Course Name - Operations and Revenue Analytics

Professor Name - Prof. Rajat Agrawal

Department Name - Department of Management Studies

Institute Name - IIT, Roorkee

Week - 04

Lecture - 20

Welcome friends, as in our last two classes, we were talking material requirement planning. And we discussed that how we have to do the work much in advance than the due date of delivery of our final product, with the help of one example in our last class we discussed that the product which we are delivering in the eighth period, we have to work for that from period number one when the sub-assemblies have started coming. Then only you will have the due delivery of that product possible in the eighth period, one very simple condition we took that if whatever is the requirement we are going to deliver the same requirement as and when it is possible, but in real life as we said that there may be many constraints also we may not be able to deliver what is needed in a particular time. Because of different type of cost related constraints and that is what we are going to discuss in this particular session that what are the different considerations, when we are deciding the size of our order and this we call as improvements in our MRP system, where we are seeing that different types of lot sizing models are possible. One simple case which we have already discussed in our previous class that is the lot size of how much order is required the same order quantity we are delivering.

So, in this particular class we are going to discuss that can there be a better policy, can there be a better policy of deciding the size of our lot, if I require let us say what I want to say that we discuss in the inventory also, my immediate requirement is let us say 5 units, but it may not be economical to buy just 5 units and I know that there will be a future requirement also. So, in place of 5 I generally purchase 10 units 5 for immediate consumption and remaining 5 for the next requirement. So, and in some cases whatever is the requirement I just purchase that many. So, lot size of the order is a very important issue because of cost related implication and this is important whether we are talking of independent or dependent demand. In independent with the help of let us say EOQ, EPQ, optimal order quantity all these are different type of scenarios we have discussed in our previous many classes.

But, now we are bringing this lot size issue in case of our dependent demand system also which we are calling as MRP. Like, dependent demand system because of much wider variety of plant it is used to have more use of our lot sizing principles. So, the simplest of all the methods of deciding how much should be your order quantity is the lots for lot ordering. So, we are going to give the order of a particular lot as per our requirement. So, in this case the order and the run size for each period are equal to demand for that particular period and you are giving order of only that much of quantity which is required for a particular period obviously, you can easily understand that there will be no inventory holding in this particular case.

So, your inventory holding cost is 0 practically for lots for lot ordering inventory holding is 0. So, one important you can say use case for lots for lot ordering that those items, those components, sub assemblies which are very expensive to hold where the holding cost is very high because of some precious nature of those components, it is advisable to go for lots for lot ordering. In case we will show with the help of data also but qualitatively I will like to say that there may be many items where the holding cost is not so significant in that case may be lots for lot may not be a good idea. But, wherever the holding cost is significantly high you should go for lots for lot ordering system, because it reduces your holding cost to 0 level practically. But, there are some limitations also, some limitations are also there.

Because, it usually involves many different order sizes. Every time your demand is changing and the order quantity will also change. And therefore, you may not be able to get the advantage of economies of fixed order size. Because, every supplier or every setup may not have that kind of convenience, expertise to handle different types of order size and because your order size may vary from one cycle to another cycle, there may be challenges in fulfilling that requirement and it may increase the cost. So, whatever benefits you are going to have for reducing the holding cost to zero level those benefits to some extent neutralized because of variable order sizes.

And another thing is it may require a new setup for each production run, every time you are producing. So, sometime you are producing for 100 items, another time you are producing for 500 items, another time you are again producing for 100 items. So, this variable product run may again put some kind of pressure on your manufacturing system, but this when you are doing the production of these items in house, because in MRP it is not necessary that all the items which you are which are there in your structure are procured from some outside agency. These may be all these items are produced in house itself. So, in that case the production run will change from period to period.

