Decision Support System for Managers
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Module – 04
Lecture – 04
Economic Order Quantity (EOQ) (Contd.)

Hello and welcome to "Decision Support Systems for Managers"! We are into module 4, 'decision support systems for materials managers' and we are today in lecture 4. Now, in the previous lecture, we had given you introduction of 'economic order quantity' and we told you the relevance of 'economic order quantity'; what is the relevance?

What we mentioned point number 1 that all over the world there is a tremendous focus on reducing supply chain costs. Point number 2, to reduce supply chain cost we have found out that warehousing comprises of a huge amount of cost for supply chain. So, point number 3, so if somehow we can synchronize by production with the demand, then to a great extent wherever possible if we can synchronize the production with demand then to a great extent we can reduce our warehouse cost; ok.

Then, point number 4, but another item is coming in that we can reduce warehouse cost fine, but then we have to at least we require some space in the warehouse. So, how much space do we require? We have to reduce warehouse space, but how much space do we require. Next point that how much space do we require actually depends on how much quantity is coming in the warehouse every day and how much quantity is going out of the warehouse every day; right.

If the coming in of material and going out of material if these 2 can be synchronized, then at the end of the day there is no material left in the warehouse. So, you do not need that much of space, ok. So, how much material will come in? One is demand definitely. Second is economic order quantity. My demand may be 300, but my, but a huge truck is coming.

So, if I send 500 units in the truck from the factory my I am repeating my end market demand is 300 units per day; end market demand is 300 units per day. But, a huge truck is coming from the factory and that truck can hold 600 units. So, if I am sending 600 units in the truck my per unit transportation cost is coming down as compared to sending

300 units. 300 units is demand. So, ideally if I send in the truck 300 units then at the end of the day there is 0 stock in the warehouse and gone I read that's warehouse space.

But, if I send 600 units my truck is full. So, per unit transportation cost comes down right. So, wherever, but then what is the problem that if I am sending double, so I will require more warehouse space and for that there is a rent. There is a cost associated with storing that product.

So, wherever my transportation cost and the storing cost is offset is cut intersects that is the quantity that should come in my warehouse every time, agreed. So, if I send more products my per unit transportation cost comes down. So, my that is my; that is my ordering cost.

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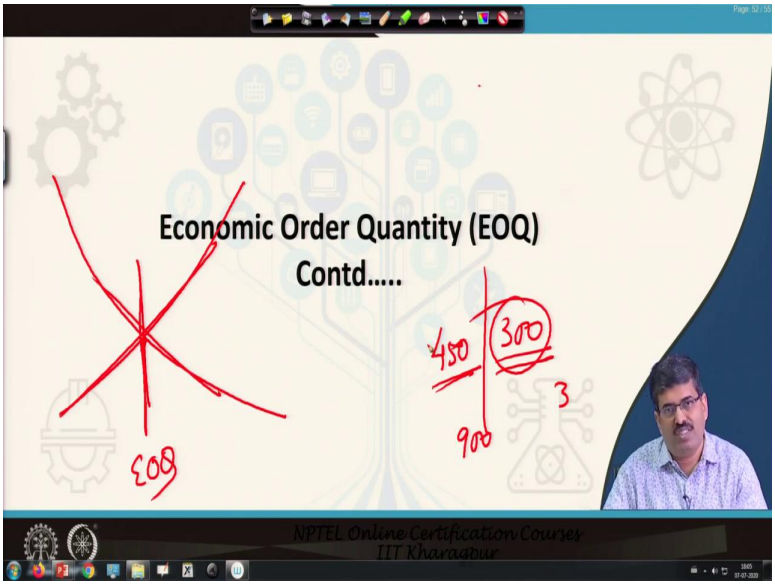

My per unit transportation cost is coming down. If I send 600 units per unit transportation cost is coming down. But, what is happening I have to store this product. So, my storing cost is going up as more and more products are coming in my storing cost is going up, ok. So, the intersection point of this is the win win quantity and that is called as the economical order quantity or economic order quantity in the common term; clear. So, this much I should order right now this.

So, now, you will say, but my demand was 300 units and after calculation my economic order quantity may come in as 450. So, do I store 450 units? My demand is only 300. Do

I store 450 units per day? Answer is yes, because that calculation has come from this only that 450.

So, what will happen? This will come 450 and every after every 2 days you will give a gap of 1 day. There will be no supply from the factory on the third day. Because, after every 2 days what is happening your stock is 900 right, and this stock will get exhausted in 3 days. So, the third day there should be no supply from the production unit, ok. And, that is the way how it operates. Third day there is no supply from the production units.

So, you are storing 150 units extra. Is it more costly? Answer is no because we have already calculated that cost from here that what is the optimal storing versus transporting that much you will have to do and the other extreme point is you will have to synchronize your demand and supply that your supply is 450 units your production quantity. So, your demand should also be 450, then everything is fine. So, this much we have covered right. This much we have covered; right.

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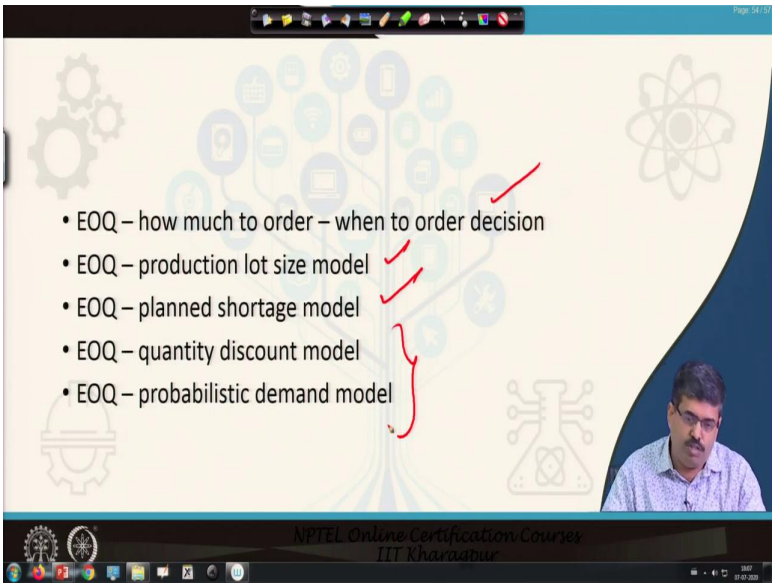

Now, EOQ or Economic Order Quantity has different models; production lot size, planned shortage, quantity discount. You order more we will give you more discount very simple. We buy from shops buy 2 get 1 free what is that discount, right. Same thing from warehouses also you store more, the mother warehouse or the warehouse leasing company they will charge less, ok. You take more space they will charge less per square meter space per square meter of space; ok.

So, these are different models; we will do this one we have already covered. This one we have covered. We will do production lot size and we will do planned shortage. Other 2 books provide enough material we have given you the references, so you go through them and you should be able to continue and solve them; ok.

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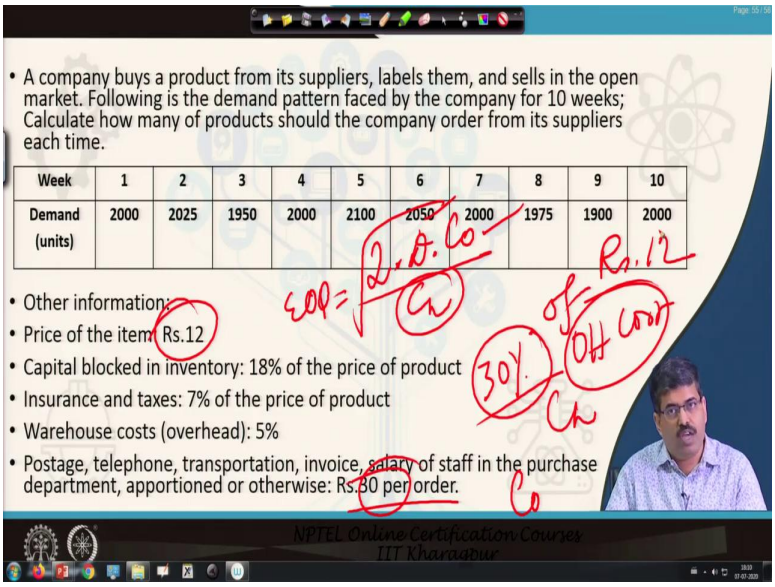

Let us take this problem. A company buys a product from its suppliers, labels them and sells in the open market, ok. Company buys a product from its suppliers, labels them and sells in the open market.

