Production and Operation Management
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Lecture 36
Lot Sizing in MRP Systems

Welcome friends so now we are entering into the 6th week of this course. In our last few sessions, we were discussing about material requirement planning. And if you remember, in the last session, the numerical example which we were discussing, we had a constraint in that problem that whenever we were producing, we had to produce 200 units.

And that is a typical decision we may need to take in our material requirement planning, before that, in those examples, if you remember, in one case, if I required only 100 units in the third week, I gave the order of 100 units in the second week, if I required 150 units in the 7th week, I gave order of 150 units in the 16th.

So, whatever quantities I was requiring, I used to give order of those many numbers only. But in the last example, the case was not so, I was requiring maybe just 27 units, but I gave order of 200 units, because of the constraints of the production. So, that type of situations are very common, that many a time you will not be able to give order of only those number of quantities, which are required in a particular week.

Sometime it may be very expensive to produce in smaller numbers and in most of the organizations, we have a batch production system. So, if you go to that discussion of our independent inventory management, where we discuss the economic production quantities systems, so even that EPQ concepts may be used in our decisions of how much to order in a particular lot and this will be the subject matter of our discussion in this particular session that how do we have the lot sizing decision in our MRP.

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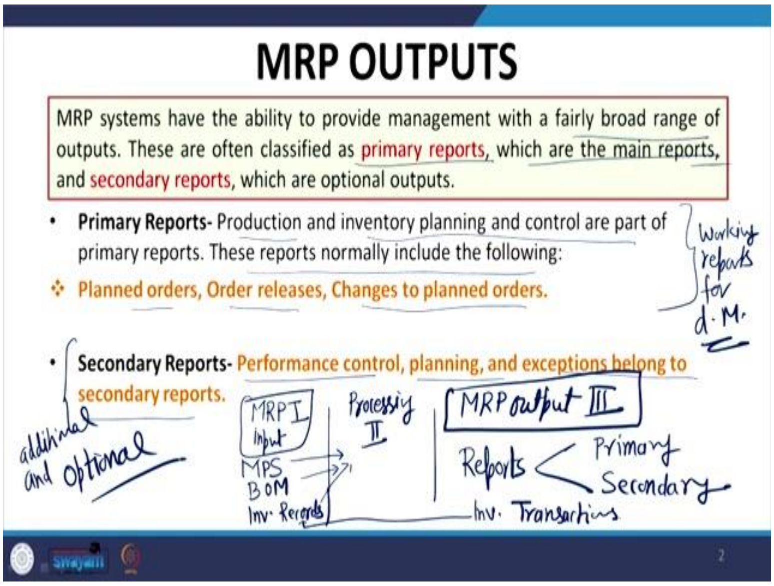

Now, here as we have already discussed in our earlier 2 sessions, that there are 3 important components of our MRP discussion MRP input, which are master production schedule bill of material and inventory records. This is the first part MRP input then processing that is the second part and third part is MRP output. So, these are the 3 important components in our MRP discussions.

Now in the MRP output we created reports and reports can be of primary and secondary and we also create reports of inventory transactions. And these reports of inventory transactions are fed to the inventory records so that it again becomes the part of our processing. So, this is how the complete system of MRP is understood.

Now, what is these primary and secondary reports? Let us quickly try to understand these concepts. So, primary reports are related to production and inventory planning and control. And these reports normally include planned order, order releases and changes to planned orders, so these are the part of these are the important you can say components of the primary reports, these secondary reports are additional information. So, these are with respect to your performance control, planning and exceptions belongs to secondary reports.

So, some very exceptional things, the particularly performance related issues, these are the part of secondary reports. So, normally secondary report is to track whether your things are as per scheduled or not. So, to know the quality of your MRP secondary reports are used, but decisions are taken on the basis of primary report. So, as mentioned also that fairly broad range of output classified as primary reports, which are the main reports. So, our working reports these are the working reports on which for decision making and secondary reports are additional and optional.

So, it may be needed by some organization to see whether my MRP system is working properly or not working properly. So, that is about the third phase of MRP system about the output. Now, when we are discussing this output per part, then time fencing and quantity, time fencing and quantity these are the 2 important decisions which will come in these 2 things, planned order and order releases, when to order and how much to order same as we discussed in case of our independent inventory management system.

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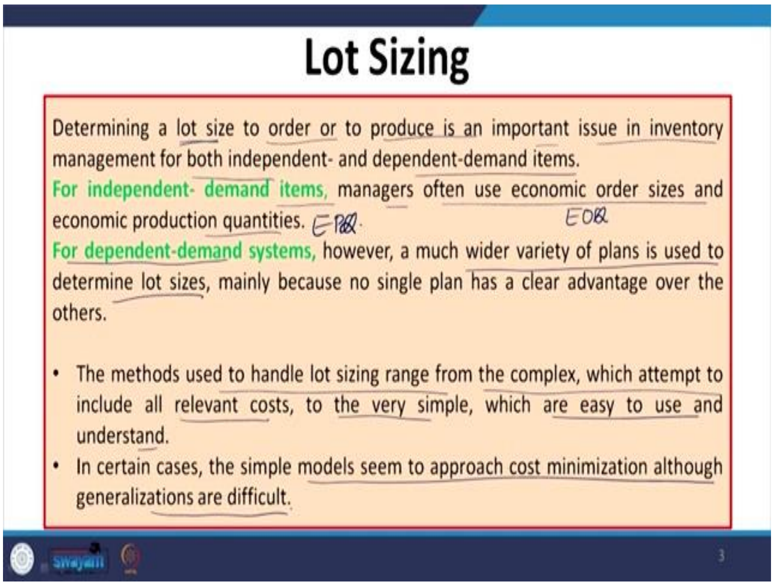

Now, here the lot size is going to affect the cost of our inventory system, whether it is dependent or independent, we want to minimize the cost of inventory and we also do not want to compromise with the production schedules for the sake of cost reduction. I will also not like to degrade my production schedules I do not want any kind of disruption in the production schedules, so, for that purpose this lot sizing is very important. Now, determining a lot size to order or to produce is an important issue in inventory management for both independent and dependent demand items.

