Modelling and Analytics for Supply Chain Management
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Lecture-21
Space calculation - I

Welcome, welcome to module 4 week 6 of Modelling and Analytics for Supply Chain management. In the previous weeks, you have learnt about the Warehousing Location Decisions that is how to locate and where to locate the warehouses and we have learnt various models for warehousing location.

For example when you have data, when do not have data, when you have only yes no type of perceptual decisions when you have full cost data, when you have demand data only, when you only have the geographical coordinates along with demand data, so all this types of decision making all we have done using the types of data the nature of the data that you have, so this was you warehousing location decisions.

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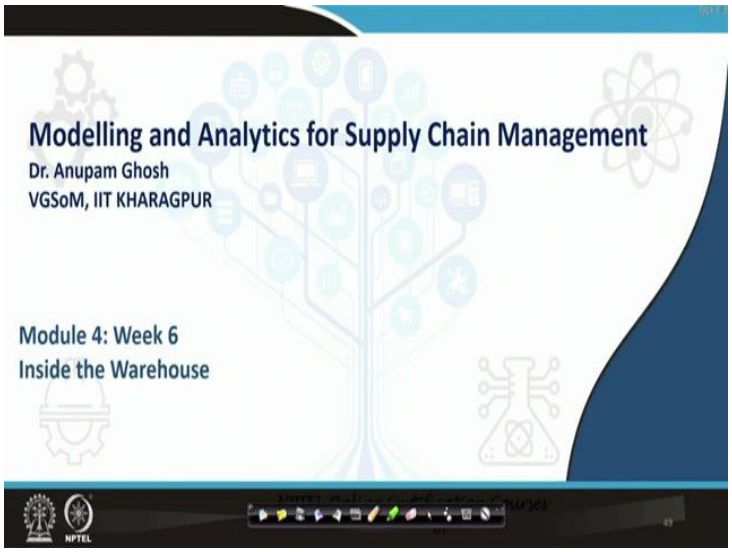

Today we come to your decision for how much space do you require in the warehouse, in the last week we have given you a brief recap about how to decide on how much space you require, for example if it is rice sacks you can stack 2 or 3 stacks over one over the other. But if it is a refrigerator you cannot stack 2 or 3 refrigerators one over the others. So, depending on the nature of the product the space required in the warehouse will increase or decrease, but

there should be some mathematical way to arrive at that space calculation, today we will do that part of warehousing decisions. So, space calculation in a warehouse.

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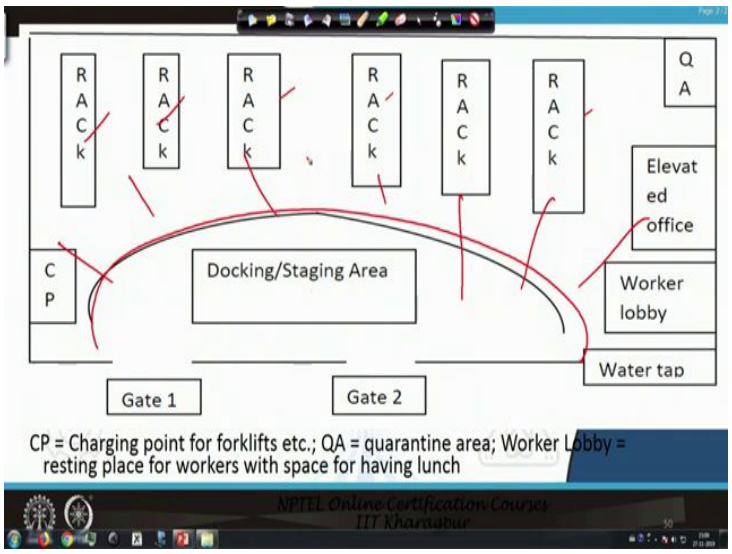

Now, if you remember this was a rough warehouse diagram that we have shown you in the previous class. So, if you see today what we will do is, if you say this is the warehouse, this is the warehouses and we will so if you see we had shown you this diagram in the previous class, what we say it is so today just a recap our topic is calculating space in a warehouse.