Following is the demand pattern faced by the company for 10 weeks; calculate how many products should the company order from its suppliers every time? Same thing in the previous problem we said by demand pattern is 300 per day. So, what is the demand in 1 week? 300 into 7 2,100; ok.

Here, instead of that we have given the week wise demand just add them up just add them. So, these are the demands. Question is how many products should the company order from its supplier each time? In the previous model, what was how much was the ordering? 450. Now, here we have to calculate how much you should order. What is the other information? Price of the item is 12 rupees, capital blocked in inventory is 18 percent, insurance and taxes 7 percent, warehousing cost 5 percent.

If you notice all these are what? All these are your stock holding cost or storing cost. If you do not store your money is not blocked it is sold. Immediately, you sell it your money is not blocked say 18 percent. Insurance and taxes there is a warehouse tax. Do not store no tax say 18 plus 7, 25 percent and warehousing cost overhead 5 percent. So, basically if you see 30 percent is your 30 percent is your overhead cost or cost of holding ok. 30 percent is your cost of holding; ok.

Now postage, telephone, transportation, invoice, salary staff, etcetera, etcetera rupees 30 per order. This is your cost of ordering; cost of ordering. So, see we have got everything to calculate EOQ right. You got na. What was my formula? EOQ is equal to I am using the formula that was there 2 annual demand or consumption into ordering cost by cost of holding. What is the annual demand?

Add up all the demands that is your annual demand. So, D, what is your ordering cost? Rupees 30. What is your holding cost? We just now calculated 30 percent of rupees 12, ok. You have everything. So, now, you can calculate the economic order quantity, ok. I am just stopping here for a second to enable you to look at the screen and understand or you may pause your screen also and understand, so that we can move on; right; ok.

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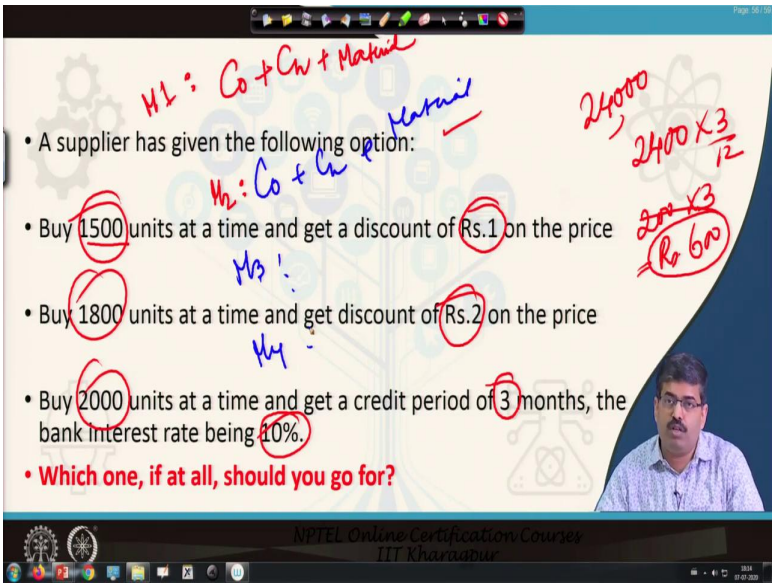

Now, let us change it. So, this was your economic order quantity you get something. Now, the question is a supplier is given the following options. Buy 1,500 units at a time and get a discount of rupees 1 on the price. What was the price? Rupees 12. Now, he is

saying you take at rupees 11, but you buy more. You buy 1,800 you take you get at rupees 10, 2 rupees discount buy 2,000 you get a credit period of 3 months and the bank interest rate being 10 percent.

So, 12 rupees into 2,000 units 24,000 rupees. Bank interest rate is 10 percent. So, how much? 2,400 into 3 by 12, rupees 600 is the discount clear. So, you given these 3 options and you choose which one is more beneficial. So, first one you have calculated the EOQ as given in the previous problem just the previous slide, you calculated something na. We gave you the formula you just need to put in the numbers take a calculator and calculate. You got some EOQ. From that EOQ what will you do? Let us see whether we have any blank slide here; no; yeah.

From that EOQ what will you calculate? Annual ordering cost, annual holding cost; go back to the previous slides that we mentioned plus the material cost. This was my model 1. Model 2 no EOQ now. Your EOQ now becomes what? 1,500 because you have to buy this to get discount, with 1,500 how many orders per year because, your annual consumption is something right. Your annual consumption is how much? Annual demand you have to add; ok.

So, with that you get the number of orders. Total demand divided by 1,500 every time number of orders you get. Number of orders multiplied by ordering cost, what was the ordering cost 30 rupees. So, that then you get the annual ordering cost now. You get the annual ordering cost, ok. Again you can get holding cost and again you can get material cost which is now 1 rupee less.

Similarly, for model 3 and model 4, and you see which one is less that is your model, you are saving cost for your organization. Do you have to take warehouse space again, that cost? No, because you have taken holding cost. Holding cost includes your warehouse rent everything. So, this is the comparison model.

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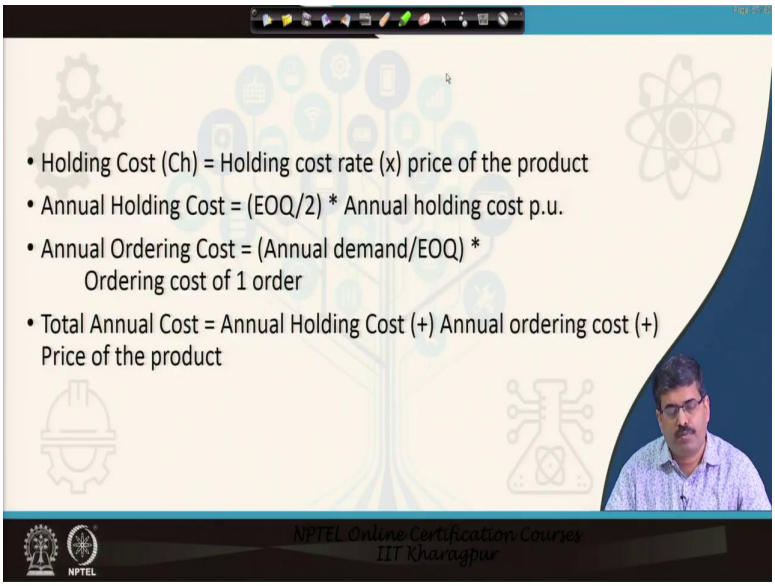

Just whatever I have mentioned is given in this slide, ok.

