We were talking about this table. I explained this table in depth. So you really should be able to evaluate any sensitivity analysis table. There are a couple of slides after this slide. I have already explained all of these parts. Here are the final values. Reduced cost we said – forget it in this cost. We don’t go into reduced cost. Allowable increase, allowable decrease are in here, objective coefficients are here. They can be increased by this much or decreased by this much, and still the production plan is the same. Here also we talk about right-hand side. This is the final value of right-hand side. This is what we need. This is what we have. Shadow price tells us how much is the value of each unit of this right-hand side. Then we have again, allowable increase, 12 + 6, allowable decrease, 12-6. If these numbers are all 6, that is by accident. There is no relationship between this of and that 6 and this 6 and that 6. Those could be any number. So right-hand sides are here. Allowable increase, allowable decrease.

Look here at product 1. Its coefficient is 3. Allowable increase is 4.5. So if it goes from 3 to 7.5, this production plan will remain the same. For example, if it goes to 7, because it is within the range, production plan remains the same, so 2 instead of being multiplied by 3 is multiplied by 7. That would be $4 increase. 4 times 2 is 8. So I can see from here that if coefficient of product 1 is changed from 3 to 7, the objective function value will increase by 2 multiplied by 4, which is 8. Therefore, if here the coefficient of product 1 is changed to 7, the objective function value increased by 8, it was 36. If I add 8 to 36, that is 44. So if I enter these numbers into Excel sheet, and if I ask solver to solve the problem from the beginning, it will come back with 2 to 6 production plan, and a total profit of 44, but I really did not need to ask solver to solve the problem from the beginning, because I can foresee that if change is within the change, then the production plan remains the same. $4 increasing profit because production is 2 units of product 1. 2 times 4 is 8, $8 increase in total profit. However, if profit is changed to 8, then it is not within the range anymore. So I cannot say 8 compared to 3 is 5 units increase. 5 times 2 is 10, therefore the total profit is increased by 10 and goes from 36 to 46. I cannot say this because it is not within the range. All I can say is this: I know profit is increased to 8, and I know if it is increases to 7.5, then the objective function will increase by 7.5-3, which is 4.5 times 2 is 9. I know that if profit was changed to 7.5, my objective function would have increased by 9 units. So while I do not know how much would be the increase in the objective function, which it is changed to 8, because I know how much it would be if the coefficient was changed to 7.5, therefore, I know 8 is better than 7.5, and I know 7.5 would cause $9 increase in profit, then I could say the profit would increase by at least $9 if the profit per unit of product, 1 is changed to 8. So I know that the profit will go at least to 36 + 9, which is 45, but it would be perhaps more than 45, but I know it would be at least 45.

So I go and ask solver to solve the problem, and then it is solved. I find out that profit is 47 because the production plant changes, because it was out of range. It was out of range – when it is out of range, I usually don’t know what will happen exactly. In this case, we were able to say that the profit while we don’t know how much it would be, but the profit would be at least 45. It is at least 45. It is 47, which is greater than 45.

Okay. Look at this problem. We have the objective function. We have the constraints, functional constraint, non-negativity constraints, and we have this question. For combination of 3 units of product 1 and 3 units of product 2, so X1 is 3. And X2 is also 3. So I put 3 to replace X1. 3 to replace X2.

So I put 3 here and 3 here and 3 here and 3 here. So it is 3 + 9 which is equal to 12, and 12 is less than 14. And here it is 3 times 3, which is 9, plus 6 which is equal to 15. 15 was equal to 15. Therefore, the left-hand side of constraint 1 is less than the right-hand side, but constraint 2, left-hand side and right-hand side are equal. Whenever left-hand side is less than right-hand side, our conclusion is shadow price is equal to 0. Therefore, in constraint 1, left-hand side is less than right-hand side. The shadow price is equal to 0, but for the second constraint, left-hand side is equal to. Right-hand side, therefore, shadow price is not 0. Shadow price is not equal to 0. Only for the first constraint, the first resource. Only resource 1, yes, resource 2, no. Both resource 1 and 2, no. Neither resource 1 or 2 no. Can only be discovered after solving the problem? No. Therefore, the answer is A.