So, if you see your warehouse space is equal to your area where you load and unload the goods plus your storing area, so one is your staging area where you load unload the goods and from there you take them to the racks, so your actually racking area. So, this, so if we add up this 2 spaces then basically you can calculate the total space required in the warehouse, so this is our job today.

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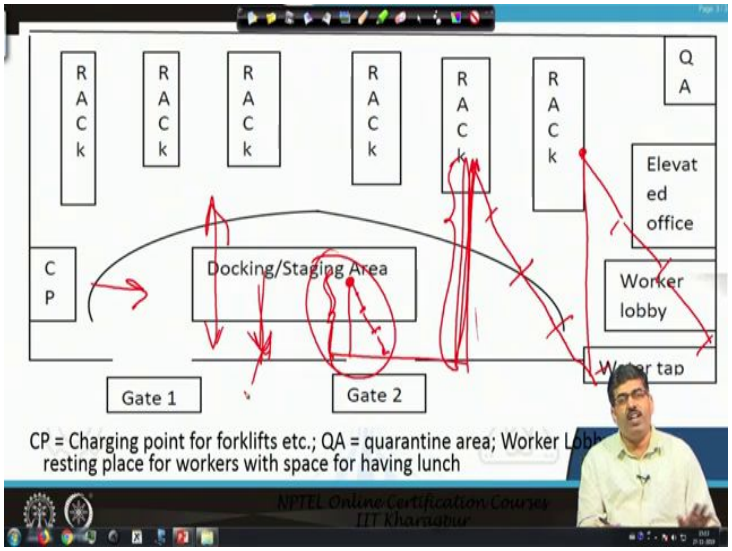

Now, just if you see these say now take a situation where your warehouse is receiving products once in a month, take a situation when your warehouse is receiving products once in a month. So, receiving once in a month and then dispatch is daily, the dispatch is daily. So, what will happen you require more warehouse space, you will require more warehouse space because product is coming once and then every day or every week the stock of products in the warehouse is decreasing, week 1 it is come down, week 2, week 3 and week 4 it is 0, then again you are receiving the products.

So, when this is your receive pattern, now assume instead of receiving the products once in a month you are receiving the products once in a week and then products are daily dispatch, so what will happen? Take this diagram, so your product received is only much and then your daily dispatch is this much.

So, the total quantity of products in the warehouse in the earlier model was this much quantity now the total quantity of products maximum quantity, maximum quantity of products in the warehouse in the earlier model was this much, was this much, now the maximum quantity of products in the warehouse is only this much.

So, for which model will you require less warehouse space? You will require less warehouse space for this model, because you are receiving almost daily once a week. So, the simple way to understand how much space you require in a warehouse is to ask the first question, what is

the frequency of receipt of materials. If your receipt is only once in a time once in a while, then you will require more warehouse space like this.

If your receipt is once in a week or every day then it is the product is coming in, the product is coming in and again the product is going out, the product is going out. So, you will require very less warehouse space. So, your warehouse is a cost centre, warehouse space requires huge cost, huge rent, so since warehouse space is a cost centre you will have to go back and check-up how you can arrange your delivery schedules, how you can arrange your delivery patterns, so that the deliveries, the receipt and delivery it is a product in and product out is very very frequent.

More the product in frequency and more the product out frequency, what will happen warehouse the products are staying in the warehouse for very less time and very less quantity, so warehousing space required also will be less. So, I repeat, when the product in and product out is very very frequent, so the time and the quantity for the product is staying in the warehouse is very less, so you will require very less warehouse space.

So, what is the moral of the story? The moral of the story is you should plan your distribution system in such a way that products do not stay for too long in the warehouse, more it stays more warehouse space it require, more warehouse space it requires more is the warehouse rent, so more is the cost. So, products should not stay in your warehouse that is the moral of the story.

How you can make sure that products do not stay in the warehouse? Have very very frequent in and have very vey frequent product out. So, plan your distribution, your order patterns everything according to that, this is the moral of the story. So, now let us move to the next one.

