Decision Support System for Managers
Prof. Anupam Ghosh
Vinod Gupta School of Management
Indian Institute of Technology, Kharagpur

Module – 04
Lecture – 18
Estimation of Space Requirement in a Warehouse and Concept of Economic Order Quantity (EOQ)

Hello and welcome to "Decision Support Systems for Managers"! We are into module 4 and the 3rd lecture. In the 1st lecture, we have given you warehouse location models, factor rating model; and the factor rating model, and the break even model.

In the 2nd lecture, we have given you a brief about centre of gravity model and the Ardalan heuristics model. And, we gave you a problem on the total cost model, we did not solve it, we said you try to solve it. In case you are not able to solve it, we will come across similar problem in the product mix module which we will come a bit later ok. So, there you will find application; ok. Still, if you are not able to solve, in the last module I will solve this problem for you; right.

Today, then now that, so the first; so look at it. So, what were the issues in front of the materials manager? The first issue was where to locate the warehouse; ok. The next issue that comes in is very-very important that is what is the space that I will rent for warehouse, or if I am building a warehouse, how much area should be there for building for the warehouse; so, that means, basically it boils down to how much space do I need for the warehouse.

Most organization now, do not build warehouses. There are specialized warehousing companies, they build giant warehouses and the smaller companies rent space within that warehouse; ok.

So, there are two issues; first issue is for the warehousing agency; how big a warehouse should I have? And for the smaller companies, next issue is how much space do I rent within that warehouse. And in the as in as I told in the previous module, that as of today if you are looking at warehousing rent within the city if you are trying; for Kolkata, it is about rupees 25 per square feet per month.

Sorry; sorry; Kolkata [FL], Kolkata is rupees 35 per square feet per month. And if you are going on the outskirts of the city; if you are on the highway, highway leading to Kolkata going Kolkata, the hubs basically, there it is about rupees 25-26 per square feet per month.

So now imagine, if you are having a 1,00,000 square feet of area, how much rent can you fetch for the warehouse. And if your organization is renting 10,000 square feet of area, then again you are if you are on the highway you are paying rupees 2,50,000 rupees per month, just for storing material.

So, now you understand why there is tremendous pressure on the materials manager and the warehouse manager to keep on reducing warehouse space clear. So, our topic today is, how do you estimate, how much space you require in a warehouse ok. Again, these are parts of semi structured problems; ok. How do you estimate, how much space you require in a warehouse. So let us proceed; ok.

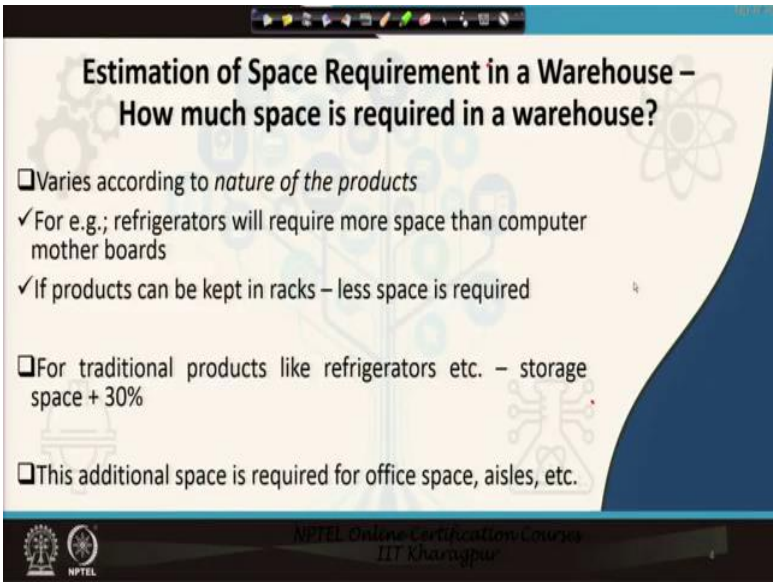
Now, see estimation of space requirement; how much space is required in a warehouse it varies according to nature of the product ok. Let us take an example, first point as I mentioned it varies according to nature of the product. .

Let us take an example; refrigerator, we all have refrigerators in our homes. Have you ever seen, in the local shop also which is selling television and refrigerator and other electronic items, have we ever seen one refrigerator stacked over another? You will never see; ok.

But television; modern day the LED TV's and the LCD TV's and the smart TV's, they are put in the horizontal form and they are stacked one over the other. But have you seen refrigerators being stacked? Answer is no. But have you seen mixer grinders getting stacked one over the other? Answer is yes but only up to a certain height.