Now when we try to answer some questions. This is the sensitivity analysis of a report. We go to the first question. What is the optimal objective function value for this problem? The answer to this question is quite straight forward. This is production plan here. These are the coefficients of the objective function. Therefore, the optimal solution is 2 times 3 + 6 times 5, multiplication. That would be 36. Therefore, the answer here is 36. But there is also another way to answer this question. Because we said that the shadow prices show the value of one unit of right-hand side, since I have 4 and 12 and 18 units of right-hand side, therefore, if I multiply these numbers by these numbers, I should get the same value with the objective function. Therefore, there is an explicit way of computing the objective function using production plan and profits or costs. The other way is an implicit way using shadow prices and right-hand side. 0 times 4 is 0. 1.5 Times 12 is 18. 1 times 18 is 18. If I add these numbers together, I will get 36, and that is what I had here.

What is the allowable range for changes in the objective coefficient for product 2? Still we are talking about product 2. Product 2 allowable range, it is 5. It can increase by infinity. E with a positive number in front of it here is positive 1. That means infinity. E with a negative number in front of it means negative infinity. When you see E in a number that is scientific representation of the number, 1E + 30 means 1 times 10 to the power of 30. That is 1 and 30 0s in front of it. That is infinite. So it can go to infinity. It can go up to infinity, and it can come down by 3 units. So it can come from 5-3, which is 2. Therefore, as long as it is within the range, greater than or equal to 2, less or equal to infinity, that is within the range and when it is within the range, production plan remains the same. 2, greater than or equal to 2, less than or equal to infinity. We really don’t need to write this because any number is less than or equal to infinity.

What is the allowable range for changes in the right-hand side of resource 3? Because it is a resource, I should go to the bottom part of the table. It is resource 3. I should look at this one. The right-hand side of this constraint is 18. It can go up by 6 units. And it can come down by 6 units. So it should be greater than or equal to this. Then it should remain within the range. When it is within the range, shadow prices remain the same. So allowable range is from 12 to 24. Greater than or equal to 12, less than or equal to 24. If the coefficient of product 2 in the objective function is changed to 7, product 2, its coefficient is 5. If it is changed to 7 that is two units increase, plus 2. But even if it changes to infinity, it is still within the range. So the production plan would remain the same. We still produce 6 units of this product. But instead of multiplying 6 times 5, we should multiply it by 7, which is 2 units more than 5; therefore, 2 times 6 request to 12 you need increase in objective function value. If the coefficient of product 2 is the object, if it has changed to 7, what will happen to the value of objective function? It will increase by 12 units.

If the coefficient of product 1 in the objective function is changed to 8, product 1, in the objective function, this coefficient is changed to 8. That is 5 units increase. 5 units increase is out of range. The answer is we don’t know what will happen, so the easy answer is we don’t know. But if instead of 8 it was 7.5, then instead of 5 it was 4.5 units increase. And 4.5 was within range, therefore, production plan would have remained the same. 2 instead of being multiplied by 3 was multiplied by 7.5, that is 4.5 units increase, so it was 2 times 4.5, which is equal to 9. At least 9 unit increase.

Because if it was 7.5, we had 9 unit increase, 8 is always better than 7.5. 8 could perform at least as good as 7.5. At least there will be 9 unit increase in profit. Increase by at least 9 units, more than 9 units, more than or equal to 9 units, at least 9 units. If the right-hand side of resource 2 is increased by 2 units, what will happen in objective function? Resource 2 is 12. It is increased by 2 units, + 2. 2 is within the range. Allowable increase is 6. Therefore, shadow prices will remain the same. This shadow price of 1.5 instead of being multiplied by 12, it is multiplied by 12 + 2, therefore, that would be 1.5 times 2 equal 2. 3 units increase in the objective function.

If the right-hand side of resource 1 is increased by 2, what will happen to the objective function? Resource 1 increased by 2. Resource 1 is 4. It is increased by 2. 2 is within the range because allowable range is infinity, therefore shadow prices will remain the same, but shadow price of this resource is equal to 0. Therefore, 0 would be multiplied by 2, and that is 0. There will be 0 units changed in the objective function. That means there is no change in the objective function, no change. If the right-hand side of resource 2 is decreased by 10 units, what will happen? Resource 2 is decreased by 10 units. Allowable decrease 6, 10 is greater than 6. Out of range, we don’t know what will happen. Now go ahead and solve this problem. Look at the slides and answer the questions.