Now we want to solve the problem. This is the problem in which we were supposed to manufacture two products, and we had three resources, and we had the consumption of each product from each resource. For example, product 1 is consuming 1 unit of resource 1 per unit of product 1, 0 units of resource 2 and 3 units of resource 3. Product 2 consumes 0 units of resource 1, 2 units of resource 2, and 2 units of resource 3. Available number of resources from resource 1 is 4, resource 2 12, resource 3 18. This is what we have. We call it right-hand side. This is what we need, and we define it later and call it left-hand side. What we need left-hand side, we should compute it. What we have right-hand side is given by the problem. Consumption of each unit of product from each unit of resources is known. Profit of product 1 is 3 units. Remember it was 300. We said we would use 3 to make it simpler. And here I type solutions. So look here I have done nothing. All I have done, I have typed some information that was given by the problem into a spreadsheet. Just to have typed that data. For any other problem I assign one column to each product and one row to each resource. Products are consuming resources. Then on right-hand side I have how much of each resource do I have. On left-hand side I should define some equations to let me know how much resources I need. This is my profit per unit, and this is my production plan. This is my solution which finally will tell me how many product 1 I should produce and how many product 2 I should produce, and I want to define my solution in a way to maximize the value of my objective function. My objective function is my total profit. However, up to now on this page I have just typed data into a well-organized spreadsheet. Okay. These are my changing cells. These two cells because I have two products, I define two cells as my changing cells. Correct? And the objective of this problem is to find these changing cells, to find the solution in a way that the objective function value is maximized, the total profit is maximized. In order not to forget the situation, I know that what I need, and I have not computed it yet, whatever it is should be less than or equal to what I have. What I need from resource 1 must be less than or equal to what I have of resource 1. What I need of resource 2 must be less than or equal to what I have of resource 2. And what I need of resource 3 left-hand side of resource 3 must be less than or equal to what I have of resource 3 right-hand side of resource 3. I typed this lesson and signs to remember that left-hand side to be equal to the right-hand side. Later on I should formally transfer this information to Excel. I have typed it now just for myself to remember it. By typing them here, those information will not be transferred to Excel. It is only over there for me to remember it.

So, I come here. I know that what I need of resource 1 is what goes into each unit of product 1 and what which goes into product 2. How many of product 1 do I produce? This many. How many units of product do I produce? This many. But I don’t know how many is here and how many is here, but I know the objective of my problem is to identify these two values in order to maximize my profit. What I declare is sum product function. It says sum product B5, C5; B9, C9 what this sum product means is if you multiply B5 and C5 one by one by B9 and C9. Don’t forget this is my X1 and X2, therefore this function says if I multiply 1 by X2 + 0 by X2, that would be what I need from resource 1. Correct? Sum product. B5 and C5, 1 and 0, multiplied by B9 and C9 and B9 is X1 and C9 is X2. That is what I need from constraint 1. Because I am going to copy this function into the other lines and because I want this parameters to be multiplied by X1 and X2, therefore, I make X1 and X2 absolute referencing not relative referencing because if I don’t make it absolute referencing when I copy down, then these two numbers will not be multiplied by row 9. They will be multiplied by row 10, and I don’t want that. I want when I copy this cell down still B6 and C6 multiplied by B9 and C9; therefore, I make them absolute referencing. How do I make them absolute referencing? How do I automatically put this dollar sign in front of B, in front of 9, and in front of C? When I am here I just push F4. If I push F4, then those dollar signs will automatically go there. Now it says sum product of this one and this one, and this one and this one, and this one would be over there. Now if I copied this cell down here in this cell I will have 0 times this + 2 times this and it’s over there. That would be my left-hand side and what I need from resource 2. Then if I copied down here it says 3 times this one + 2 times this one is what I need from resource 3 because product 1 needs 3 units of resource 3. Product 2 needs 2 units of resource 3, then if I say sum product those two cells multiplied by these two cells means 3 times this one and 2 times this one, and it’s over there. And if I coped once again, that would be 3 times this one + 5 times this one, which is my total profit. This is my total profit, and what I want to maximize. So I want this constraint, this constraint, this constraint to be satisfied, and I want this value to be maximized by playing with these numbers. The other things are all constant.

This is the target cell. The target cell, changing cells. Changing cells are our solution, our production plan. We may refer to these values as solution, production plan, or changing cells. This cell, which I have now defined it as 3 times this one + 5 times this one is my target cell or my objective function, target cell or objective function, which is sum product of B8 and C8 times B9 and C9. Profit times production, profit times production will give me the total production.

Now I go to tools, from this list I select solver. If you don’t have solver, then perhaps you have add ins here. You can add solver to your Microsoft Excel. If inside add ins you don’t see solver, then that means that the copy of Excel that you have doesn’t have solver, then you have no other choice but to go to the lab and use those computers. So I go to solver. I click on solver. Then a window like this pops up. Such a window pops up. It tells me where is your target cell, and I have already defined my target cell to be here. So my target cell is this one, which is D8. I will go over there, and I click on D8. So here is D8. Then it says is it a profit that you want to maximize or a cost you want to minimize. It is a profit we want to maximize, so click on this but don’t max. Then it asks what are your changing cells and what are your constraints. I will explain these things one by one.