So, if you are having a warehouse for refrigerators they cannot be stacked one over the other, so you will require huge space, but if you are having a warehouse for mixer grinder or television or some other products which can be stacked one over the other, there it will require lesser space in comparison to refrigerator. So, that was our first point, it varies according to the nature of the product.

(Refer Slide Time: 05:18)

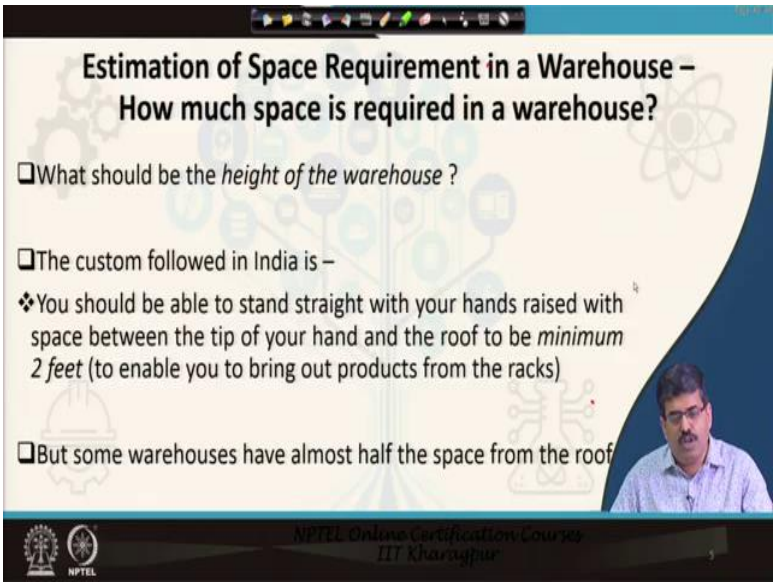


Another thing you see, some products can be kept in the racks. That is the second tick mark point on your slide. Some products can be kept in the racks ok. If it is if it is kept in the racks or if you are able to keep the products in the racks then we are at a great advantage.

You imagine, just think about the locals shop near your house; which is selling soaps, shampoos, rice, dal, tomato ketchup, bread; everything. That person has racks and the side walls, and he is also keeping rice and sugar on the floor. And there he is keeping one sack over another; a sack of rice and then on that on top of that another sack of rice ok. So, wherever you can have racks, you require lesser space, because you can keep on storing to certain height right. So, products are kept in racks, less space is required.

Now, for traditional products like refrigerator the rule is; whatever the area that is taken by keeping the refrigerator only, another 30 percent of that area will be required. Why? Because workers need to move they need to bring out the refrigerators, they need to put them in trucks. So 30 percent of that area will be required, but this is a normal rule of thumb, sometimes it works, sometimes there are other dimensions which we will see later on; clear!

(Refer Slide Time: 07:01)



What, next question what should be the height of the warehouse? Now the custom followed in India is, you should be able to stand and raise your hands like this, why? Because there will be something on top which you need to pull, which you need to pull back on your shoulders and bring it down, the manual worker who is doing it.

So, the height is human height plus the hand height plus a gap between your hand and the roof, otherwise your hand will be hit, your hand you will be injured. So, you should be able to stand straight with your hands raised with space between the tip of your hand and the roof to be minimum 2 feet, to enable you to bring out the products from the racks.

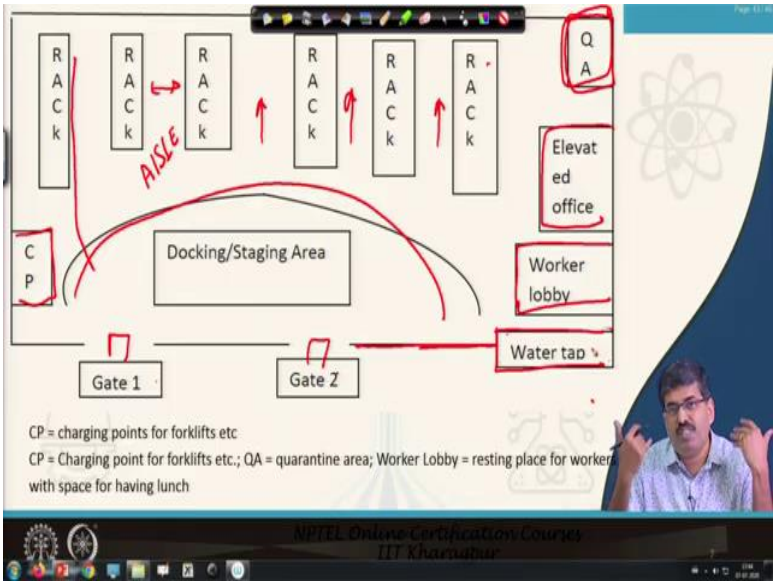
But you know, some issues, some warehouses have just 1 feet gap between the hand raised and the roof. There are issues with that, reasons for that, etc. So this is the custom followed in India. .