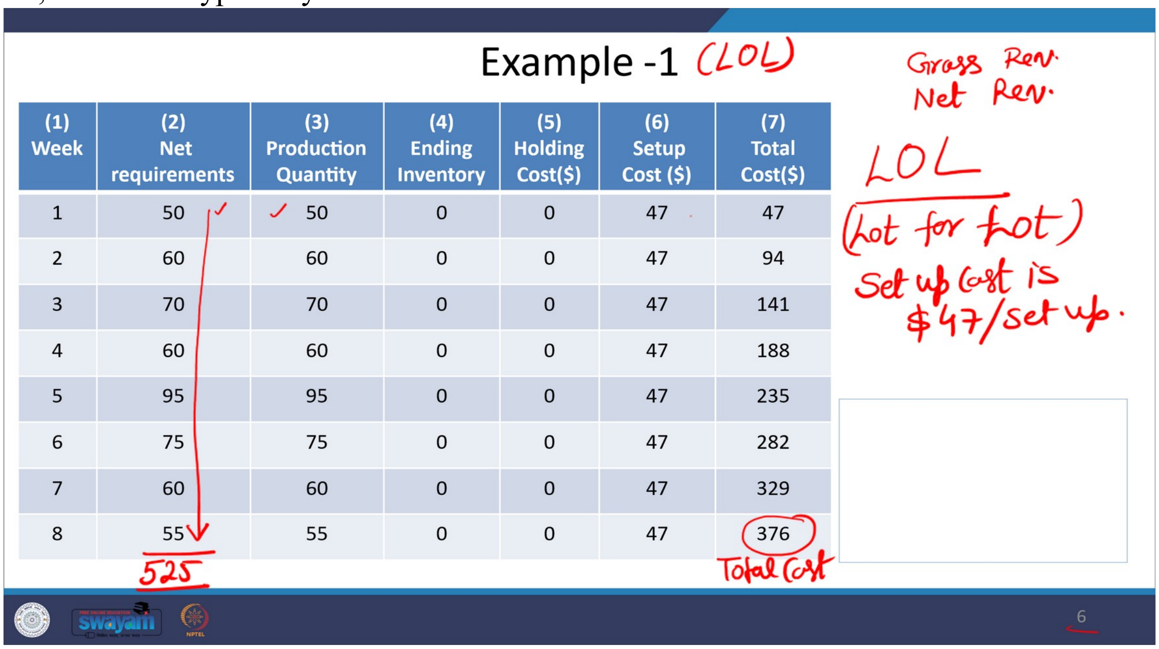
Because whenever there is a demand, you are going to start the production run. You will never have items in inventory, so you cannot fulfill some of the demand from readily available stocks. That also increases your lead time for delivering the final product because you never have any items in stock. You need to start the production, and only then will you make the final assembly. So, the lot-for-lot sizing may sometimes increase the lead time for delivering the final product. Let us see one simple example with the help of this data, where for different weeks the net requirement—you may remember two or three important terms: gross requirement, net requirement. Net requirement comes from the gross requirement by subtracting your inventory on hand. But since there is no inventory on hand, your gross requirement is your net requirement. That is what it is, and since we are following LOL, this table represents LOL (lot-for-lot).

So, in this lot-for-lot system, you are going to produce the same quantity as your net requirement. So, you can see in columns 2 and 3, they are exactly the same. Whatever your requirement is, you are producing the same, and there will be no inventory holding because you are consuming it in the same period. So, column 4 has only 0 entries. And since there is no inventory holding, there will be no inventory holding cost.

Every time you run a production cycle, you are doing some kind of production activity. There is a setup cost. The setup cost is 47,000 per setup. So, you have to pay every week a setup cost of 47 dollars, as you can see in column 6 from period 1 to period 8. Every time, you are paying 47 dollars, and that is your total cost.

This is the total cost of the system, which you are incurring: 376 dollars.

So, this is one type of system where the total cost is this much.