For independent demand items we have already discussed manager often use EOQ or EPQ type of decisions EOQ EPQ, these models we have already studied and for dependent demand systems a much wider variety of plans are available and mainly because no single plan has a clear advantage over the others depending upon how cost parameters are arranged, how our requirements are fulfilled, what type of constraints are there in my production system? How much is the availability of the machine.

So, variety of factors are affecting the lot size decision in case of dependent demand system. And therefore, it is mandatory to discuss almost all those types of popular systems which are used for lot sizing decisions in case of dependent demand items. So, methods used to handle lot sizing ranges from the complex, which attempt to include all the relevant costs to the very simple which are easy to use and understand.

In certain cases the simple model seemed to approach cost minimization although generalizations are difficult. So, as I mentioned that we need to see from case to case basis that which particular model is more suitable in that particular scenario.

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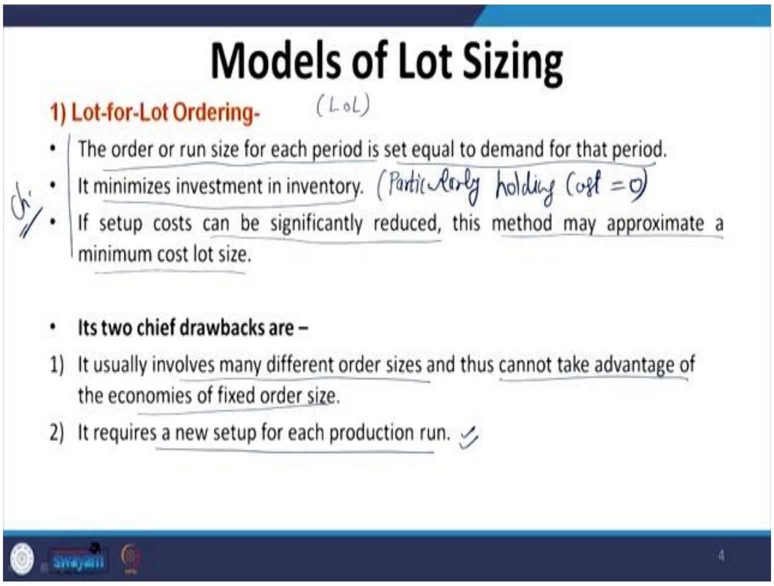

Now, let us see some common type of lot sizing models. One simple type of load sizing model is which is known as LOL lot for lot, LOL stands for lot for lot ordering. Now, in this case, if you remember the example, where we had quantities like 100 in one week 150 in another week and we ordered 100 in that week and 150 in next week. So, that is a case that whatever is the net requirement, you order only that many quantity that is lot for lot ordering.

So, here the order or run size for each period is set equal to the demand for that period, whatever is the requirement of a particular period, you are going to order only that much quantity. Obviously the benefit of this particular system is it minimizes investment in inventory, particularly holding cost will be 0 almost, you will not hold the inventory whatever is required you are producing only that much. So, this will reduce your cost of holding or carrying cost to 0 level if set of but you may need to make multiple setups, you need to make multiple orders if it is a case of procurement.

So, if setup costs can be significantly reduced, this method may approximate a minimum cost lot site, if my setup cost is really low, if my ordering cost is really low, so this is a method which may approximate to minimum cost a lot sizing, but if in case every time you develop the product and a lot of efforts are required, and then you can translate those efforts in terms of cost. So, if it is significant then, obviously that may add into the cost of inventory. So, 2 drawbacks, these are the characteristics.

Now, let us see what are the you can say downside of this LOL, it usually involves many different order sizes and thus cannot take advantage of the economics of fixed order size. When you have fixed order size, you can arrange your resources to produce the limited amount of quantity or a fixed type of quantity.

But when the order quantities are varying from period to period, it is a difficult task to arrange your resources. So, you require a lot of flexibility so, that your system can respond to varied quantities and obviously, flexibility comes at a cost. So, it is the one important downside that because of the variable size of order, you will not be able to take advantage of those which are associated with the economics of fixed order size.

The second limitation is it requires a new set of for each production because every time you have a new order, you have to make jigs, fixtures, and toolings all those things for producing that order. So, a lot of resources so, practically these things are true, but theoretically I am saying that if setup cost can be significantly reduced, it is going to have a 0 inventory cost kind of lot sizing decision, but practically you have to incur some cost in the setup. So, this is about the lot sizing. Now, let us see how does a lot sizing is going to happen when we have LOL.

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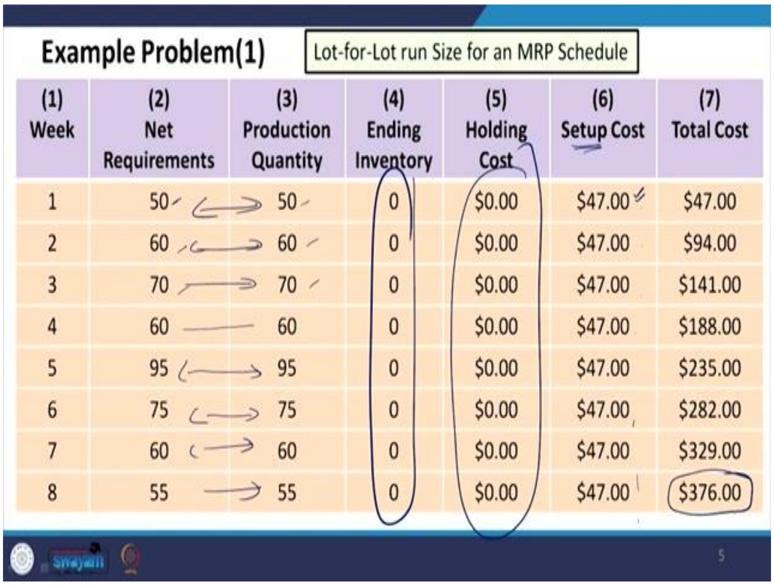