So, it is a minimum, minimum height that you can have ok. But if you go into a warehouse, or even if you see pictures you will see warehouse if you are standing, it is at least the height is at least 5- 6 stories, sometimes 10 stories, also that is the height. So, rack; rack; and rack, rack after rack; ok.

(Refer Slide Time: 08:33)

Now, let us see, how tip; how a warehouse looks like ok. A typical warehouse layout diagram; ok. This is a typical warehouse layout diagram; ok.

(Refer Slide Time: 08:41)



What does it say? It says that, so what is happening here? You see this is a this is a typical warehouse layout diagram; ok.

Now, what is happening? Let us let us see, this is gate 1, gate 2 and we have taken 2 gates. A typical warehouse will have 10-15 gates, of which, in normal times you will see

only 4 or 5 gates are open. When the warehouse is in full swing operations, then maybe more gates will be open.

Why more gates are not open? Because the more number of gates you have, more number of employees you need to keep to man those gates, otherwise there will be theft, etc; ok. Not only theft, sometimes heavy rain, so the rain can enter also and they can damage the goods. So in most cases, whichever gates are not required, the shutters are down.

Now, so we have just drawn 2 gates. What happens? This is the gate at which the trucks will stand ok, this is the gate at which the trucks will stand ok. Now, when a truck enters, it faces the warehouse backwards ok, it faces the warehouse backwards; that means, its face is not facing the warehouse gate, but it is opposite. .

So, what happens? The truck goes backward and the back dala is opened. The back door of the truck is open, the side doors are not opened normally ok. Why? Because if you open the side doors back door is also open. So, there is chance of some pilferage happening. So only the back doors are opened. So, these back doors basically enter the warehouse gate, and the workers take out the products and dump them down on the floor. This dumping is done in this area which is called as the docking area or staging area.

These are terms that are used in US and we have borrowed these terms because all over the world similar terminology is used for these operations. So, it is put in docking and the staging area.

So, they are dumped, once they are dumped somebody is noting them down, with a scanner or something pen, paper, whatever. Just a physical count as to whether everything has come in properly. Is there any item missing. Nowadays with barcode scanners and all the time taken here is reduced to a great extent, otherwise you note it down it takes lot of time.

Now, once they are down, some workers are there, some machines are there who are carrying these products to the racks. These are the racks, R A C K R A C K racks ok. And these are the, what we call as aisle. That is the gap between two set of racks. This is the; this is; this; these are the gaps through which; these are the aisles through which the forklifts will go pick up a product and come back; ok. So, these are the racks; right.

Now, what happens? So, this now what is this CP? Now, this forklifts are battery operated. They are not electric operated because there is high risk of getting a short circuit etcetera. So, this forklifts; once the days' work is over, they are the battery, is put to charge. The CP is basically the charging point. They are normally at one end, separated segregated.

So even if there is a problem with electricity short circuit or anything, lot of care is taken that that problem does not spill over to the area where the goods are stored. So they are a bit. So, charging points are a bit in a separate area.

The same is with the quarantine area. Now, this word quarantine, unfortunately enough, now even a child knows what the meaning of the word quarantine is; why? Because of Covid 19; that is basically plaguing the word. It has taken the world by storm plaguing the world, an entire world, entire world order, industry, economy, transport, people, movement, education, everything is in a bit of a ruffle. Everything is a ruffle, since the end of March. This is in March 2020, since the end of March, this is in a big ruffle.

So, this quarantine area this QA quarant then the word quarantine even a kid now knows the meaning of quarantine, which till 1 year back the kid was not aware of; ok; what is? So, what is QA; quarantine area? Sometimes what happens is, certain products are inflammable.