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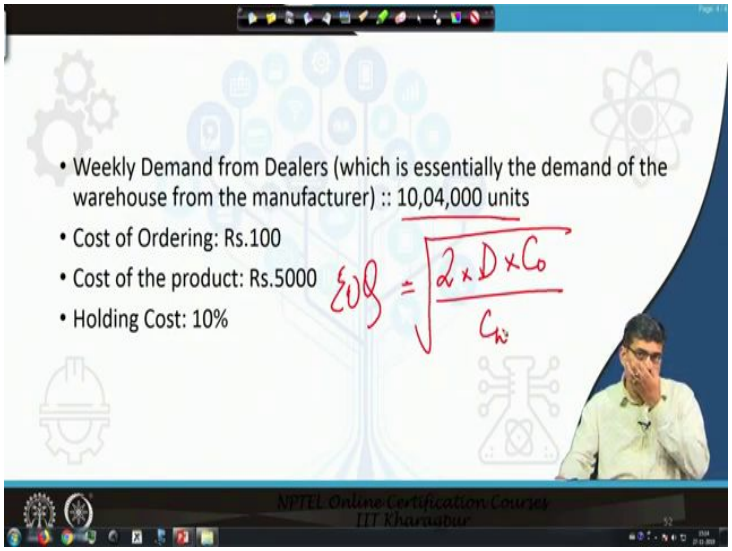

This whatever I have mentioned we have explain through using a small problem. Let us say there is weekly demand from the dealers, which is the demand again of the warehouse from the manufacturer, let us say the weekly demand faced by the warehouse is 10,04,000 units, ordering cost is 100, cost of product is 5000 and holding cost is 10 percent. Applying the EOQ formula, what do we have?

We have 2 into annual consumption into cost of ordering divided by cost of holding or caring cost . This is the formula, 2 into annual consumption or demand into ordering cost divided by holding cost whole square root, this is the economic order quantity formula. Now if you apply that formula what will you get?

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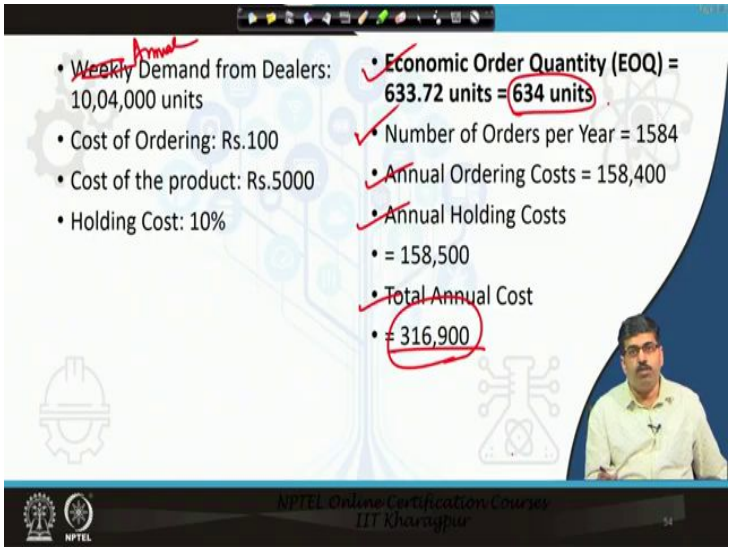