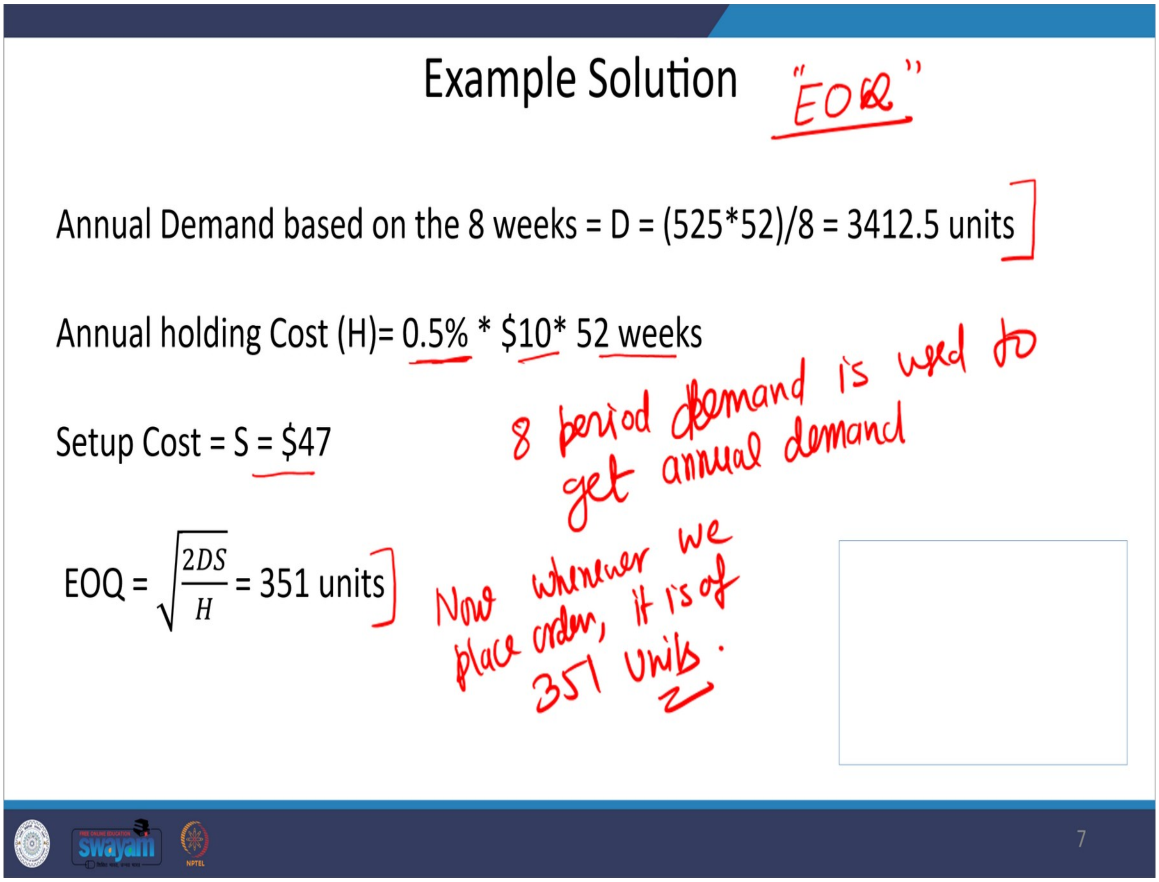


Example -1

(1) Week	(2) Net requirements	(3) Production Quantity	(4) Ending Inventory	(5) Holding Cost($)	(6) Setup Cost ($)	(7) Total Cost($)
1	50	50	0	0	47	47
2	60	60	0	0	47	94
3	70	70	0	0	47	141
4	60	60	0	0	47	188
5	95	95	0	0	47	235
6	75	75	0	0	47	282
7	60	60	0	0	47	329
8	55	55	0	0	47	376

Now, let us move further, and we will see in this second example that we are going to have a kind of system which is based on the EOQ system, where our annual demand is something. And now, if you see, the demand for 8 periods is given to us. At these 8 periods, demand is used to get the annual demand. So, the total 8-period demand is 525, and this 525 is used for getting my annual demand of this particular product, which comes to 3,412.5 units.

The holding cost is at the rate of, let us say, a period holding cost of half a percentage of the material price. The material price is 10 rupees, and half a percentage is our annual holding cost. The setup cost we already assumed: every time you do the setup, you incur a cost of 47 dollars. So, using this information, our economic order quantity becomes 351 units. The economic order quantity becomes 351 units. So, the meaning of this EOQ is that now, whenever we place an order, it is for 351 units.