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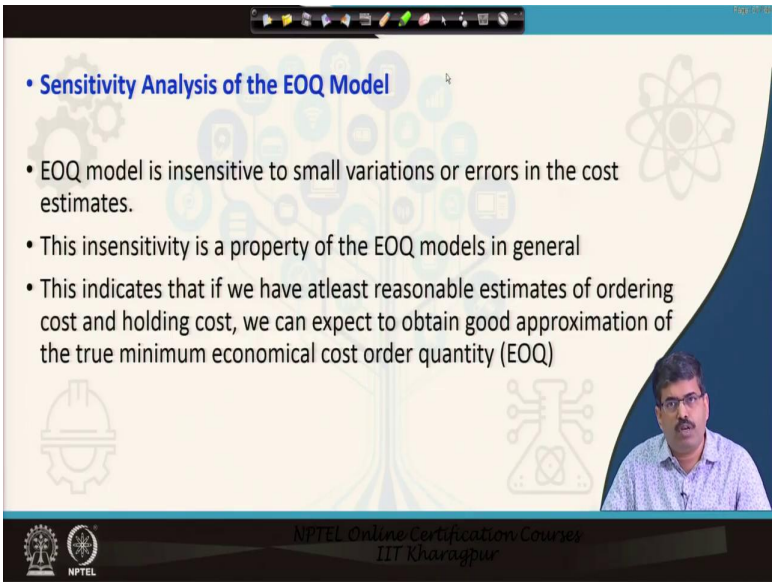

Sensitivity analysis of the EOQ model. EOQ model just remember this EOQ model is insensitive to small variations or error in cost estimate. This insensitivity is a property of the EOQ models in general. This indicates that if we have at least reasonable estimates of ordering cost and holding cost we can expect to obtain good approximation of the true minimum economic cost order quantity; ok.

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Now, the second variant is production lot size model.

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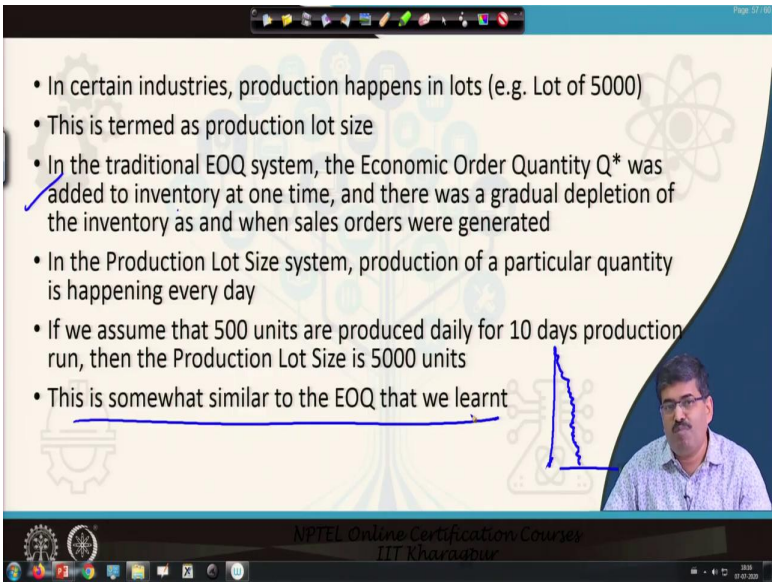

In certain industries, production happens in lots example lots of 5,000. This is termed as production lot size system, ok. In traditional EOQ system, the EOQ was calculated EOQ was, sorry in the traditional EOQ system the EOQ was added to inventory at one time and there was a gradual depletion of the inventory here. EOQ was added to inventory at one time and there was a gradual depletion of inventory as and when sales orders were generated.

In the production lot size system, production of a particular quantity is happening every day. If we assume that 500 units are produced daily for 10 days production run, then the production lot size is 5,000 units.

This is somewhat similar to the EOQ that we learnt, ok. So, we cannot as such order an economic quantity we have to take 5,000 units just the previous example. 10 days production will happen then this becomes a lot and it goes. Remember, medicine if you see medicine batch number is given that is a batch something similar; right.

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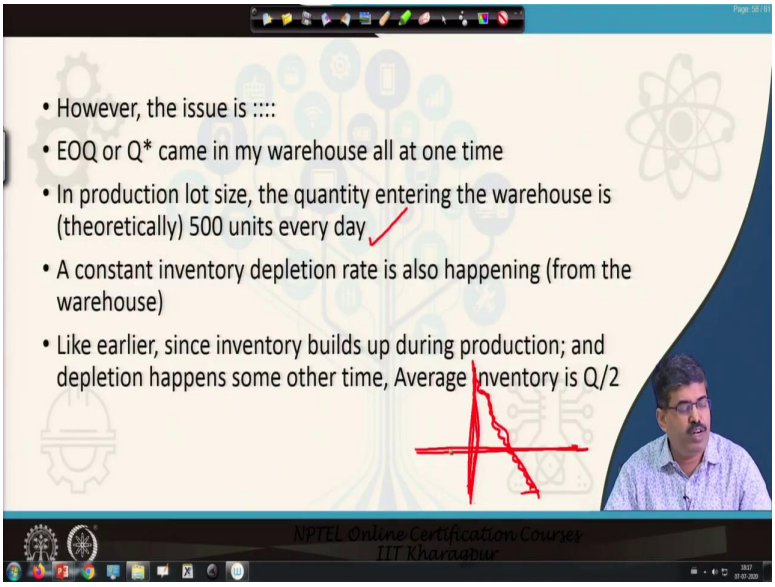

However, the issue is EOQ or Q star came in my warehouse all at one time. In production lot size, the quantity entering the warehouse is theoretically 500 units every day. A constant inventory depletion rate is also happening. So, 500 units are coming in, stock is increasing, 500 units coming in, your stock is increasing and this is your stock and your stock is also going out selling.

So, in production lot size everyday 500 units are coming in it will come in for 10 days. So, constant inventory depletion is also happening inventory is going away. Like earlier, since inventory builds up during production and depletion happens some other time average inventory is again EOQ by 2 or Q by 2, right. Maximum 0 divide by 2 average.

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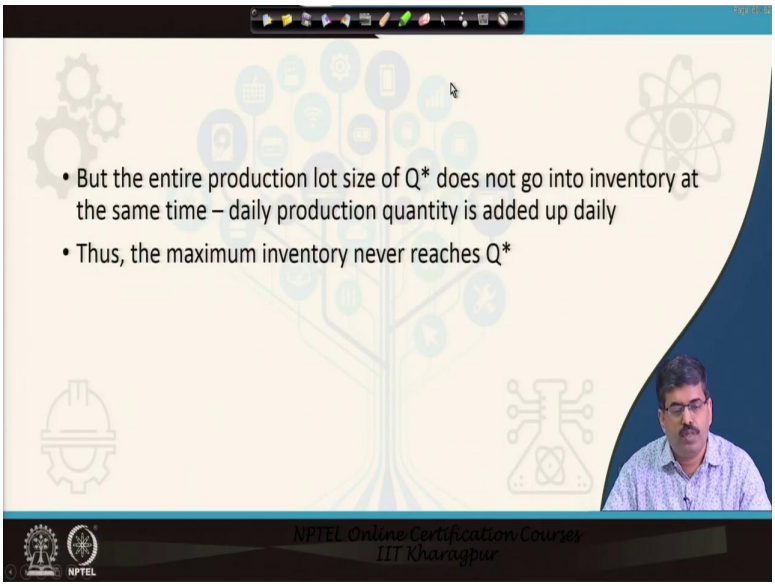

But, the entire production lot size does not going for inventor at the same time. Daily production quantity is added up daily, thus the maximum inventory never reaches 5,000 units never reaches the EOQ quantity, ok. Never reaches production maximum quantity 5,000 as we mentioned 5,000 will come in 10 days, so it will never reach on this thing; ok.