Suppose, the warehouse is storing some lubricants some lubricants for automobile industry. And suppose there is a leakage in the drums that are storing those lubricants. So there might be some hazards ok. So, these any such product which is inflammable and there is a damage they will be taken to this quarantine area and kept there. And that area will be a caged area, so that nobody can enter, and the lock it will be locked and the lock keys will be with the warehouse manager of the materials manager; ok. That is a quarantine area; ok.

Not only that, quarantine area also means certain products they are there whose expiry date who the expiry date has gone; means. So to prevent the pilferage, when the people can take it away and sell it though the expiry date has gone. So, to prevent any such thing to happen they are put in the quarantine area and again they are locked and the key is taken away.

So quarantine area not only is for inflammable goods, quarantine area is also for these types of products which whose expiry has gone, lapsed; this products have lapsed.

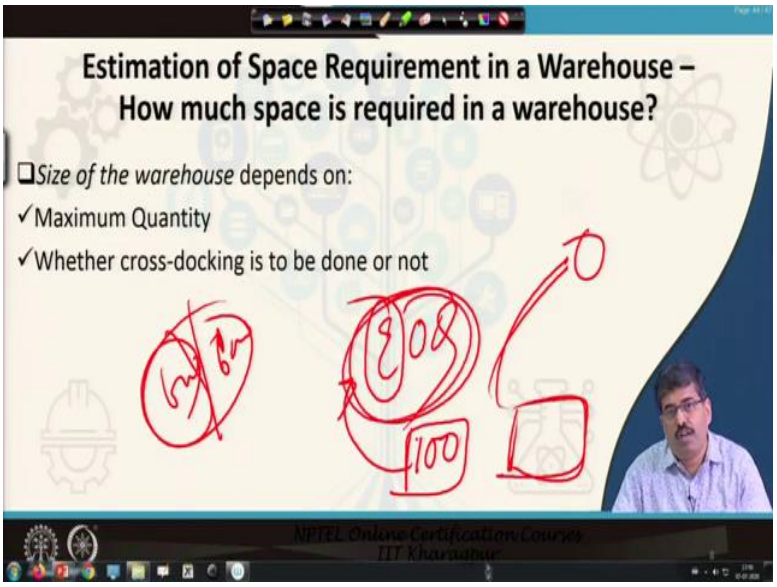
Now, what is this is a elevated office? Warehouse in general has an elevated office. It is never on the floor, why? One is, you get some space below and the second because space is costly, and the second thing is from a bit height, you can watch everything whenever you want ok. And just either below or at the side of this elevated office is the worker lobby; worker lobby in the sense that they can rest there, they can have their food, etc.

Now, if you see the water tap, this is something, if you if you notice very carefully I am erasing this part just, so that you understand it better. If you see, this water tap, this line this is the boundary line of the warehouse; the water tap this box is half inside half outside ok. The water tap box is half inside half; this is purposefully drawn like that. .

This means there will be a single water pipe, few water taps will be facing inside the warehouse few water taps will be outside facing outside the warehouse, why?

The workers who are work, warehouse workers they will use the water taps that are inside and the pipe is same and the people outside; means maybe, some security guards maybe the truck drivers, the helpers or anyone who comes, they need not go inside the warehouse to drink water, they will take water from outside ok. That is the reason why water taps are both ways ok. So this is pretty much the model diagram of a warehouse.

(Refer Slide Time: 17:32)



So how to estimate? So, this is the space this is the diagram. So, the question is how much space will you require? Will you require so many racks or will you require only 3 or 4 racks?

Lesser you require, lesser is the space requirement. So, how do you estimate, how much space do you require? Very simple, I am repeating the question, how do you estimate how much space you require ok? Very simple, my warehouse receives 100 products per day, 100 products. Every day it is receiving 100 products per day from Monday to Saturday.

So how many products is received? 600 products. And all the products go away to the dealers and wholesalers on Sunday right. So how much broad space do I need? I need space worth or which can store 600 products, because Monday, Tuesday, Wednesday, Thursday, Friday 500 products are already stored, Saturday 600 products are there, so I need space that can store 600 products. All is going away on Sunday option 1.

Option 2; Monday 100 products come in the morning all throughout the day; Tuesday sorry Monday night or evening all 100 go away; Tuesday again 100 products are coming in all throughout the day evening, goes away; same Wednesday 100 products are coming in the evening going away; this way up to Saturday..