Example Problem(1) Lot-for-Lot run Size for an MRP Schedule

(1) Week	(2) Net Requirements	(3) Production Quantity	(4) Ending Inventory	(5) Holding Cost	(6) Setup Cost	(7) Total Cost
1	50	50	0	$0.00	$47.00	$47.00
2	60	60	0	$0.00	$47.00	$94.00
3	70	70	0	$0.00	$47.00	$141.00
4	60	60	0	$0.00	$47.00	$188.00
5	95	95	0	$0.00	$47.00	$235.00
6	75	75	0	$0.00	$47.00	$282.00
7	60	60	0	$0.00	$47.00	$329.00
8	55	55	0	$0.00	$47.00	$376.00

Now, the net requirement I am just taking a particular you can say section of our discussion, that net requirement in a particular week is 50 unit. So, your production quantity is 50 here it is 60 it is 60 here it is 70 here it is 70. So, your whatever is the quantities required in the second column, these are same in the third and therefore, every time your ending inventory is 0, your ending inventory is 0 because whatever is required you are producing only that much and therefore, the holding cost also becomes 0.

We just discuss that because there will not be any carrying of inventory from one period to another period. So, you incur 0 inventory costs but for every time you are doing a setup when you are doing a setup you incur a cost of 47 dollar whenever you are doing a setup you incur a cost of 47 dollar. So, each period you have to make a setup and you are incurring 47 dollar every time.

So, the total cost is 376 dollar where the holding cost component is 0, this entire 376 is coming on the basis of setup cost, if the setup cost is reduced significantly, then you can reduce this total cost component also. So, this is about LOL where your holding cost component is 0 almost because you are not carrying any inventory.

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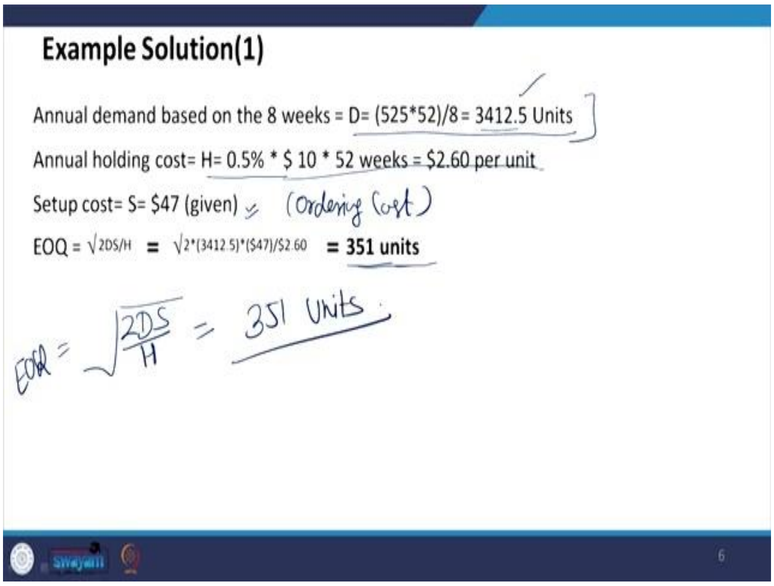

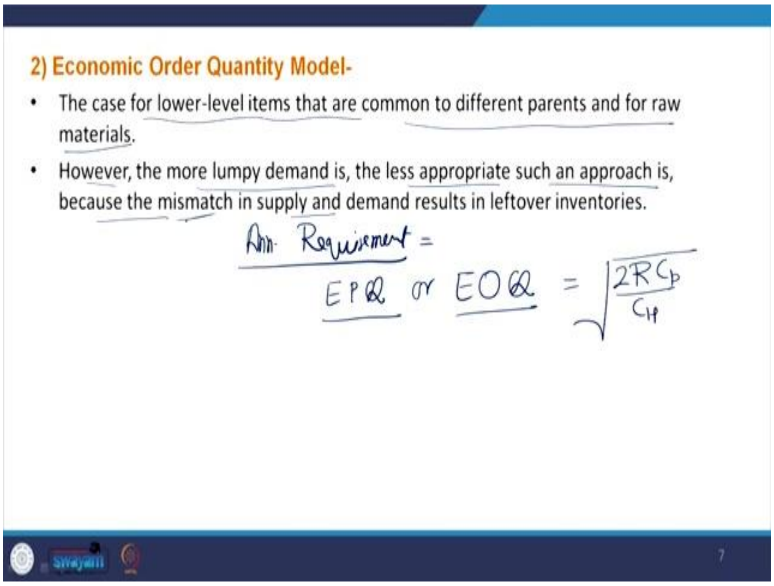

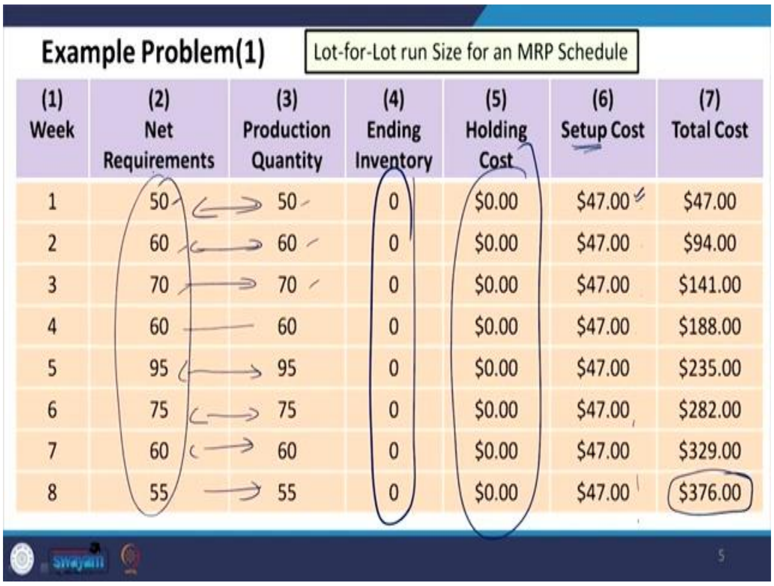

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5	95	95	0	$0.00	$47.00	$235.00
6	75	75	0	$0.00	$47.00	$282.00
7	60	60	0	$0.00	$47.00	$329.00
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So, here see, we have just seen that the second particular thing we have this D is now going to have a particular case where annual demand based on the 8 week is 528. And this is based on some numerical data that we are going to see in our second example that is economic order quantity model.