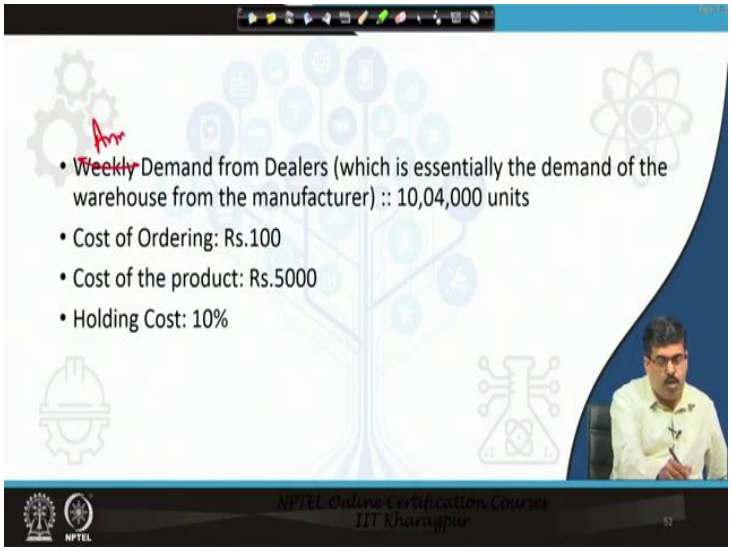

You will get the following, you will get the numbers of orders 1584 and the economic order quantity that means you should order every time 634 units, annual ordering cost 1,58,400 rupees annual holding cost is this and total annual cost is this. So, what is the outcome you should order when your annual demand or weekly demand is 104 1004000 units, then your economy order quantity is 634 units. It is not weekly sorry there is small this thing this is annul demand, annul demand I will just check up, ya this is again your annual demand. So, this is your model, what is your cost 316000.

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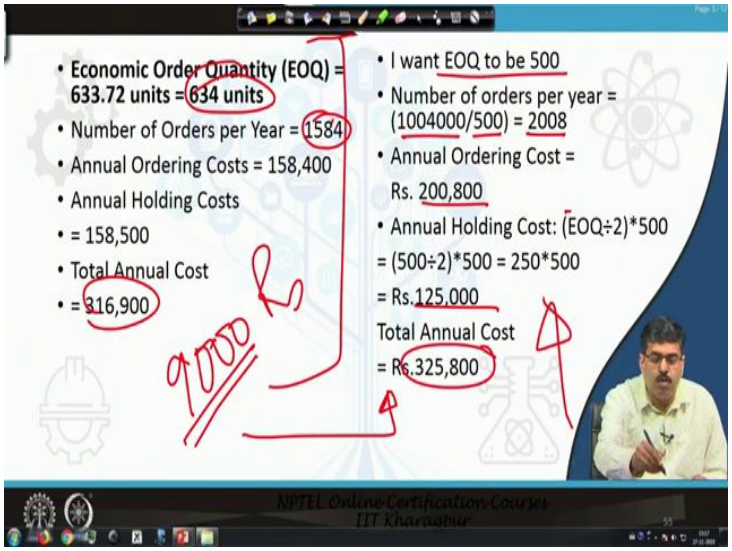

So, what is happing now is this is your economic order quantity, that is 634 units, now I want lesser number of products to enter my warehouse, because lesser number of products if will enters the warehouse then I would need less space, so I want lesser number of product to enter my warehouse every time. So, I want my EOQ to be 500 the economic order quantity to be 500.

But my annual demand is same, so each and every time if I order less order quantity, then what is the total number of orders earlier model the total numbers of orders or total number of delivery's in my warehouse was 1584 now it is 2008, annual ordering cost is this, annual holding cost is this and annual cost is 3 lakh 25 earlier model was 316.

So, what is the incremental roughly 9000 rupees is extra, that I pay if I reduce the number of quantities that I will receive every time, lesser number of quantities if I receive every time my warehouse rent will come down because I will require less warehouse space. If my warehouse rent savings is more than rupees 9000 I will go for this model. If the warehouse rent savings is less then rupees 9000 then I will go for this model. So, this is what it is all about.

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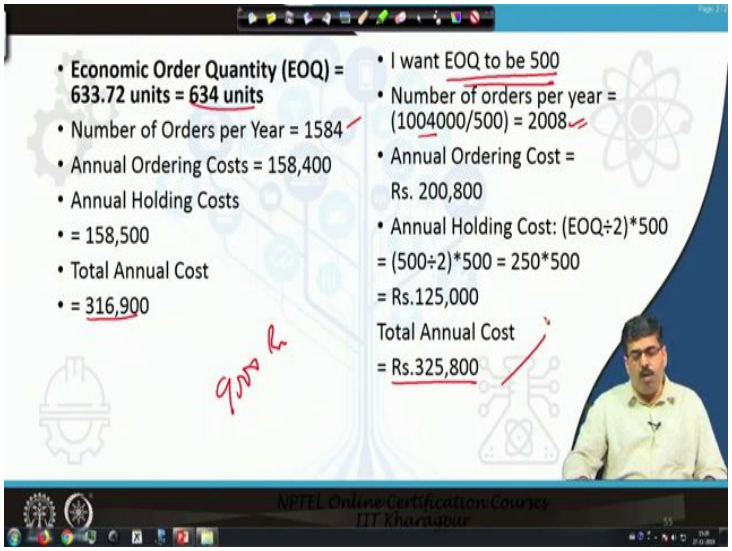

What happens as we mention that my I want to reduce the quantity that I receive from my warehouse every time, so I want my economic order quantity instead of 634 units I want it to be 500 units. So, but that will means more cost because my annual demand is same, so number of orders will increase for 1584 to 2008.