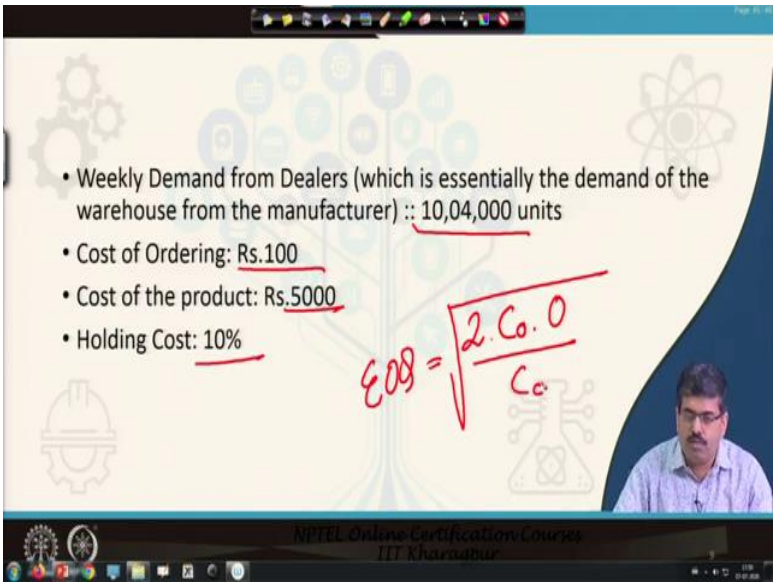
How much space do you require? Only 100 units worth of space, only that much space that can store 100 units right agreed.

So, your warehouse space depends on the manner in which the products are coming in and moving out of the warehouse right. Now, that manner in which the products are coming in and going out, how much quantity is coming in and how much quantity is going out, that will depend on cheaper cost.

I will send as a factory manager, as a factory owner, I will send that much of products to the warehouse which will make my total cost cheaper. That is my transportation cost, and my storage cost, and my paperwork and other costs; ok.

So transportation cost, storage cost, warehousing cost, so that much quantity which will make this per unit cost the lowest, I will send that much quantity.

(Refer Slide Time: 20:46)



And that much quantity is called as that much quantity is called as the economic order quantity most economical order quantity. .

So, if I am able to calculate this economical order quantity, and if I say that economical order quantity is 100 units that is every day I will send 100. So I should make efforts as the materials manager that if everyday 100 units come in, somehow I will force the organization and the sales team to ensure that every day wholesalers and distributors also ask from me for 100 units. So at the end of the day, what is my warehouse stock? 0. What is my warehouse stock? 0.

100 units coming in from the factory, because that is the most economical. They find out that if they send in lots of 100 that is the most economical. So, I should ensure as the materials manager that 100 units should go away in the evening from my warehouse. So, at the end of the day, there is zero stock. .

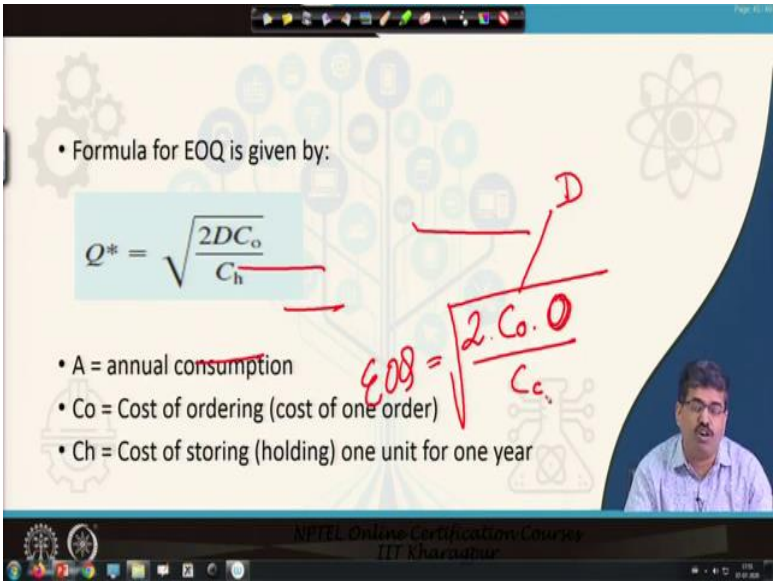
If I can do that, my warehouse space is less, if I cannot do that then every day 100 units worth of economical quantity, most economic quantity will come, pile up, pile up, pile up pile up Saturday 600, then Sunday 600 goes. So my storing cost is 600 worth of goods; ok.

So that is why this economical order quantity calculation becomes very important for warehousing; ok; and the formula is very-very-very-very simple; ok.