In the earlier case, you were placing small orders of 50, 60, 70, 60, 95, and so on. Now, we will not place these small orders. We will place an order of 351 units whenever there is a requirement to place the order. So, now let us see how we are going to use this information. So, our EOQ comes out to be 351.

Example - 2

(1) Week	(2) Net requirements	(3) Production Quantity	(4) Ending Inventory	(5) Holding Cost($)	(6) Setup Cost ($)	(7) Total Cost($)
1	50	351	301	15.05	47	62.05
2	60	0	241	12.05	0	74.1
3	70	0	171	8.55	0	82.65
4	60	0	111	5.55	0	88.20
5	95	0	16	0.80	0	89.00
6	75	351	292	14.60	47	150.6
7	60	0	232	11.60	0	162.20
8	55	0	177	8.85	0	171.05

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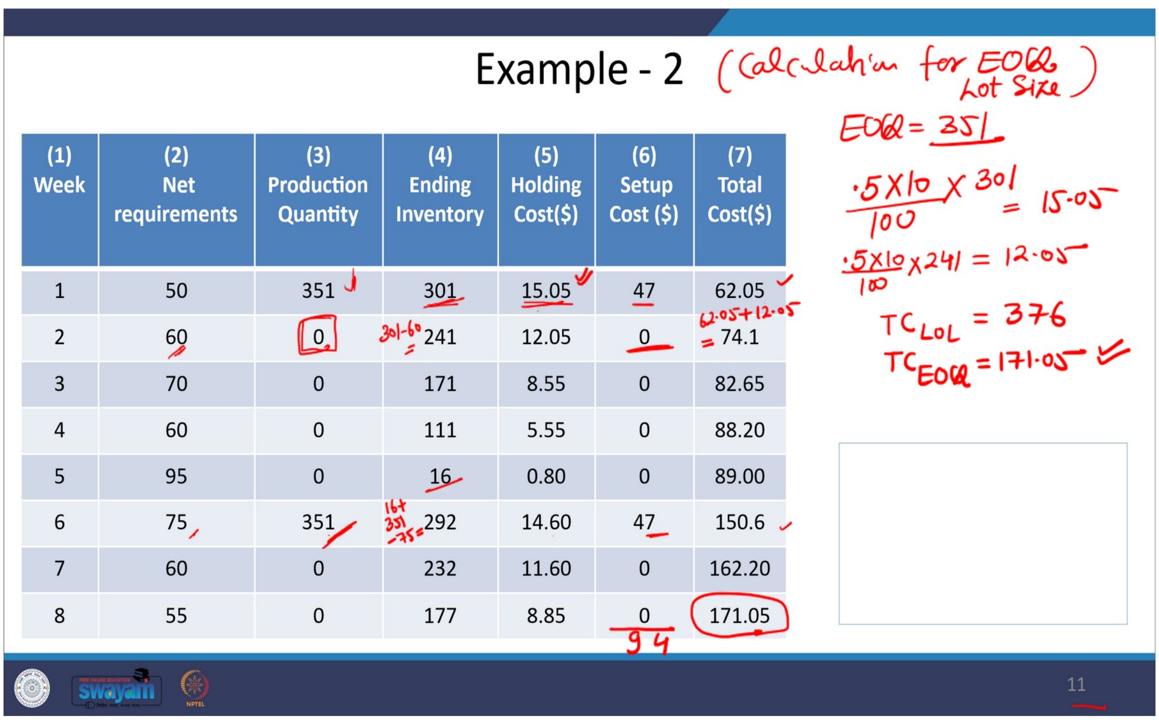
EOQ is 351 units. Now, the EOQ lot size in week 1 is enough; this is the assumption to meet requirements for week 1 through week 5 and a part of week 6. Then, in week 6, another EOQ lot is planned to meet requirements for week 6 to 8, and here we see that the EOQ plan leaves some inventory at the end of week 8 to carry forward to week 9 also. So, you see this particular table, which is a revised calculation of this particular calculation where we had LOL on slide number 6, and now if I go to slide number 9, this is the calculation for EOQ lot size. And EOQ is equal to 351.