So, ultimately my total annual cost will be roughly 9000 rupees more. So, if my warehouse savings in warehouse rent is more than 9000 rupees I will go for this model. Now, you learn about economic order quantity in inventory management decisions, this is just to give you a snapshot about what are the considerations that you should keep in mind when you are thinking of calculating warehouse space. Now, take for example just continue with this, take for example the amazon model, amazon wants to store the least quantity in its warehouse that is most logical because your warehouse storing cost increases if you store more. So, it will want to have a very very less EOQ quantity here in this diagram.

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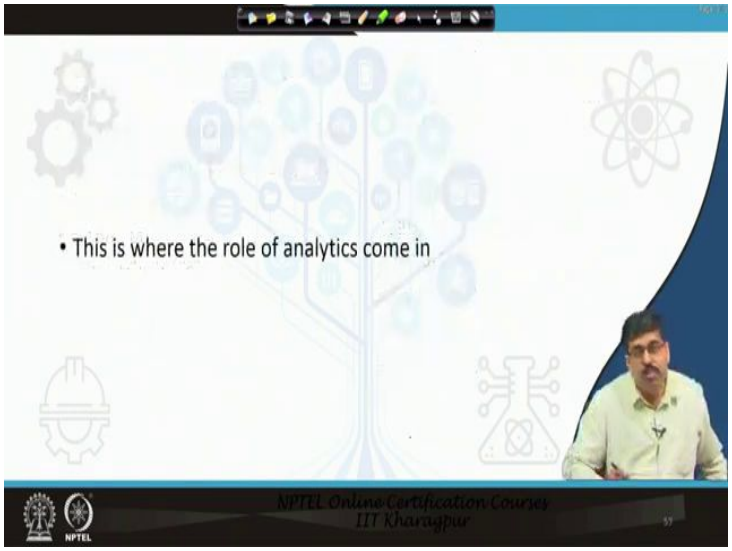

This is where your analytics comes in.

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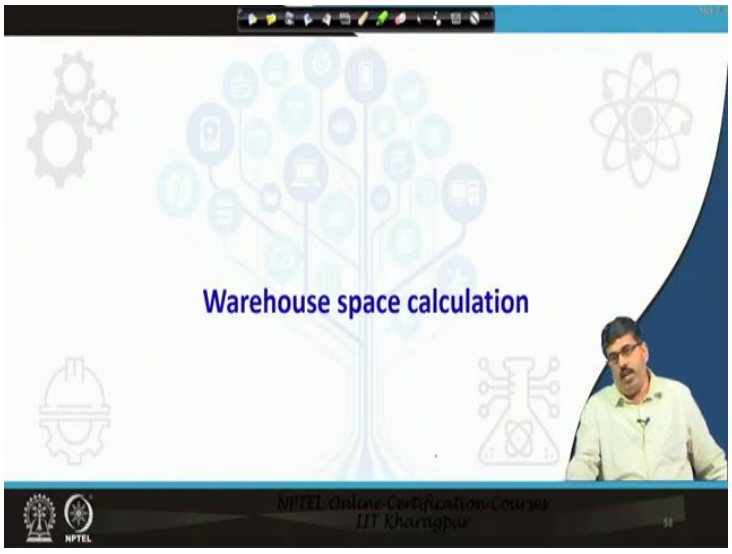