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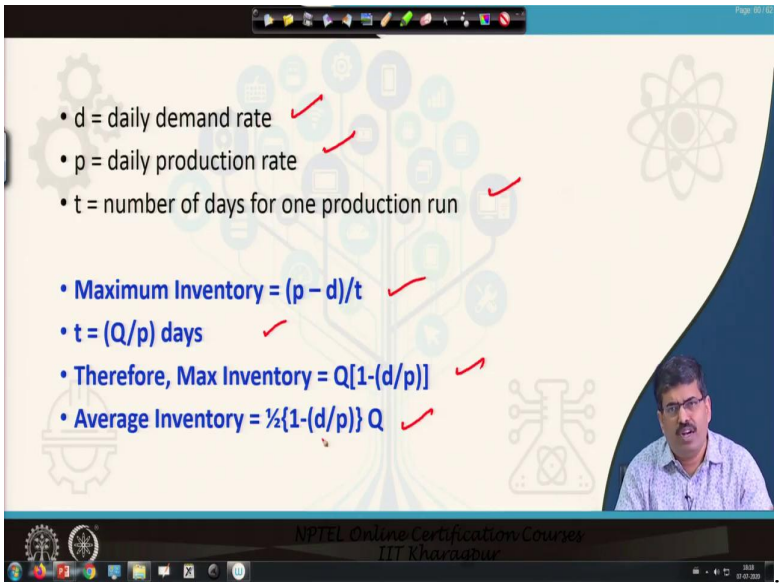

So, this is the formula. This is the formula just go through the formulas. The, these are already given to you. The daily demand d is daily demand, p is daily production, t is

number of days of one production run in the example 500 units per day 10 days 5,000 units. So, t was 10 days, ok. Maximum inventory p minus d by t, t is equal to q by p maximum inventory is this average inventory is half of this, ok. Nothing rocket science just simple formulas.

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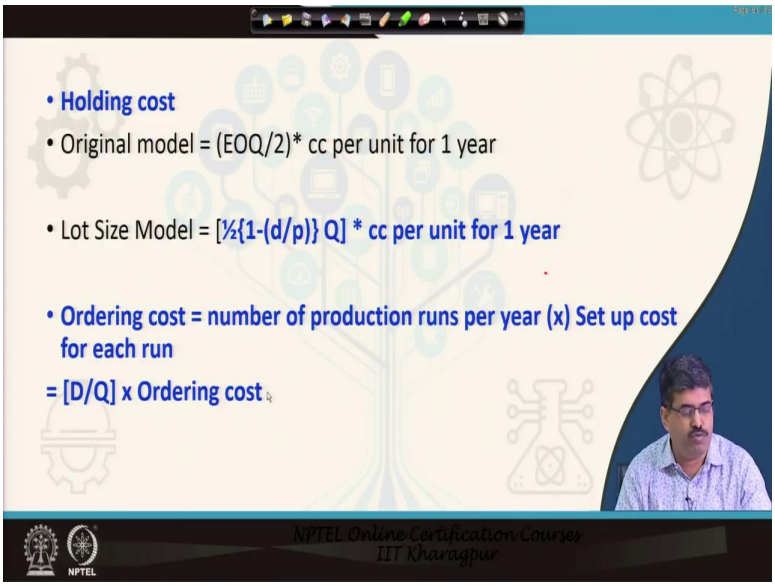

Holding cost; in a original model was EOQ by 2 into carrying cost or holding cost per unit for 1 year in this lot size model this is the formula. Ordering cost number of production runs per year into setup cost for each run.

There is a setup cost; ok. Set up cost means after the machine stops it again if it is run it takes some time some amount of machine maintenance, running etcetera before it can actually start production. So, that is called as setup cost, and that formula is also given to you; right.

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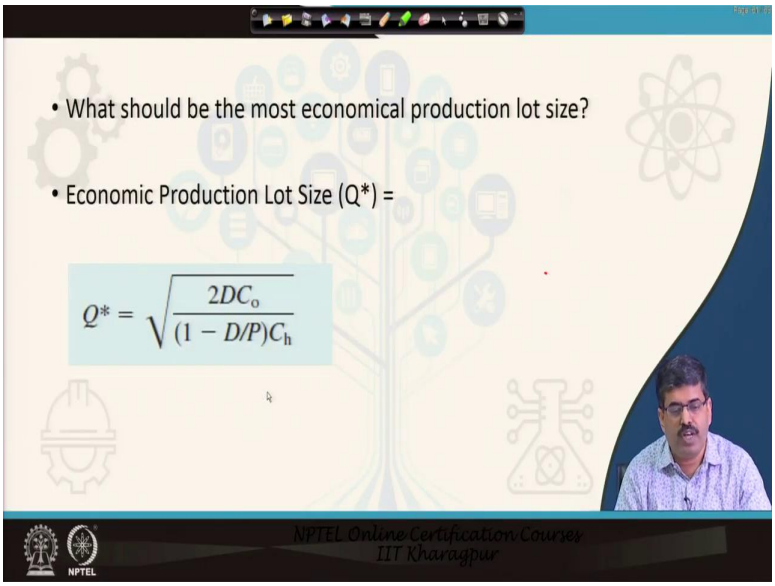

And, this is the formula for economic production lot size model, ok. Whatever is there in the previous slide this formula reflects that only; ok.

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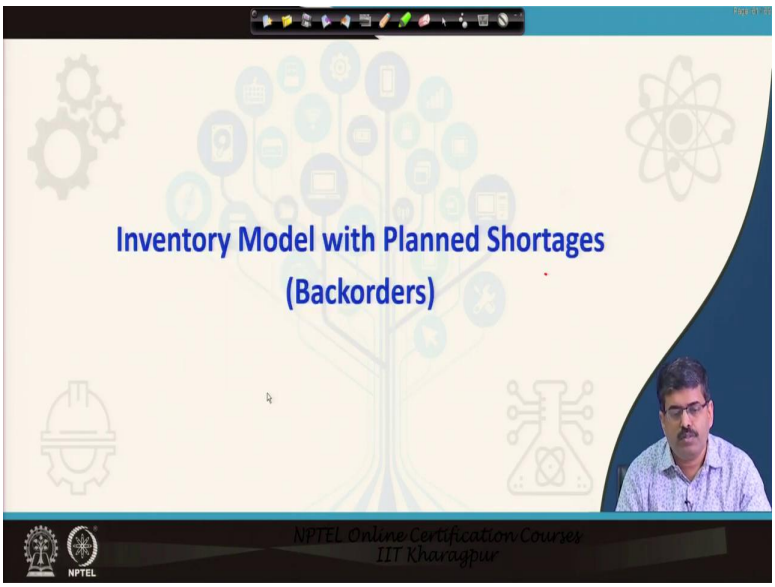

Now, we will take a very-very interesting EOQ model that is a backorder model; ok.

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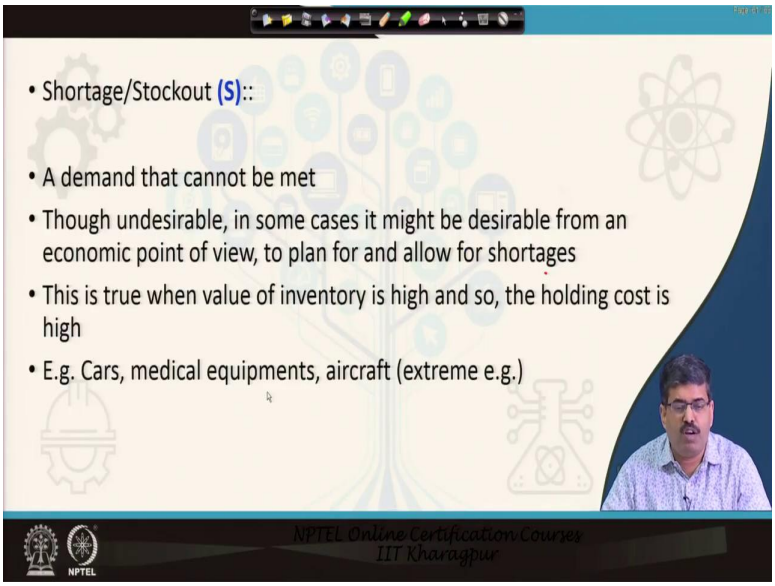

What is a backorder model? Now, for certain products there will be stock out there is a shortage a demand that cannot be met. Though undesirable, in some cases it might be desirable from an economic point of view to plan for and allow for shortages. This is true when value of inventory is high. Car, medical equipment, aircraft is an extreme example. For example, cars.