Now, in this economic order quantity model, we have some annual requirement and that annual requirement is divided in such a fashion that it is like EPQ Economic Production Quantity or if you want to purchase it becomes economic order quantity. So, you use that formula of under root to 2 RCP upon CH or if it is a production quantity, so you have to use CH into 1 minus R upon P as a factor in the denominator.

Now, it is obviously going to balance the 2 types of cost, your cost of ordering or cost of setup and cost of carrying the inventory. So, in this particular case, we expect that the cost of inventory should be less than any other method, than any other method the cost of inventory should be minimum in this particular case, but here the case for lower level items that are common to different parents and for raw materials.

So, this is their and however the more lumpy demand is the less appropriate such an approach is because the mismatch in supply and demand results in leftover inventories, so whenever the demand pattern is lumpy, this is not a suitable case and because there may be some leftover items at the end of the, you can say your MRP schedule and it may create some kind of additional cost, because some leftovers that means, additional cost of carrying the inventory.

Now, let us see the example with the help of this EOQ model. Here, if you see our previous calculation, when we had this calculation, our holding cost is coming 2 rupees 60 paisa per unit the setup cost as we used in the previous example is 47 dollars. So, this is the ordering cost also and now we use this formula under root 2 DS upon H and when we use this formula for determining the economic order quantity, and we use these values that based on because for 8 weeks, we had the demand for 8 weeks, we have the demand because 50 to 55 this is available to us and the total of this 8 week demand is coming to us.

And on the basis of that, we have calculated the overall demand that is the annual demand and that is coming to 3123 units somewhere like that. So, we have economic order quantity coming as 351 units. Now, let us see that, how this is going to be used in this particular case.

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Example Solution(1)

Annual demand based on the 8 weeks = D= (525*52)/8 = 3412.5 Units

Annual holding cost= H= 0.5% * $ 10 * 52 weeks = $2.60 per unit

Setup cost= S= $47 (given) (Ordering Cost)

EOQ = $\sqrt{2DS/H}$ = $\sqrt{2*(3412.5)*(\$47)/\$2.60}$ = **351 units**

$$EOQ = \sqrt{\frac{2DS}{H}} = 351 \text{ Units}$$

Example Problem(2)

EOQ Run Size for an MRP Schedule

EOQ = 351

(1) Week	(2) Net Requirements	(3) Production Quantity	(4) Ending Inventory	(5) Holding Cost (5%)	(6) Setup Cost	(7) Total Cost
1	50	351	301	$15.05	$47.00	$62.05
2	60	0	241	$12.05	$0.00	$74.10
3	70	0	171	$8.55	$0.00	$82.65
4	60	0	111	$5.55	$0.00	$88.20
5	95	0	16	$0.80	$0.00	$89.00
6	75	351	292	$14.60	$47.00	$150.60
7	60	0	232	$11.60	$0.00	$162.20
8	55	0	177	$8.85	$0.00	$171.05

Example Problem(1)

Lot-for-Lot run Size for an MRP Schedule

(1) Week	(2) Net Requirements	(3) Production Quantity	(4) Ending Inventory	(5) Holding Cost	(6) Setup Cost	(7) Total Cost
1	50	50	0	$0.00	$47.00	$47.00
2	60	60	0	$0.00	$47.00	$94.00
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So, our net requirement is same as we had in the previous example 50 60 70 60 95 75 60 and 55. Now, the production quantity because our EOQ came 351 so, first time I will produce 351 units and therefore, there will be some leftover units 301 again I have enough units available with me.

So, the demand of the second week will also be fulfilled from this available inventory. So, now finally I have 241 then again I will consume 70 units, I have 171 I will consume 60 units, I have 111 then I will consume 95 units, I have 16 units again I have to get a new order and this new order will be off 351 units, because whenever I will order I will order in the size of 351 and so on, I have 292 232 and 177 units as my ending this talk.

Now, since 301 units are available with me and my holding cost is given to me is the 0.5 percent that is the 0.5 percent is the holding cost. So, on the basis of this 301.5 percent of the material cost is the holding cost. So, it becomes 15 dollar it is 12 dollar it is 8.5 dollars 5.5 and so on. These are the calculations of the holding cost which is charged at the rate of 5 percent. Whenever I am doing a setup, I required a cost of 47 dollars. So, these are the 2 times when I am doing the setup in the 8 weeks period. So, that is the setup cost.

So, I can get the calculation of the total costs. So, now this total cost is coming 171 dollar somewhere around that. And you recall, it was 376 in the case of LOL, LOL when there was no holding cost. Even in that case, the LOL was giving the total cost to me as 376 dollar which became 171. Even when some holding is taking place I am holding 300 200 171 110 292 230 177 kind of units, but setup cost was too much in the case and therefore in the previous table the total cost of this lot sizing was much higher than this cost which is now available.