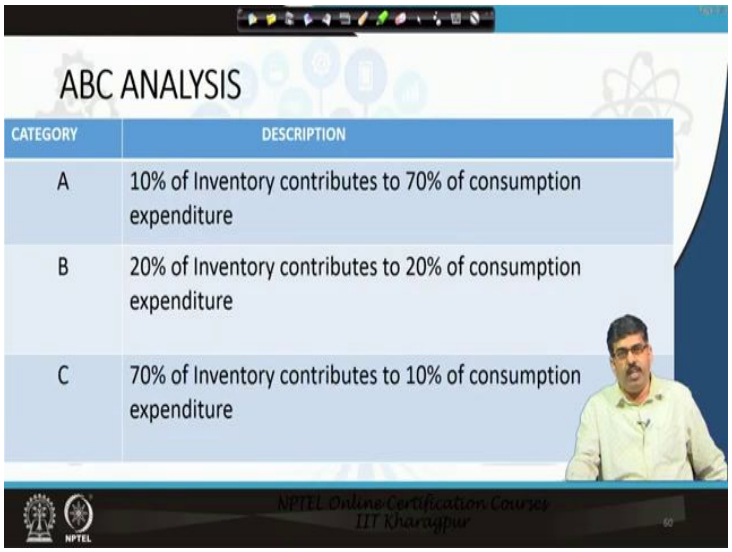

So, how to decide now warehouse space so warehouse calculations, some basic and as we mention ABC Analysis again you will learn and inventory decisions, 10 percent of inventory contributes to 70 percent of consumptions expenditure, 20 percent of inventory contributes to 20 percent and 70 percent contributes to 10 percent somewhere like (())(12:27) situation.

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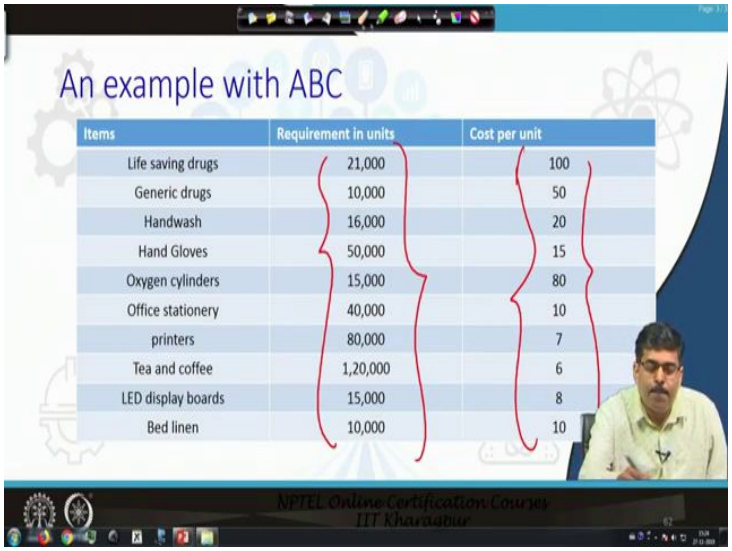

This is an example with ABC, so this is, this is an example with ABC analysis what it says is the lifesaving this is the requirement in units of different types of items in a hospital and this is the cost per unit. So, from warehousing decision point of view this is the requirement and this is the cost, which one will you store more in the warehouse? Question number one.

Question number two, if the warehouse has only one entry gate or exist gate that is on one side only, so which are the items that you will keep right in front, which is the items that you will keep at the end or toward the end of the warehouse? This are again some decisions that you will have to take. So, here in comes what is ABC, What is FSN analysis etcetera, fast moving, slow moving, non-moving.

For example in a hospital the basic medicines like paracetamol, antibiotic, hand cloves, hand shower these are the most fast moving atoms, so fast moving, slow moving, non-moving, so fast moving atoms have to be kept at the beginning, then the medium moving and lastly the non-moving items.

Similarly the essential items have to be kept in front, the not so essential in the middle and the others at the end. So, that is again a part of warehousing and store layout decisions. So, this is just to give you a snapshot of so many things that you need to keep in mind when you are calculating warehouse space.

So, we just showed you one small technique, even before beginning with this analysis we showed you once small technique on like if you are reducing the quantity received every time and having a quick dispatch with the EOQ formula we showed that might be you will require less warehouse space and save a lot of money in warehouse cost.

The second one another consideration that I just now showed with ABC FSN fast moving, slow moving, non-moving all these will contribute to calculating or helping you in calculating warehouse cost.