Now, in the first week, when my requirement is 50, my production quantity is 351, and here I am ending with 301 units. I am ending with 301 units, and 301 units will be held in my stock, and the weekly holding will come at the rate of, let us say, half a percent of material cost. So, 0.5 into 10, that is 0.5 percent. So, it is divided by 100 into 301. So, it becomes somewhere around 15.05, which is what is written here, and the setup cost is 47. So, the total cost is 62.05.

In the second period, now I will consume 60, but please see here there is no production happening because you already have 301 units in your stock. 60 minus, you are left with 241, and similarly, 0.5 into 10 into 241; your cost of holding is 12.05. But this time there is no setup; this time there is no setup because there is no production. So, your 62.05 plus 12.05 gives you the total cost of 74.1, and so on. Now, when you are finally at this level of ending inventory, 16, and in the 6th period, when you are requiring 75 units.

You will do another production of 351 units and out of 351 you have consumed 75, 16 were before you so in fact this is 16 plus 351 minus 75 equals to 292. So, you will pay now holding cost on these 292 which is 14.60 since a production is happening this time you are Paying a setup cost of 47 and now the total cost is this and in this way you are going the total cost is coming 171.05. Here, you see that you are paying only two times your setup cost which is just 94 dollars and remaining all is your holding cost and the total cost is coming holding plus setup is 171 which was 376 when you are doing LOL. So, total cost LOL was 376 and total cost using this EOQ formula 171. So, you can easily understand that it gives you huge economical benefit, huge economical benefit for using this system of EOQ, you are able to substantially reduce your total cost of holding and



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setup.

I hope it is now aptly clear to all of us. Then another type of model which we follow that is least total cost system that is it is a dynamic lot sizing system where we are not following a particular quantity. In our EOQ system, we have followed a particular quantity that is 351, one more thing I will like to tell you whether it is LOL or our EOQ system you are giving the order of this EOQ quantity in the period when the demand is there now, but, actually you need to give the order few periods before. Because, you know the concept of lead time and because of the lead time it is not possible that the same week when you have the requirement you are producing also in the same week, if I require item in the sixth week maybe I have to start the production in third or fourth week, then those items will be available that is what we have already discussed in the MRP. But, right now our purpose is to explain you that in how many different ways lot sizing can be done.

So, two systems of lot sizing we have discussed. Now, going for the third system that is the least total cost. It is a dynamic lot sizing technique that calculates the order quantity by comparing the carrying cost for various lot sizes and then select the lots which are nearly equals. And then another type of lot sizing system is least unit cost. Now, it is also a dynamic lot sizing technique, but here we are calculating the cost for the entire lot and here we are calculating the cost for each unit of the lot.

It is a dynamic lot-sizing technique that adds ordering and inventory carrying costs for each trial lot size of method 3, divides by the number of units in each lot size, and picks the lot size with the lowest unit cost. So, that is the difference between the third and fourth; in one case, you are comparing the lot size for the entire lot, and in another, you are comparing the unit cost. So, let us see the example with this system when we are considering the least total cost system, and in this case, the quantity ordered. The data is the same as what we have seen in the previous class: 50, 60, 70. For the sake of convenience, let me take the data: 50, 60, 70, 60; 50, 60, 70, 60; 50, 60, 70, 60. These are the 4 weeks' data. Let me add the 5th week's data also: 95, 75, 60, 55, 95 also. So, if I am considering only week 1, it is 50; week 1 and 2, 110 (50 plus 60); week 3, 50 plus 60 plus 70; and week 1 to 4, 50 plus 60 plus 70 plus 60.

And then, if we want to have up to week 1 to 5, 50 plus 60 plus 70 plus 60 plus 95. And then, if I want to add more data, this is 50 plus 60 plus 70 plus 60 plus 95 plus 75, etc. So, in this way, your ordered quantity is changing from 50 to 110 to 180. These are different possible lots, you can say, possible lots. The carrying cost and the ordering cost, if it is 47, 47—whatever your lot size is, that is the 47. Now, the carrying cost will depend on how many items you are going to carry for one period.