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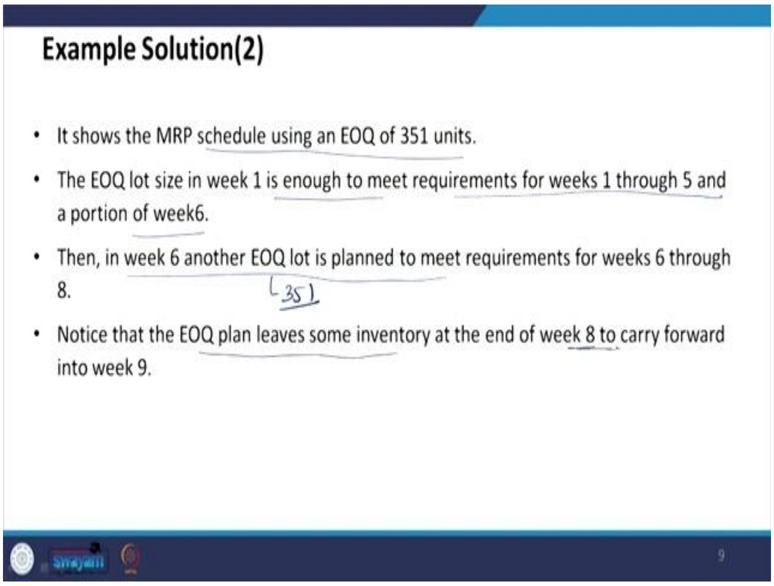

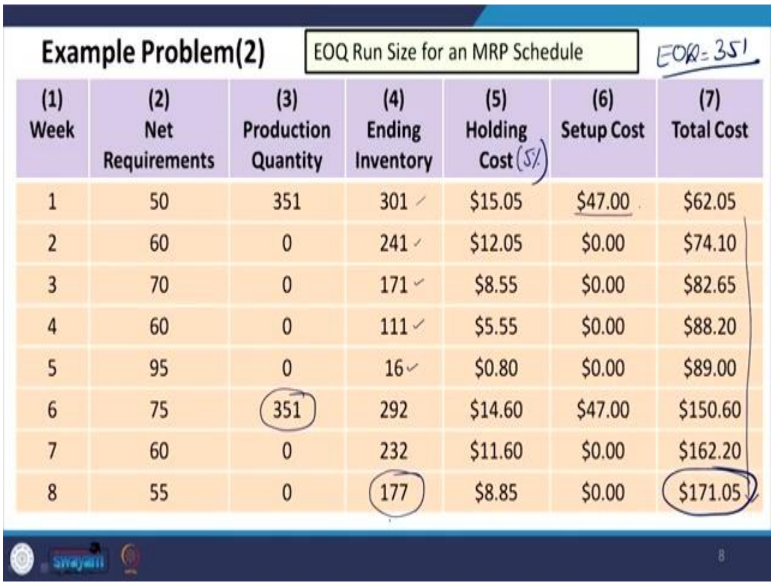

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Then the solution is saying that whatever it shows that MRP schedule using EOQ of 351 units that EOQ lot size in week one is enough to meet the requirement of week 1 through 5. And then in week see another EOQ is planned and that EOQ is of 351. And then EOQ leaves planned some inventory at the end of week 8, so that it can be used in week 9.

We understand that the system is going to be behaving in a perpetual manner. So, for that whatever is leftover like in the ending inventory, it is 177 units here, but that is not a loss. It will be used in the subsequent periods that is period number 9.

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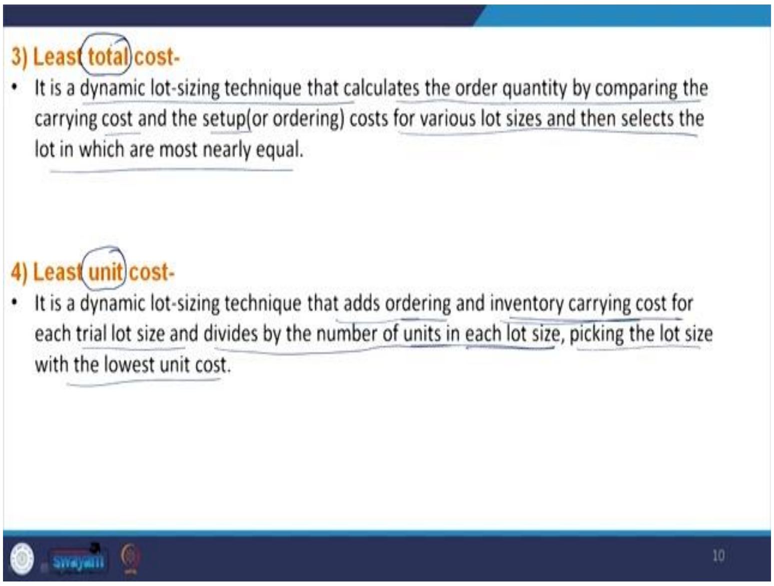

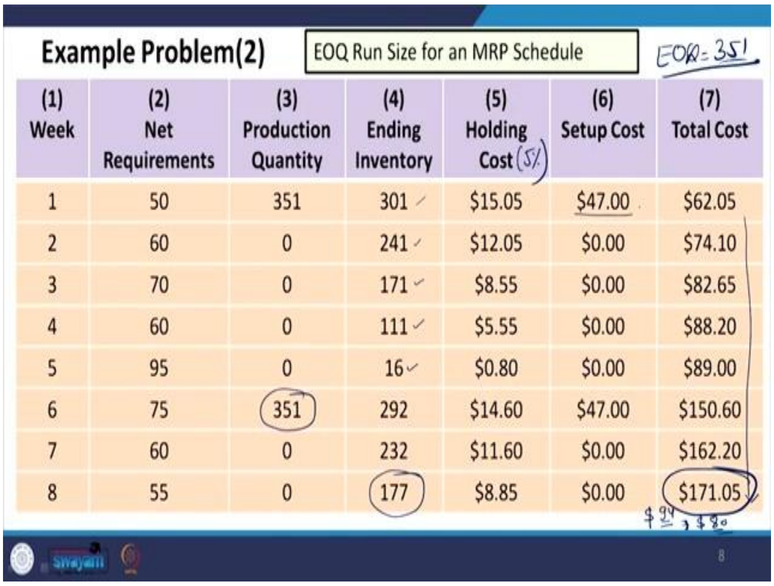

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Now, another method which we use that is least total cost method. It is a dynamic lot sizing method technique that calculates the order quantity by comparing the carrying cost and the setup cost for various lot sizes and then selects the load in which we are getting these 2 costs nearly equal some time you see in this particular case our calculations of 351 due this calculation.