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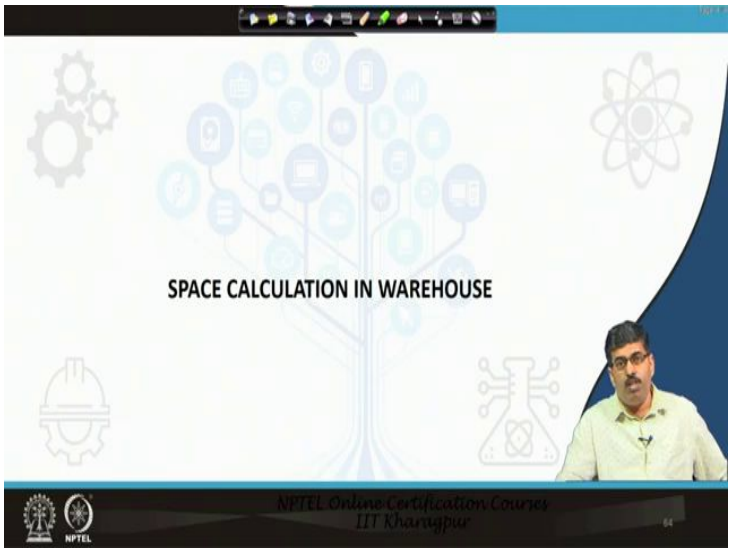

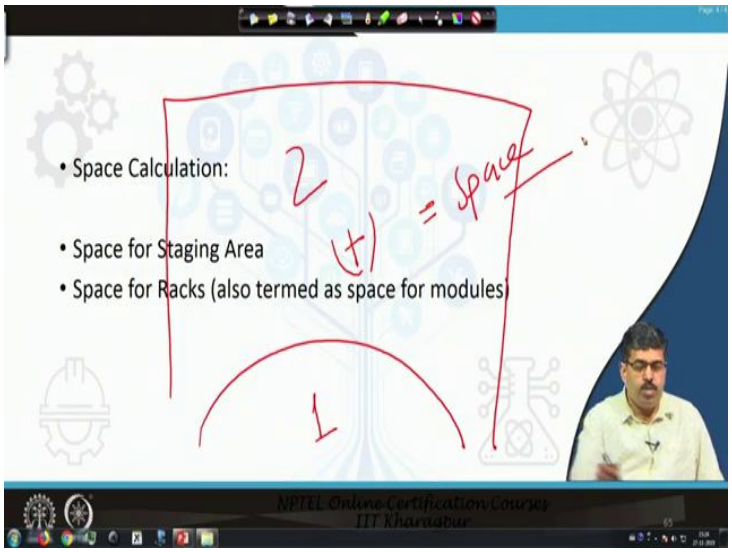

So, let us move on space calculation in the warehouse. As we have mention go back to our diagram one verses staging area, the staging area right in front and the other was the if you

remember this was my staging area and the other was the racking area, so if I calculate, so 1 plus 2 is equal to my space.

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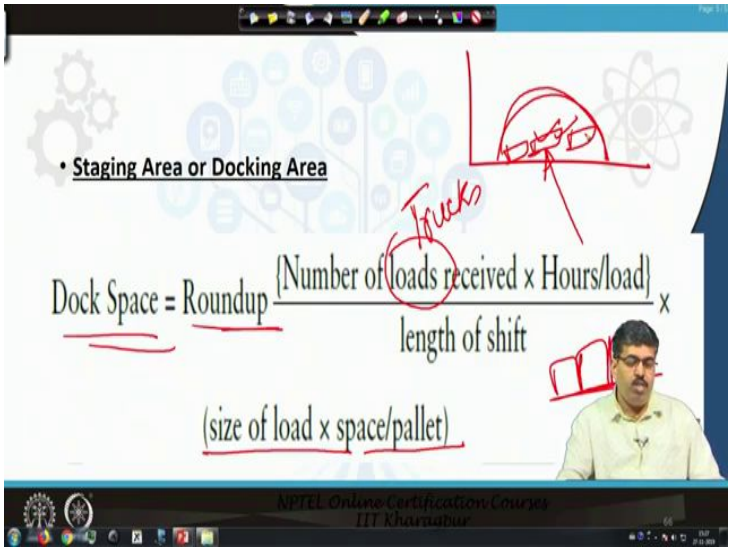