If a company in their showroom has sent red colour blue colour green colour cars fine, but there is no demand for these colours, or a company has sent a particular model lot of cars but it is not selling.

So, it is always better to have some shortage in inventory. Let the demand come let us take some time we will send it to the customer, ok. This is called as a planned shortage or a planned stock out; ok. Because then otherwise products just is not sellable and it builds up. There is no use of it; right; ok.

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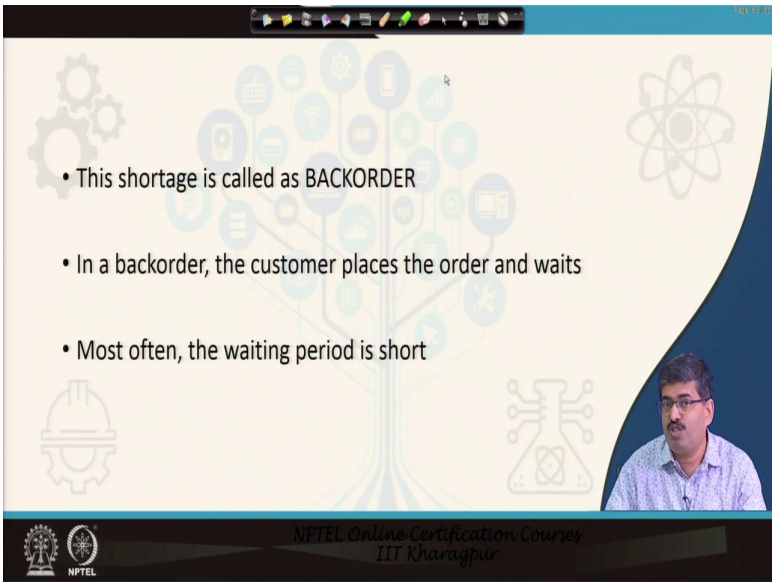

This shortage is called as backorder. In a backorder, the customer places the order and waits. Most often the waiting period is short; ok.

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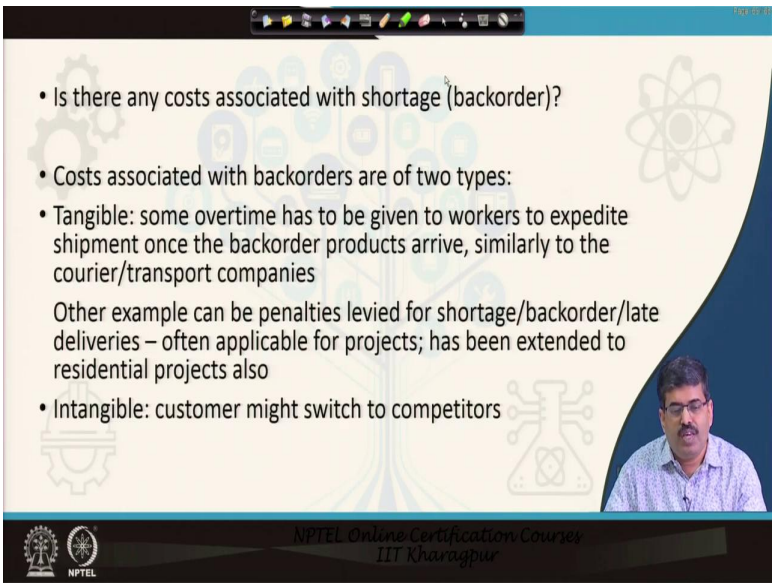

Is there any cost associated with backorder? Cost associated with backorders are 2 types. Tangible some overtime has to be given to workers to expedite the shipment once the backorder products arrive. Similarly, to the transport companies. Other examples can be penalties levied for shortage late delivery is often applicable for project has been extended to residential projects also; that means, if they are delayed you pay a fine.

Intangible customers might switch to competitors if you are if you do not have a product; ok.

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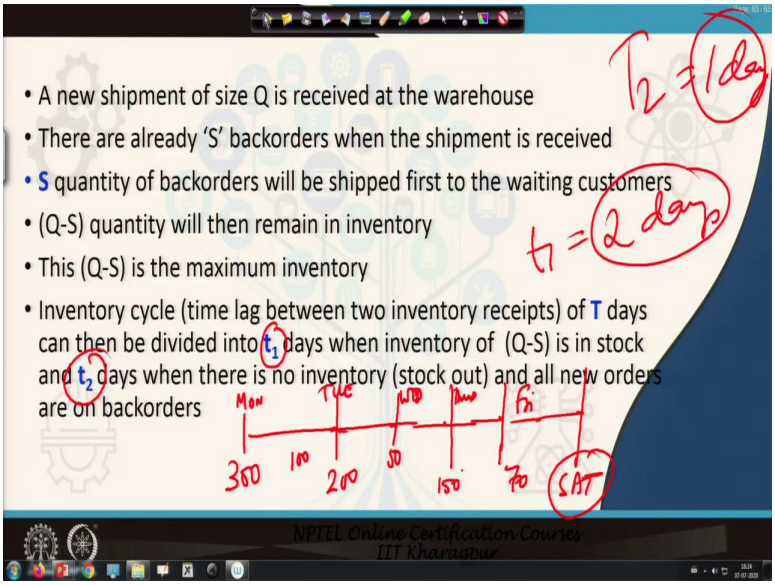

Now, let us take an example. A new shipment of size Q is received at the warehouse there are already S backorders when the shipment is received. So, product comes in 2 trucks have come in with products. So, what will happen when the demand comes these material will go to the wholesalers, but there is already backorder. The entire material cannot go to the dealers. A portion of it will go to people who have already ordered.

So, first their orders will be met, and then there will be stock, then it can go to the wholesalers, distributors, dealers, right. So, S quantity of backorders will be shipped first to the weighting customers and Q minus S will then remain in inventory very simple. Q quantity has come. S will immediately go away previous order. So, Q minus S will remain in my stock. This Q minus S is now my maximum inventory; right.

Inventory cycle time lag between 2 inventory receipts time lag between receipt of 2 inventories. I have received inventory, received supply on Monday and next supply on Wednesday. So, what is the time gap 2 days of T days can then be divided into t 1 days when the inventory is in stock and t 2 days when there is no inventory stock out, and all new orders are on backorders.

Let me explain this point, this t 1, ok. What is this? That 300 units have come in today. Today is Monday, ok. 100 units was backorder. So, immediately 100 units have gone. So, what is my stock? 200.

This is Tuesday. Tuesday we have given away all the backorders. So, how much is remaining 200 units. Wednesday 50 units order has come. Thursday 150 units orders have come. So, they have gone. So, I had a stock of 200 units, 50 has gone then again 150 has gone. So, all my stock is gone zero now.

On Friday another order for 70 units come. Can I supply this? No. So, this one now goes into backorder. So, t 1 is when the days when the inventory is in stock. So, what is t 1? Tuesday to Wednesday, Wednesday to Thursday 2 days. So, my t 1 was 2 days, t 2 when there is no inventory t 2 is how many days? After Thursday, Friday the order has come right and the next supply next supply is on Saturday.

Saturday this order can be met right. So, one day there is no inventory order has come, but there is no stock. So, t 2 is equal to 1 day. Is it clear now? So, total time periods, so 300 units have come on Monday. Next order will come on Saturday. So, total time period is divided into t 1 when the product will remain in stock and t 2 when orders are coming in, but product is not in stock.