So, if I do this understanding that what are the comparison of my holding cost and setup cost in this 171 so, if I see that comparison so around 47 and 47 94 dollar is coming because of setup cost 94 dollar is coming from the setup cost and somewhere around 80 dollar are coming from the holding cost.

So, there is a reasonably balanced holding and setup costs in this particular case, but I can try some other lots also maybe 325, maybe 375. And I will do this kind of calculation for those different lot sizes also. And those values of lot sizes, which give me almost similar values for setup cost and this carrying cost that is taken as the lot size in case of least total cost method.

Then another method is least unit cost method, in least unit cost method. This is also a dynamic method because a lot size is dynamically selected. That adds ordering an inventory carrying cost for each trial lot size and divides by the number of units in each lot size means, here we in the third case, least total cost, we are comparing the total ordering cost and total setup cost for different lot sizes.

Now, in this least unit cost method, we are going to calculate the cost of inventory per unit and therefore, the total ordering and inventory costs are used for developing this trial purpose and we used to divide it by the number of units in each lot size and then we pick the lot size with the lowest unit cost. So, there is a slight difference between here we are talking of unit cost and here we are talking of total cost.

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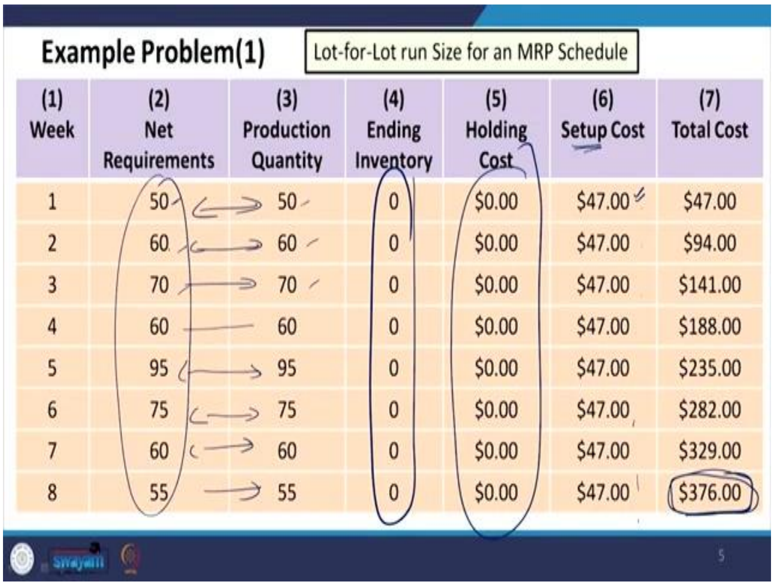
Example Problem(1) Lot-for-Lot run Size for an MRP Schedule

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4	60	60	0	$0.00	$47.00	$188.00
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Then we can see the difference between these 2 cases with the help of examples also, like these are the quantity ordered for different weeks for week one. Now, you have different types of cases that from week 1 to 2, week 1 to 3, 1 to 4, 1 to 5, 1 to 6, 1 to 7, 1 to 8 and quantity ordered are 50, 110, 180, 240, 335 depending upon that for how many weeks you want to order in a single go.

So the calculations are coming from the previous example. Like if I take the original problem for first week the requirement was 50 for the second is 60 for the third is 70. So, if I am taking only for first week it will be 50. If I take for week 1 and 2 together, it will be 110. For week 1 to 3, it will be 180 and so on.

So, for understanding the values please see data of example one, so, you will be able to understand that from where these quantity order data is applicable. Now, the carrying cost because you are only ordering 50 units and those 50 units will be consumed in the first period itself. So, carrying costs will be 0 and your ordering cost is 47 total cost becomes 47.

If you are ordering 110 so 50 you will consume in the first period 50 plus 60, so 50 will go in the first and 60 will stay for one week and for that you will incur a cost of 3 dollar. 47 is your ordering cost the total cost is 50. No here you ordering 50 plus 60 plus 70 for first period second period, third period.

So, 50 will be finished in the first period, 60 will stay for one week and 70 will stay for 2 weeks and based on that, your total carrying cost will be 10 and so on is the carrying cost calculations as you are going from 1 to 8, you will incur for one euro some units, the carrying cost for 7 periods and therefore, you see this total cost column and here we see that our least total cost, our least total cost values are those where both these quantities are in a relatively balanced condition and that is coming at this particular level,

So, this is your least cost calculation kind of thing that 38 and 47 are relatively balanced and therefore, this is used as least total cost, then you see another combinations 161718 and when you have understood that your first order is of 335 units, then how much you will order for the remaining periods. So, 75, 135 and 190 because, now you have to see only for these 3 periods, because the lease order cost is coming here.

So, now you have to see that you have order up to the fifth period and 6 onwards you have to see so 75 only or 135 or 190, again you are doing this comparison and you saw that out of 3, this is the maximum balanced one. So, this is the least total cost and therefore, you will order this second quantity and this is the second order, which you will place. So, you will place 2 orders one for from this table and second from this table and this way you will be able to fulfill the requirement.

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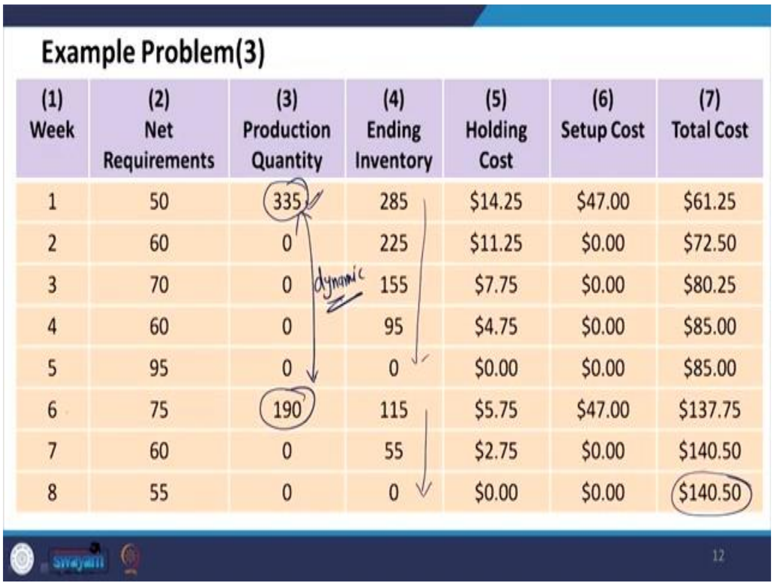