So, let us see, we this is my demand from the dealers weekly, oh sorry. This is my weekly demand from the dealers ok, 10,04,000; units cost of ordering 100; cost of the product is 5,000 and holding cost is 10 percent ok. So, what is the economical order quantity? How much do I order? Ok; formula is very simple.

What is this? We will see in the next slide; ok.

(Refer Slide Time: 23:11)

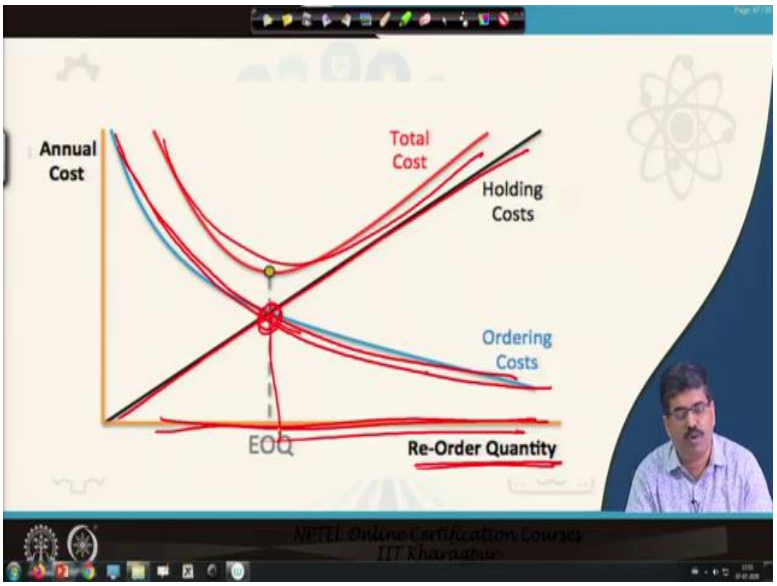


Let us little bit different economical order quantity; Q, economical order quantity Q star is equal to square root 2 D C o C h. The bit different from the formula that I wrote; each one has their own way of putting in the expression, but the nomenclature remains same.

I wrote 2 C o O by C c here it is 2 D C o by C h to into annual consumption. This in this formula is demand, demand and consumption is same C o is cost of ordering, we have just written o that is cost of ordering C; c is carrying cost of inventory, here it is mentioned as holding cost of inventory; ok. So formula is same, different books you will find different ways of expression clear; ok.

So, annual consumption as we mentioned, D a sorry here it should be D 2 D annual consumption C o is the cost of ordering and C h is the cost of storing or holding for one unit of 1 for 1 year; holding means you are keeping the inventory; ok.

(Refer Slide Time: 24:34)



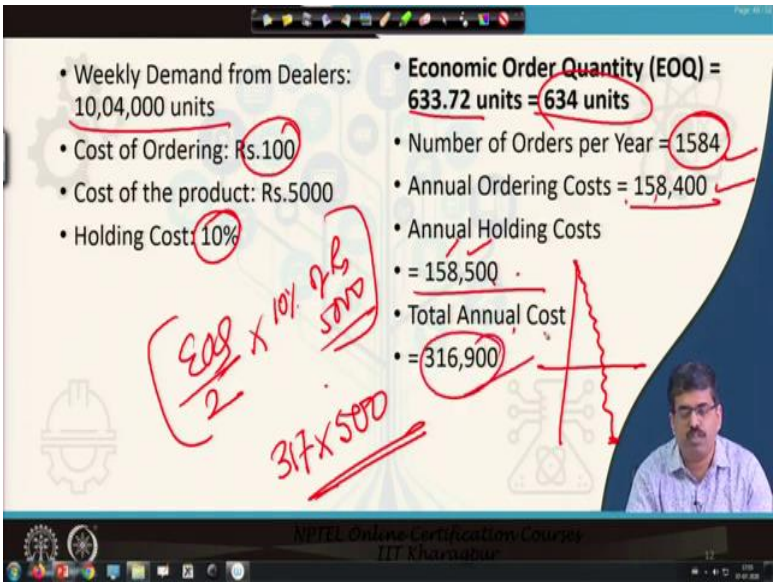
So, we had this problem; cost of ordering; cost of product; very simple. And, this is basically the graph, I think these are this is available in any standard textbook ok. So, basically, if you see, if you if you notice very carefully, my as more and more units are ordered per unit storing cost, sorry per unit your transportation cost, which is the ordering cost per unit ordering cost comes down, as more and more units are ordered.