Okay. I will go and click on D8. And D8 will appear over there. It is the function I want to maximize it. Then I go and click on these two cells. That is by changing cell B9 and cell C9. In the next step, I should declare my constraint. I will go and say this one is less than or equal to this one. This one is less than or equal to this one. This one is less than or equal to this one. Up to now I haven’t told Excel that this one should be less than or excel to this one, this should be less than or equal to this one, or this should be less than or equal to this one. So I will go over there, and because all of them are less than or equal, I can declare them all together. I can say D5 is 7. One by one should be less than or equal to F5 to F7. Here this constraint was less than or equal. I could have had greater than or equal constraint or equal constraint or binary constraint which says something can only be 0 or 1, or integer constraint which says something is 0, 1, 2, 3, 4, 5, 6, but in linear programming, as long as I do not declare that something is integer, it can be real, and that means our production plan can be 5.2 and 6.3 units. It doesn’t matter because 5.2 units, if you continue your work for 5 days, each day you produce 5.2, at the end of 5 days, you have 5, 5 which is 25, plus 5.2, which is 1, so at the end of 5 days you will have 26 units, therefore, it doesn’t matter if your solution, your production plan, your changing cells come out non-integer. If it tells you you should produce half a product per day, then if you produce 2 days, then it would be half a product day, half a product tomorrow and then one product per 2 days. Then I go to constraints. In the constraints list I see less than or equal, equal, greater than equal, integer and binary, and I know the constraint I am dealing with is less than or equal. So I declare less than or equal and I click on add, and as I said because all the constraints are of the type less than or equal then I declare them all together, D5 to D7, one by one are less than or equal to F5 or F7. I could have declared them one at a time. I could have said D5 go there. Click on less than or equal to F5. Then I could have clicked on D6 and declared it less than or equal to F6. And D7 is less than or equal to F7 and say okay. So now what I have done, I have told Excel what is the cell that I want to minimize it or maximize it, and I want to maximize it by changing which cells I have identified it, and under what constraint. Then I should go click on option. Under option I should say assume linear model. All my constraints are linear. What do I mean all linear? I don’t have X squared or square root of X. I don’t have logarithm of X. All constraints are a constant multiplied by a variable. That is what we define as a line. A line is formed by multiplication of constant, constant values and variables. No squared, no power, no square root, no sign, no co-sign, no logarithm. So I declare that everything is linear, and I say all my variables must be non-negative. So now I have declared everything. I say okay. Then this window pops up. I go over there and click solve, and it will solve the problem. I don’t out in order to maximize your profit, you should produce 2 units of product 1 and 6 units of product 2. If you do this, you will have 2 times 3, which is 6 + 6 times 5, which is 30. And I see 36 is your total profit. All constraints are satisfied. No constraint is violated. The solution is feasible and is optimal. Constraint 1 left-hand side less than right-hand side. Constraint 2 left-hand side equal to right-hand side. Constraint 3 left-hand side equal to right-hand side. And as long as these constraints are satisfied, as long as I don’t have 19 here or 5 over there, I am fine. I have not violated anything, and therefore, the solution is feasible and Excel has found the optimal solution, the best solution. No one else on this Earth can find a better solution, therefore, when we say formulate the problem, our job is not to solve the problem. By formulate the problem we say translate the narrative or the pictorial representation or a tableau representation into a mathematical representation. As soon as you are done with that mathematical representation and it is correct, then you can transfer it to Excel. When you give it to Excel, Excel automatically finds you the best solution.

Okay. Now, let me ask you a question. This is your optimal solution. Let me ask you this question. Suppose I have come to your office and I say look, I have one unit of resource 1, how much do you pay? I want to give you 1 unit of resource 1. How much are you willing to pay? Then another person comes up to you and says look, I have one unit of resource 2, how much are you willing to pay for it? Then another person comes to you and says I have 1 unit of resource 3. How much are you willing to pay for it? So at the beginning we have 4 units of resource 1, 12 units of resource 2, 18 units of resource 3. Now if someone comes to you and tells you look I have one additional unit of resource 1, how much are you willing to pay for it? What will be your answer?

Spend some time on it, and if that person comes to you and says I have one unit of resource 1, suppose they come to you and says I have one unit of resource 2, how much are you willing to pay for it? How much are you willing to pay for additional units of resource 2, such that the available number of units is not 12, it is 13. Now suppose these two people do not come to you, but a third person comes and asks you, I have one unit of resource 3, how much are you willing to pay for it? How much do you pay? Think about it. Go through my discussion once again. Sit down. Think about it for half an hour or hour and see if you can find a solution. One person comes to you with one unit of three of these resources. How much are you willing to pay for that additional unit of resources?