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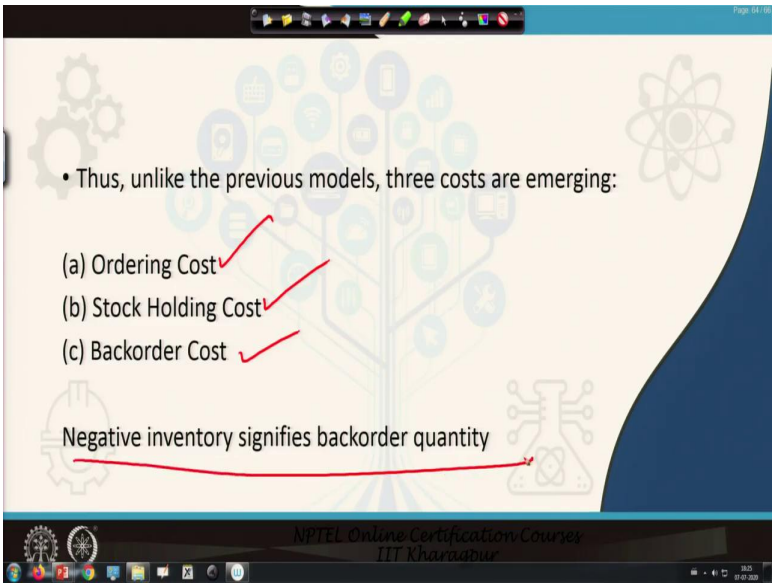

Thus, unlike the previous models 3 costs are emerging; one is your ordering cost, definitely holding cost and a backorder cost. And, negative inventory signifies the backorder quantity; ok.

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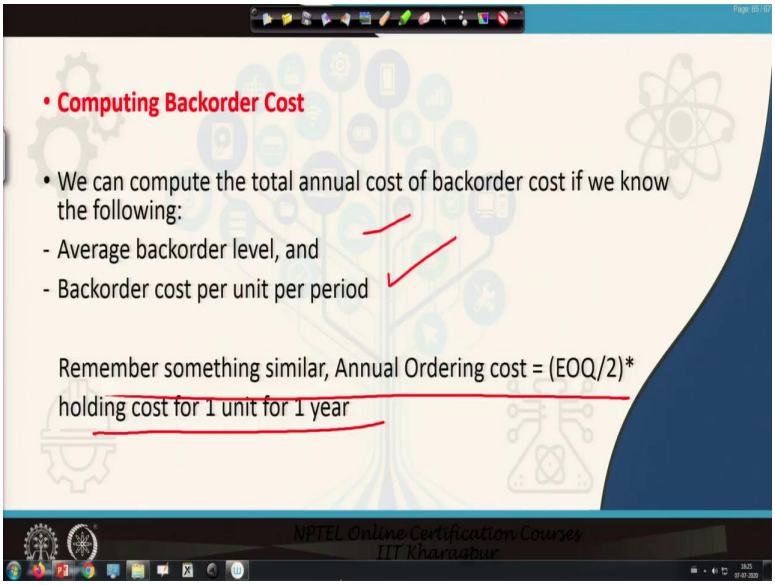

How do we compute backorder cost? We can compute the total annual cost of backorder if we know the following. Average backorder level, average backorder level, backorder cost per unit per period. Remember something similar, annual ordering cost was EOQ by 2 holding cost of 1 unit for 1 year, ok. No rocket science. Let us try to understand it very simply we will understand.

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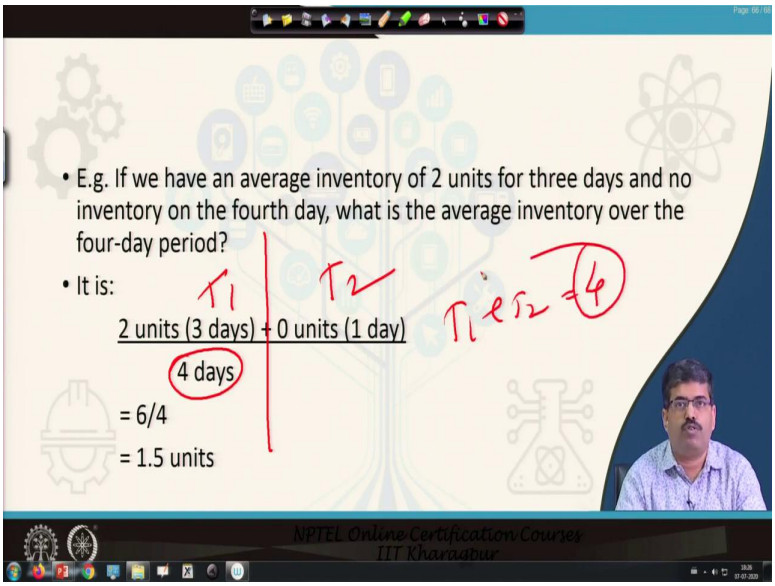

If we have an average inventory of 2 units for 3 days and no inventory on the fourth day just we did it previously, what is the average inventory over the 4 day period? 2 units multiplied by 3 days 6, 0 unit into 1 day 0 divided by 4 days 3 plus 1. So, 6 units divided by 4 is 1.5 units. This is my average inventory.

So, average inventory actually as we mentioned is broken up into days when inventor is in stock, and days this is my t 1 and days when inventory is not in stock, but order is there and total number of days 4 t 1 plus t 2 is equal to 4 right, ok. This is my formula here; ok.

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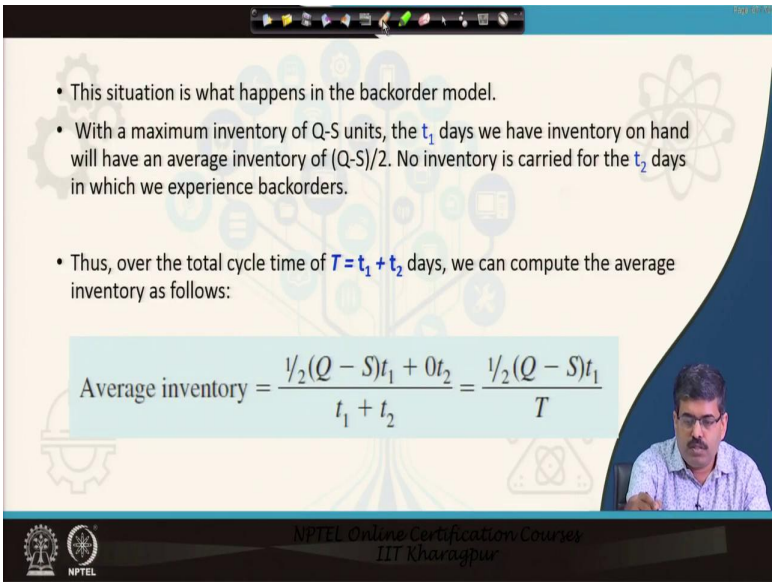

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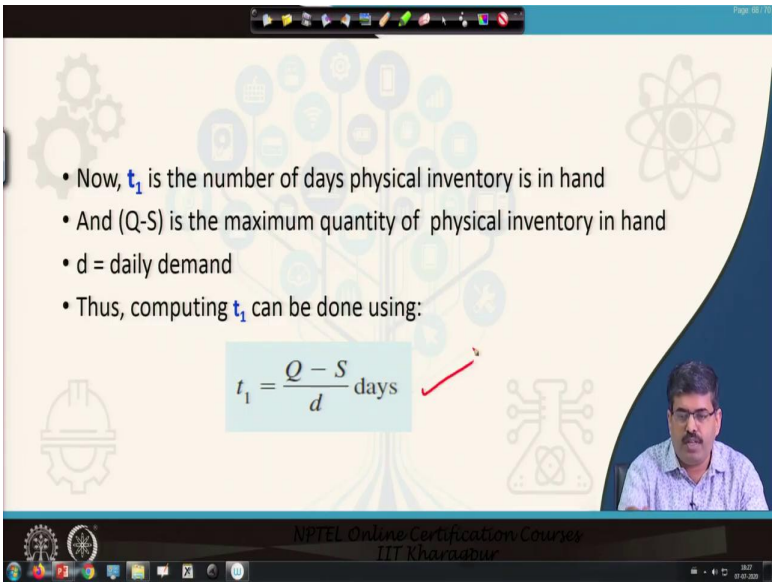

t1 again; we have given a formula here; Q minus S.