Your 1 truck is going with 4 boxes, the same truck is going with 40 boxes. So, cost of movement per unit comes down. That is what is as more and more quantity is ordered, as more and more quantity reorder quantity and more and more is ordered your, ordering cost per unit comes down; ok.

But as you order more and more quantity, you have to take more space from warehouse rent, more electricity cost, more worker cost; so your holding cost moves up.

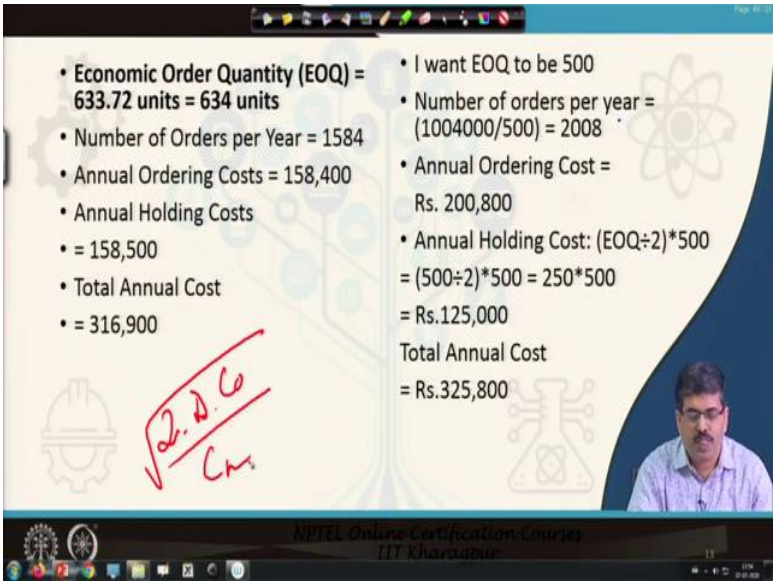
So, total cost is summation of ordering plus holding, so this is your total cost. Economic order quantity is the intersection point between your ordering cost and the holding cost, this is your economic order quantity; right.

(Refer Slide Time: 25:56)



So, let us go back, where as sorry; I am sorry; let us go back; this was your original problem we just put it in the EOQ formula.

(Refer Slide Time: 26:04)



And, this we got this sorry, we have put it in the EOQ formula as we did 2 into demand, I am using the formula that is given in there; cost of ordering by cost of holding. So just put it in this formula, you will get; sorry; you will get; you will get an, or this thing of 633 units; ok. You will get 633 units; ok.

So how many orders per year? 10,04,000 nits is your demand divided by 634 units is order quantity every time. So number of orders per year is 1484, ordering cost ordering cost was rupees 100, how many orders are you giving per year 1584 into 100. Holding cost, 1584. What is the holding cost? Holding cost is 10 percent ok, holding cost is 10 percent.

That is EOQ by 2 into 10 percent of rupees 5,000 that is 500 ok. So, EOQ was 634; that means, 317 into 500; yeah; ok.

So, this is your why is annual holding cost EOQ by 2? EOQ by 2 because you have ordered this, then every time your stock is coming down so average invented is only this.

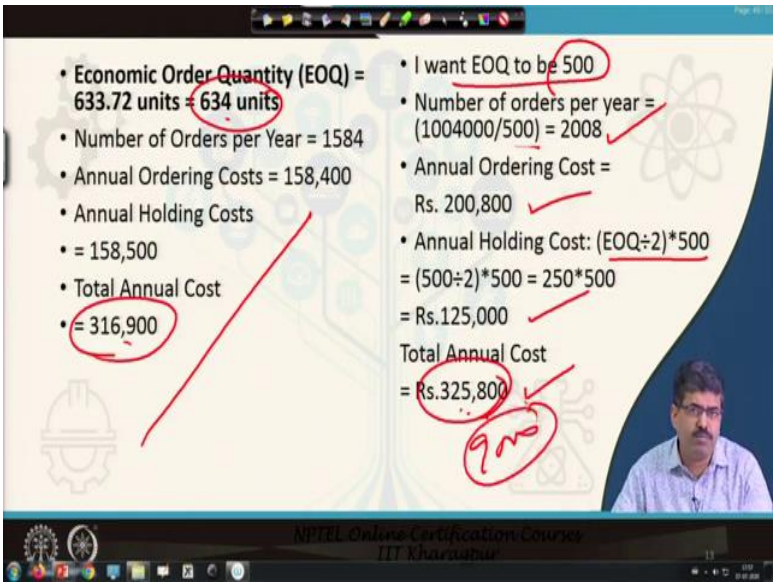
So, EOQ by 2 and total annual cost is your holding cost plus ordering cost this plus this; ok. So, this is your annual cost; ok. This is a simple problem; right.

