the dual value. The dual value for the manufacturing capacity constraint 7 is minus 0.083 here. This value indicates an additional hour of manufacturing

capacity. So, an additional hour of manufacturing capacity is worth 0.083 per minute; .



So, the sensitivity analysis also indicates that the change in prices charged by outside suppliers can affect the optimal solution. What we are talking about is this range of optimality. Remember the range of optimality. Remember when I was when I was explaining sensitivity analysis? I was explaining two terms: one is a range of optimality, and the second one is the range of feasibility.

What is the range of optimality if the coefficient is what is the allowable change of the coefficient of the objective function? For instance, what is the objective function coefficient range for this BP variable BP? Based on when we are purchasing, the range is 0.583. How did we get this range? For example, here, the current value is 0.6. So, the upper limit is 0.6 + because it is a very big value. The lower limit is 0.6 minus 0.017.

So, that is nothing but your 0.583. There is no upper limit. So, what we are inferring from this is if the purchase price for a basis remains in the range of 0.583 dollars or more, the number of bases purchased will remain at zero. However, if the purchase price drops below because the lower limit is 0.01, 0.583, if the purchase price drops below, instead of buying, the company should begin to purchase rather than manufacture the base component.

However, if the purchase price drops below 0.583, the company should begin to purchase rather than manufacture. Currently, we see that BP we are not buying from outside. When the range goes beyond the limit, then we should; however, if the purchase price drops below 0.583 dollars, the company should begin to purchase rather than manufacture the base

component. Dear students, in this lecture, I have explained the application of linear programming problems in making decisions.

I have solved a problem that I have formulated, then I have solved it with the help of Excel, and then I have explained the interpretation of that output. In the next lecture, we will examine another problem in the operations area, and then we will solve and interpret the result. Thank you very much.