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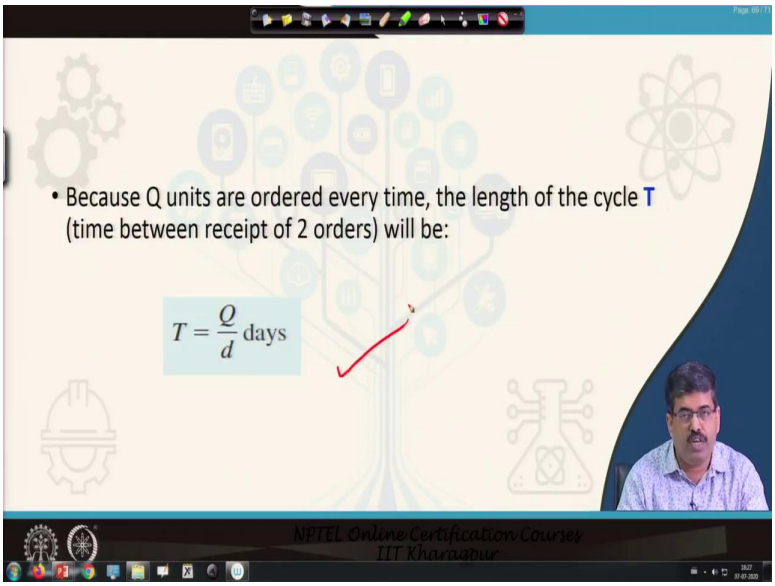

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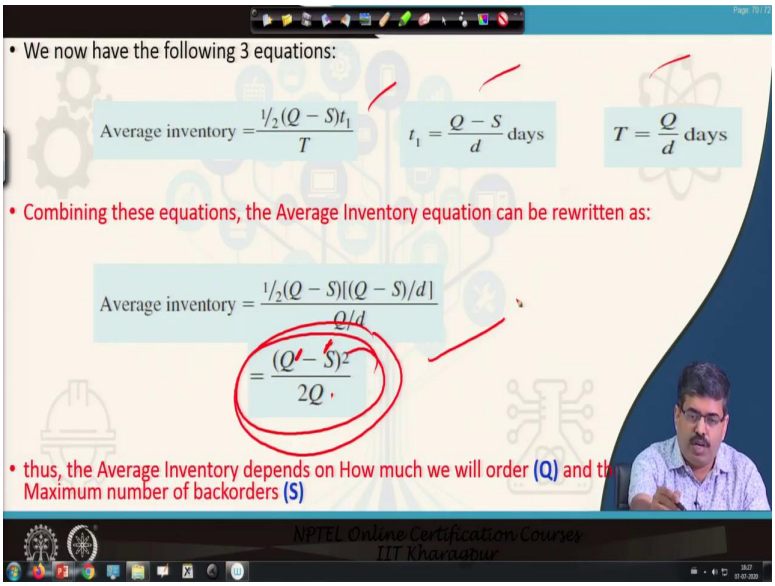

Total T we have again given a formula here. Q by d, and now we have the following 3 equations that are given on top 1, 2 and 3. Combining these equations this is the formula for average inventory.

Thus, average inventory depends on how much we will order Q and the maximum number of backorders S how much we will order Q and the maximum number of backorders S, nothing else. This is just the derivation of the formula. You only this is the formula that is required for computation average inventory; right; ok.

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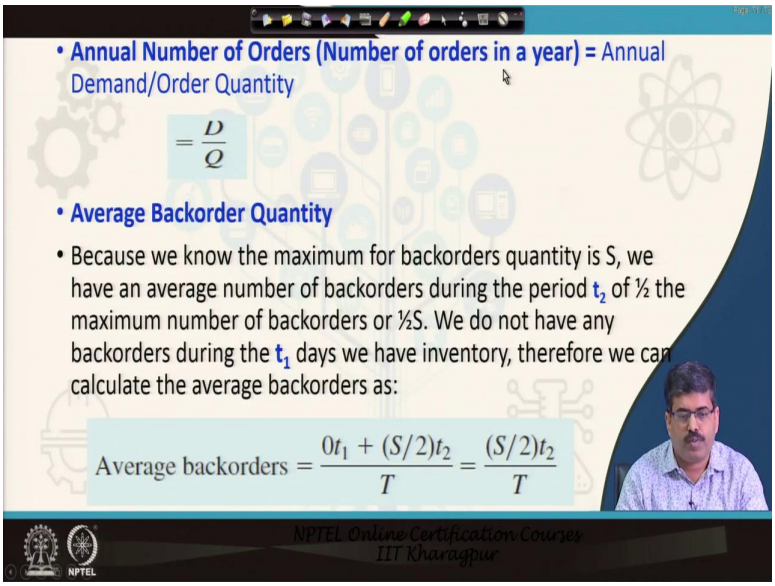

Annual number of orders D by Q, average backorder quantity is S by 2 multiplied by t 2 whole divided by total time period; ok.

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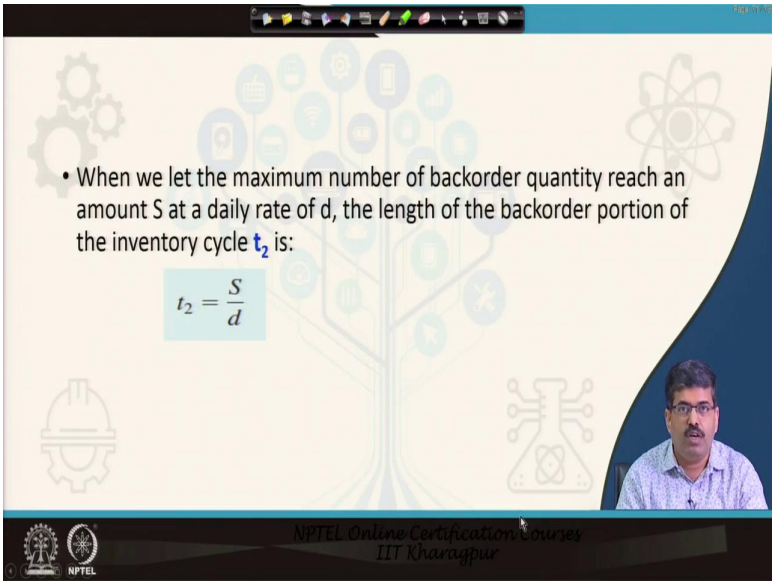

And, when we let the maximum number of backward that is going to reach an amount S the t 2 formula becomes this.