Because if you are ordering only 50, all 50 you are going to consume in one cycle, so there is no carrying cost. But if you are ordering 50 plus 60 in period one, then what happens? 60 is the ending inventory. And you are paying at the rate of 0.5 percent: 0.5 into 60 into 10 by 100. So, you get 3 rupees as your inventory carrying cost in this case. Similarly, if you are keeping 180, so in this case, 50 plus 60 plus 70. So, here you are keeping 60 plus 70 for two periods and 70 for one period.

So, in fact, it is 50 plus 60 plus 70, 130 into 10 into 0.5 by 100 that is 6.5 and 70 into 10 into 0.5 by 100 3.5. So, total holding cost becomes 10 that is here and in this order you are keeping the holding cost for all these possibilities from 1 to 8 and then you are keeping the ordering cost also. Now, out of that you are doing the total of carrying and ordering cost and you see that out of all these common the 66 is the cost which is coming here this is placing the first order. So, we see that how these total cost calculations are done and the important thing we need to see that as our carrying cost is increasing over increasing the number of our lot size the total cost is also increasing. Now, we need to select a total cost where if you go back to our EOQ calculations, where carrying cost and ordering cost are nearly equal.

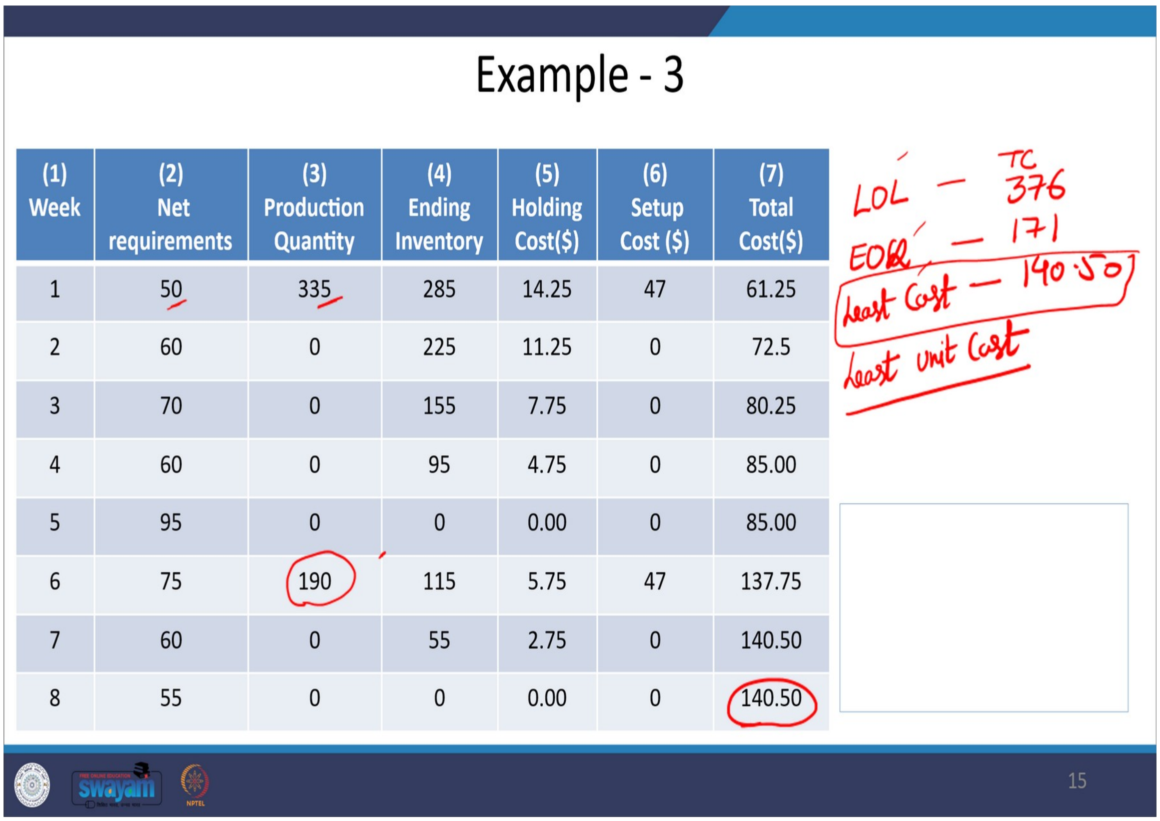
And when carrying cost and ordering cost are nearly equal let us say nearly if you see the lowest total cost is 47, but here the difference between ordering cost and carrying cost is very huge 47 units. In the second instance, the total cost is 50 and the difference has slightly reduced it is 44, further the difference has reduced it is 37 and further the difference has reduced it is 39 and then you increase the ordering cost sorry carrying cost further and now the difference is just 9 units 9 dollar difference. So, this becomes our point of placing the order that is 335 because if you go further beyond this point the difference has started increasing further it is a 9.75. And then subsequently the difference is further increasing, so the lowest difference between carrying cost and ordering cost is at the level of 335, so we get this order quantity for our week number one after this 30 then this lot of you see in this table which is a clean table the initially i will place the order of 335 and in this way I have developed the calculations for my inventory. Now, in the second round we need to see this calculation again that the inventory is fulfilling the