This was my calculation. Now, I do not want to receive 634 units. This is the economical order quantity that has come after calculation, but from the warehouse the product has to go to the wholesaler and distributor right. Now the wholesaler and distributor, they will only take 500 units per day; right. So, I want the economic order quantity to be only 500, then there will be no stock.

So now the number of orders will be 200,800 1004000 by 500 annual ordering cost multiplied by 100 holding cost is EOQ by 2 into 500. So, ultimately to come to 135 an annual cost would be 325000; ok.

Listen very carefully. So, if I reduce the order quantity.

(Refer Slide Time: 29:04)

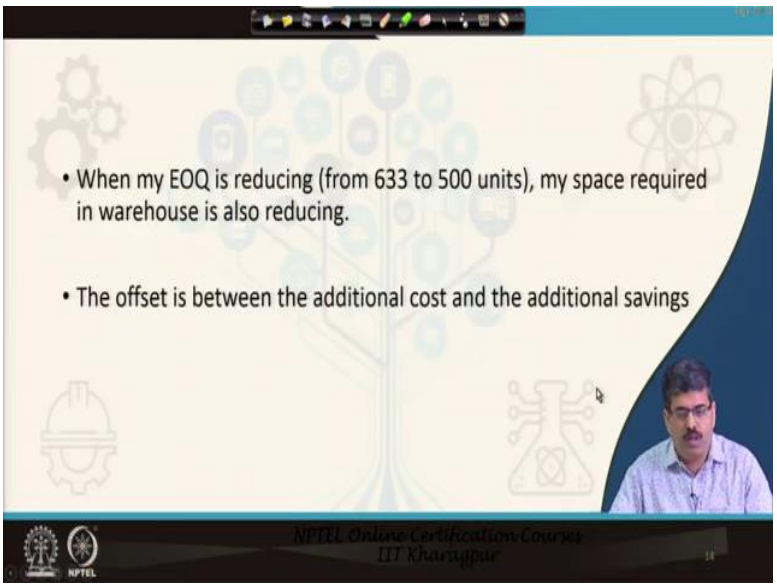


So my annual cost is going up by 9000 rupees. How much less warehouse space am I taking? Because I am reducing the order quantity from 634 to 500 units. .

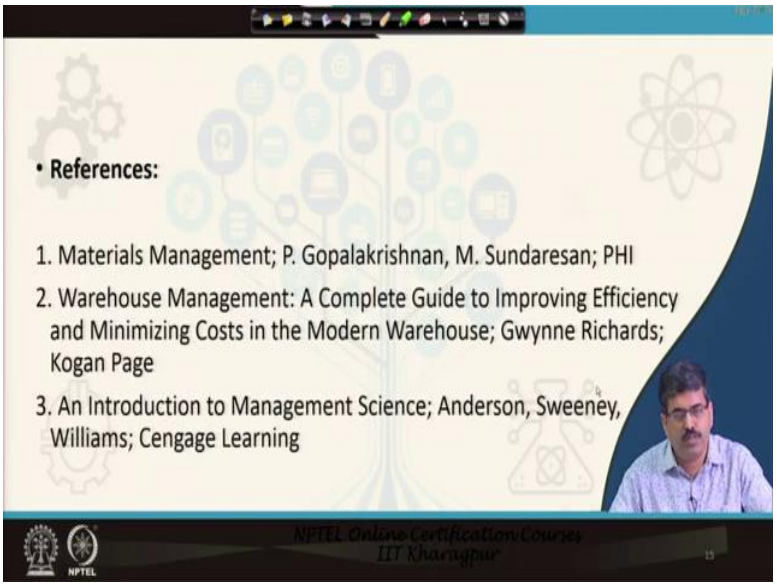
So, 134 units worth of space, I am reducing. So that much warehouse rent I will have to pay less.

So, is this additional 9000 rupees of setting that an less warehousing rent? If yes, go for this model. This is the calculation; ok.

(Refer Slide Time: 29:40)



Refer Slide Time: 29:42)



So, this is the reference material for this; EOQ is available in any book; economic order quantity; I think it; a very-very simple explanation is given in here. So, this is this so.

Thank you!