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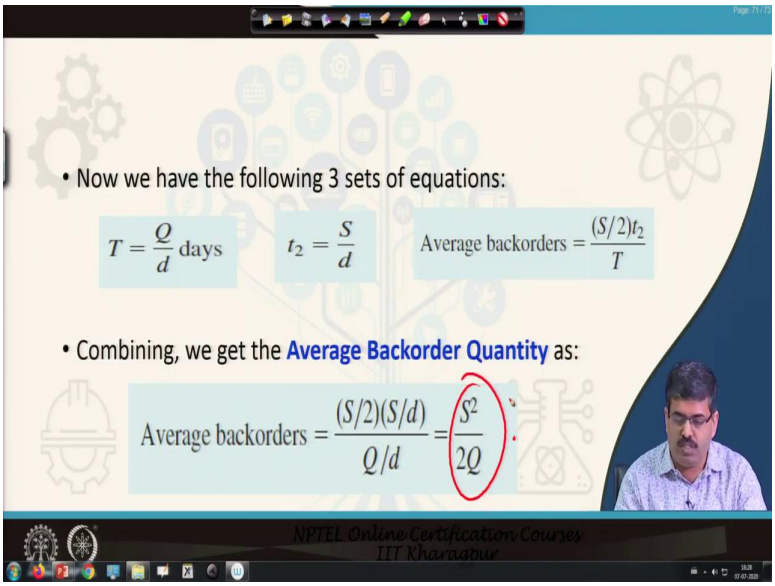

So, we have again combining we get average backorder quantity as S square by 2 Q.

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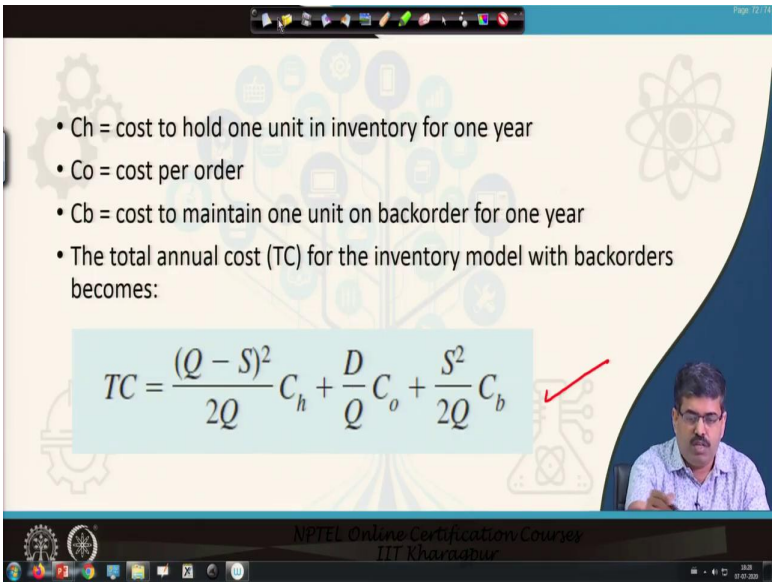

We require only this much. Those were the derivations, ok. So, this is my total cost, we just keep on combining the formulas. You just need to know these formulas ok, and ok, this is the total cost formula.

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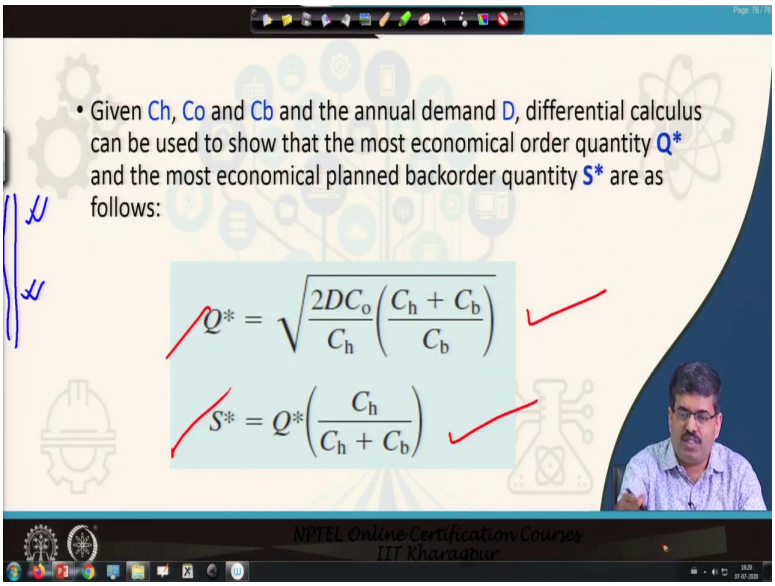

So, this all combined. This is the economic order quantity for a backorder model. This is the economic order quantity for the backorder model and the backorder quantity is this. This is the economic order quantity and this is the backorder quantity. Once you know this, once you get these numbers, then you find out whether the customers are willing to wait whether you will want to replenish this backorder by regular supply or do you want to continue with this model; clear!

So, you need once you have these 2 numbers then only you can take a decision, whether to continue with this existing model of backorder or whether you continue with a normal production schedule.

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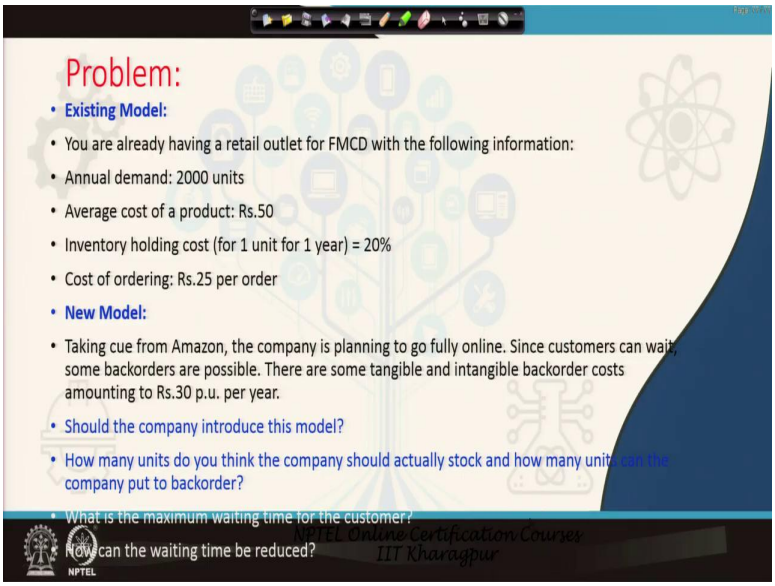

So, there is a problem that is there. Again you try to solve it. Given all the formulas you should be able to solve it. Should not have any problems; ok.

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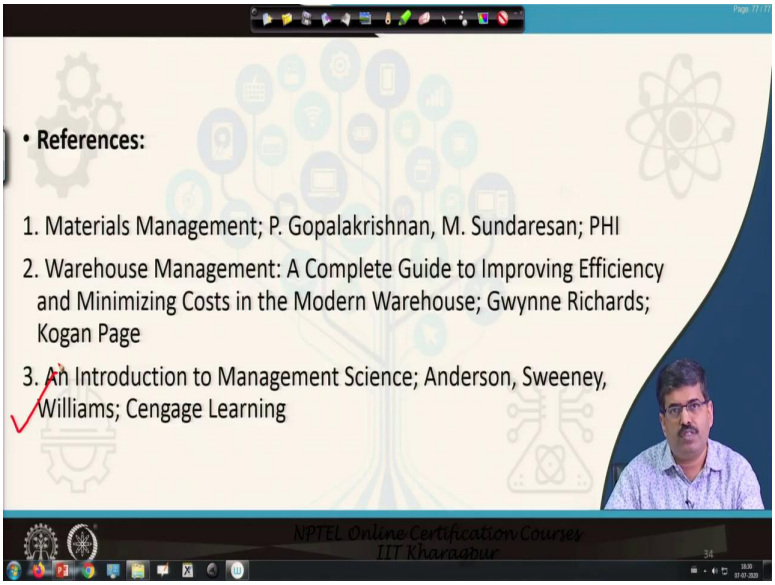

So, these are the references and extensively as I have mentioned already, you can use this reference so.

Thank you!