Example - 3

Week	Quantity Ordered	Carrying Cost	Order Cost	Total Cost($)
1	50	0	47.00	47.00
1-2	110	03	47.00	50
1-3	180	10	47.00	57.00
1-4	240	19	47.00	66.00(1st order)
1-5	335	38	47.00	85.00(least total cost)
1-6	410	56.75	47.00	103.75
1-7	470	74.75	47.00	121.75
1-8	525	94	47.00	141.00
1-6	75	0	47.00	47.00
1-7	135	3	47.00	50.00 (2nd order)
1-8	190	8.5	47.00	55.5 (least total cost)

requirement up to period number 5.

Again you start that what should be your order quantity for different kind of combinations then you see you are doing for week number only 6. In fact, this is 6, 6 to 7, 6 to 8 and like that. You have to see that what should be my second order quantity and there may be possibility of 75, 75 plus 60 and then like that. And here the difference is minimum in this particular case though it is a huge difference and it is possible to do much better calculation if I have data for more subsequent periods then I will have a bigger lot size. But, considering the limitation of data at the moment I have the second order quantity as 190 and here you see my total cost is coming 140.50.



(1) Week	(2) Net requirements	(3) Production Quantity	(4) Ending Inventory	(5) Holding Cost($)	(6) Setup Cost ($)	(7) Total Cost($)
1	50	335	285	14.25	47	61.25
2	60	0	225	11.25	0	72.5
3	70	0	155	7.75	0	80.25
4	60	0	95	4.75	0	85.00
5	95	0	0	0.00	0	85.00
6	75	190	115	5.75	47	137.75
7	60	0	55	2.75	0	140.50
8	55	0	0	0.00	0	140.50

So, in this case, we are able to see that our lot size LOL, then our total cost was coming around 376 when our lot size was EOQ. Our total cost was coming around 171, and now we have this least cost, which is 140.50. In a way, this is how analytics play a role. That you are improving—these are alternative options available in front of you: you can go with LOL, you can go with EOQ, you can go with least cost, and you see that out of these three, least cost is the most profitable or reduces the total cost of inventory in your MRP system. So, with this, we would like to conclude and leave one question unanswered for you as part of your homework, where you do this least unit cost calculation.

See whether—and let me tell you—there is no hard and fast rule that every time EOQ is going to be inferior to least cost and every time LOL is going to be inferior in all these cases. It depends upon the relative values of holding cost and ordering cost. For example, if ordering cost is very low, In that case, maybe the LOL system may also work very well because every time you place an order, holding cost is very negligible—0—and the setup cost, ordering cost, is also low. So, in that case, our LOL may also perform better.

So, it all depends on the relative holding cost and ordering cost terms that determine which method is useful. So, we cannot conclusively say that LOL is always going to be inferior. Yes, LOL is the most important and the best way whenever you have very high holding cost because it actually reduces the component of holding cost to 0 in the LOL method. So, with this, we come to the end of this particular session, where we discussed in how many different ways lot-sizing decisions can be taken in our MRP system, and with this, we will now start our discussions on how we are going to optimize revenue in a constrained environment from our next class onwards. Thank you very much.