Example Problem(3)

(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	$47.00	$61.25
2	60	0	225	$11.25	$0.00	$72.50
3	70	0	155	$7.75	$0.00	$80.25
4	60	0	95	$4.75	$0.00	$85.00
5	95	0	0	$0.00	$0.00	$85.00
6	75	190	115	$5.75	$47.00	$137.75
7	60	0	55	$2.75	$0.00	$140.50
8	55	0	0	$0.00	$0.00	$140.50

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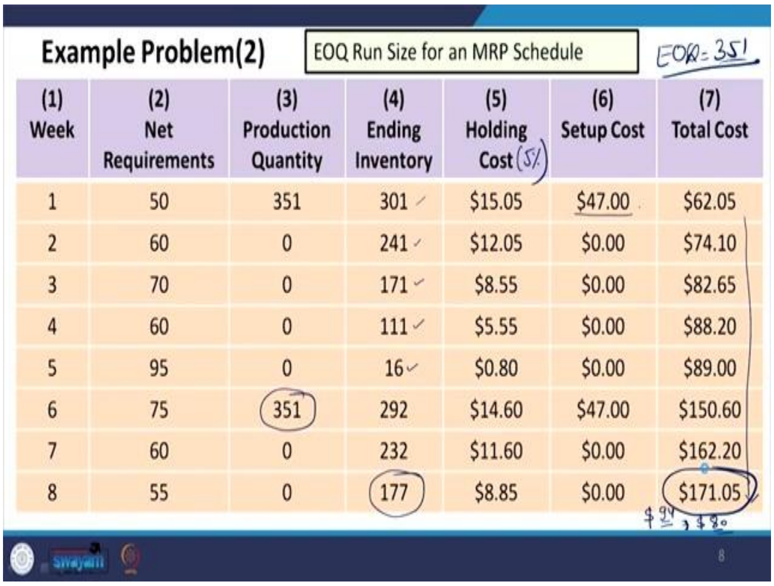

Example Problem(2) — EOQ Run Size for an MRP Schedule

(1) Week	(2) Net Requirements	(3) Production Quantity	(4) Ending Inventory	(5) Holding Cost	(6) Setup Cost	(7) Total Cost
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5	95	0	16	$0.80	$0.00	$89.00
6	75	351	292	$14.60	$47.00	$150.60
7	60	0	232	$11.60	$0.00	$162.20
8	55	0	177	$8.85	$0.00	$171.05

So, if I see the calculation, now you have decided that how much you are going to order. So, first order is of 335 units. So, first time you are ordering 335 minutes, and then you see how your inventories are reducing then at the second 6th period, because inventory will finish here, then you will order for 190 units and then you will finish your inventory in such a fashion and then your total cost is coming 140 dollars.

So, earlier it was when we were using economic production quantity method, our order cost was coming 171 units. Now, by using this dynamic method, our cost has further reduced to 140 dollars. So, you see that LOL maximum cost then EOQ a better method than that, and now we are using the dynamic method. Because in EOQ, each time you are giving same quantities, but here these are dynamic every time you may have a different order quantity, and therefore you try to reduce your inventory cost further.

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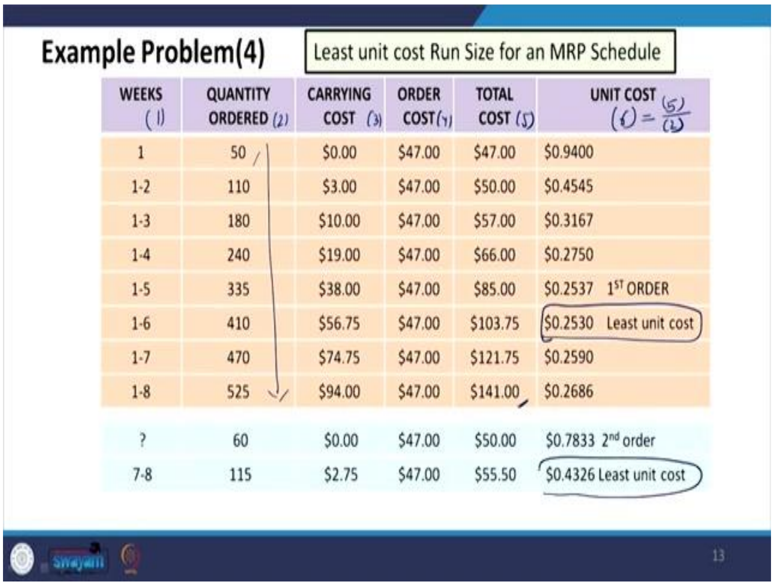
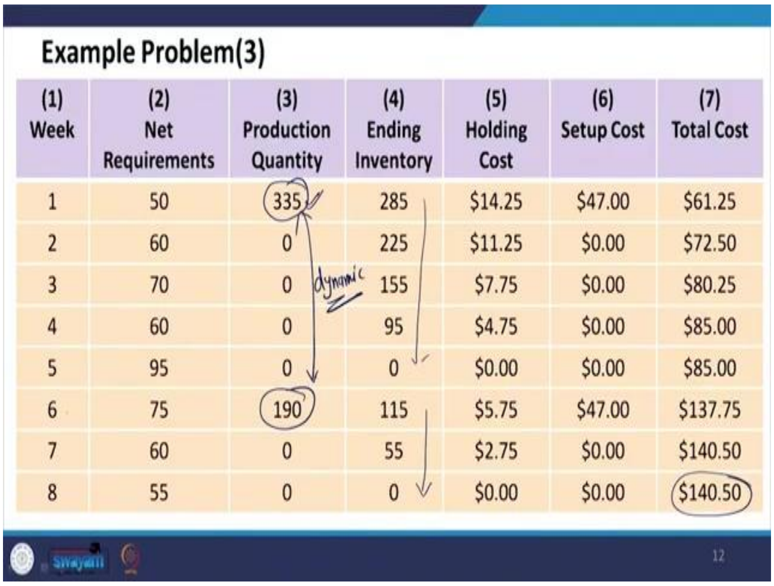


Example Problem(4)

Least unit cost Run Size for an MRP Schedule

WEEKS (1)	QUANTITY ORDERED (2)	CARRYING COST (3)	ORDER COST (4)	TOTAL COST (5)	UNIT COST (6) = (5)/(2)
1	50	$0.00	$47.00	$47.00	$0.9400
1-2	110	$3.00	$47.00	$50.00	$0.4545
1-3	180	$10.00	$47.00	$57.00	$0.3167
1-4	240	$19.00	$47.00	$66.00	$0.2750
1-5	335	$38.00	$47.00	$85.00	$0.2537 1ST ORDER
1-6	410	$56.75	$47.00	$103.75	$0.2530 Least unit cost
1-7	470	$74.75	$47.00	$121.75	$0.2590
1-8	525	$94.00	$47.00	$141.00	$0.2686
?	60	$0.00	$47.00	$50.00	$0.7833 2nd order
7-8	115	$2.75	$47.00	$55.50	$0.4326 Least unit cost

13

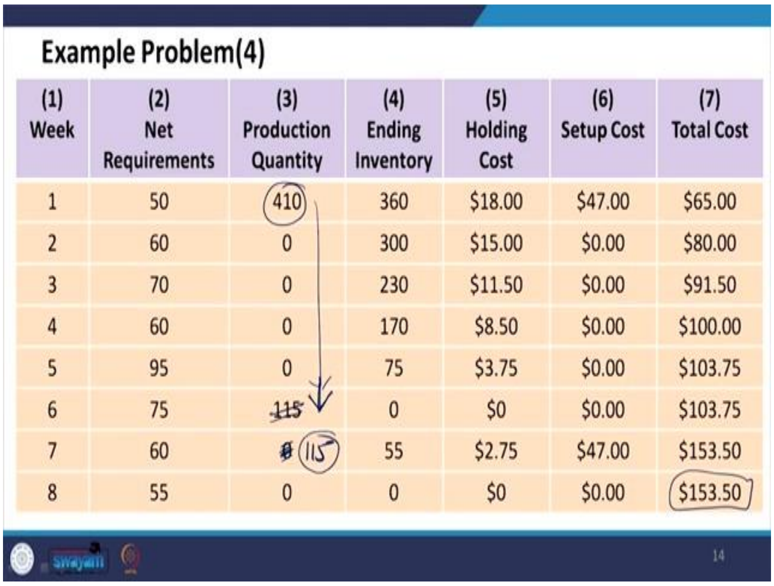


Example Problem(3)

(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	$47.00	$61.25
2	60	0	225	$11.25	$0.00	$72.50
3	70	0	155	$7.75	$0.00	$80.25
4	60	0	95	$4.75	$0.00	$85.00
5	95	0	0	$0.00	$0.00	$85.00
6	75	190	115	$5.75	$47.00	$137.75
7	60	0	55	$2.75	$0.00	$140.50
8	55	0	0	$0.00	$0.00	$140.50

dynamic

12



Example Problem(4)

(1) Week	(2) Net Requirements	(3) Production Quantity	(4) Ending Inventory	(5) Holding Cost	(6) Setup Cost	(7) Total Cost
1	50	410	360	$18.00	$47.00	$65.00
2	60	0	300	$15.00	$0.00	$80.00
3	70	0	230	$11.50	$0.00	$91.50
4	60	0	170	$8.50	$0.00	$100.00
5	95	0	75	$3.75	$0.00	$103.75
6	75	~~115~~	0	$0	$0.00	$103.75
7	60	~~0~~ 115	55	$2.75	$47.00	$153.50
8	55	0	0	$0	$0.00	$153.50

14

Then the 4th case is the case of least unit cost case where your cost is calculated not on the basis of total costs rather on the basis of lowest unit cost. So, it is the same way that from one to 8, you have possibilities of different costs as we did in the third case, the carrying costs are also mentioned here from different cases, 0 to 94.

So, already in the third case we have already discussed and that is how you calculate the total cost. Now, depending upon the total cost, you are calculating the unit cost, so, 47 divided by 50. So, this is let us say I am putting the column numbers 3, 4, 5, 6. So, this 6 is coming by getting 5 divided by so, when we are dividing the values of 5th column by the second column, I am getting this.

Now, you see, here the lowest cost is this 0.2530 and therefore, for remaining 2 periods, I am calculating this and that I am getting this least cost and therefore, for the first time I will order this 410 units and it will go like that and then I will order 450 units and it will go like this and with this my total cost is coming 153 this 115 will come in this 115 will be here because these 410 will be able to fulfill the requirement up to the 6th period. So, this 153 is the total cost coming with the help of this least unit cost which is higher than the total least total cost.

So, now by comparing these 4 different types of systems, I found that least total cost system is more suitable for ordering in this particular example, and therefore, I will go with this type of classification where I will order ones of 335 units then a 190 units and my total cost is coming 140 dollars and here it is coming 153.5 euro dollar which is slightly higher than the least total cost.

And then, we need to see actually in our industry we need to see that which method is more suitable. This is just a part of our entire MRP discussion. Then we need to use this information in our MRP table, when we have to have that planned order release.

So, these values of 410 115 these values are to be used at that particular point in planned order release. So, this is just a kind of input for developing that MRP table which we have already discussed in our previous session. So, with this now, we are able to understand different types of lot sizing decision techniques in MRP tables. We will do 1 or 2 more examples to understand that how the entire MRP is being prepared. With this, we come to end of this session. Thank you very much.