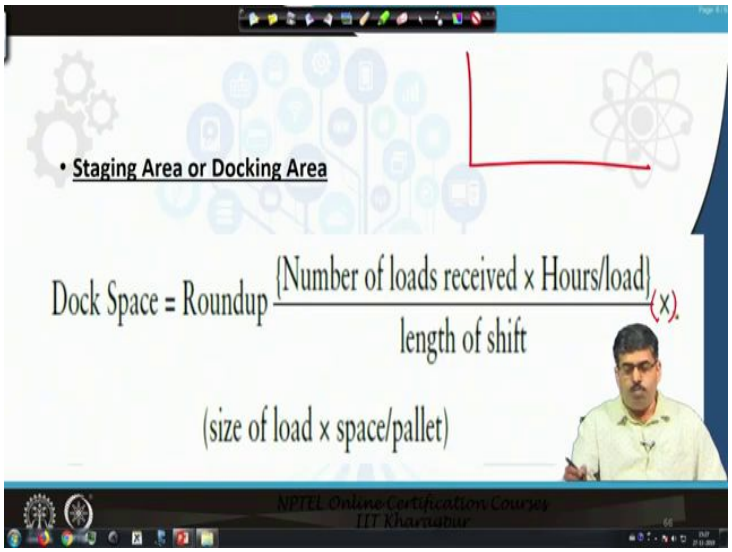

So, this is where we start, staging area as we have mentioned just this just a brief this was my staging area, that is dock space, dock space is equal is to roundup, roundup means if you are calculations comes as 1.8 you should round it up to 2, if your calculations come at 1.2 should you round it up to 1? No, you should round it up to 2 only.

Because if your total volume of the product is let us say 1.2 meter cube and you have round it off to 1 then how will you keep that product? So, roundup always means the next higher digit, roundup does not mean round off to the nearest higher digit, it means taking it to the

next higher digit. So, number of load received into hours per load by length of shift, multiplied by size of load into space per pallet.

The number of loads receive, this load basically means number of trucks, into hours per load, hours per load means time taken for loading unloading here, for one truck how much time it takes to load or unload hour per load, divided by length of shift, the workers have a shift may be half an hour may be 1 hour, into size of load, size of load means in 1 truck load means trucks we have mention size of load means in 1 truck how many pallets are there?

Pallets means the wooden platforms or steel platform on which the products are kept, that is a pallet. So, size of load into space per pallets, space required for the pallet, so this is the stocking area, how much space is required for 1 pallet? So, this is my dock space formula, formula for staging area or docking area. So, rounding up to the next higher digit number of load received into this whole multiplied by size of load into space per pallet.

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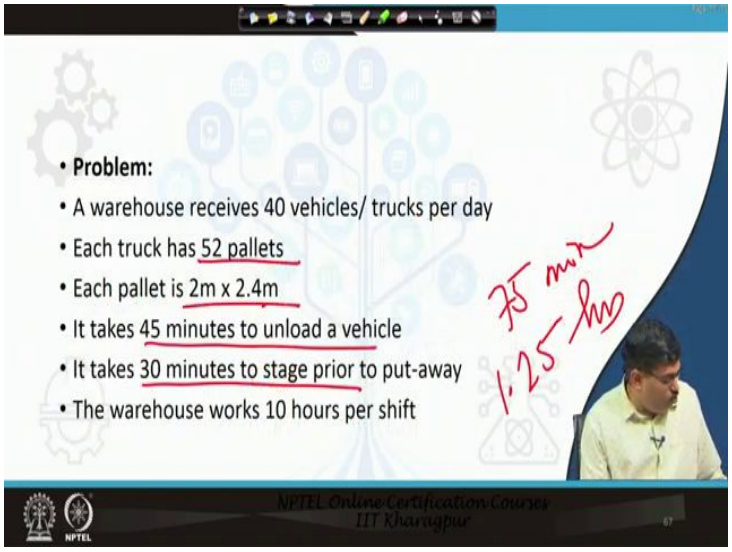

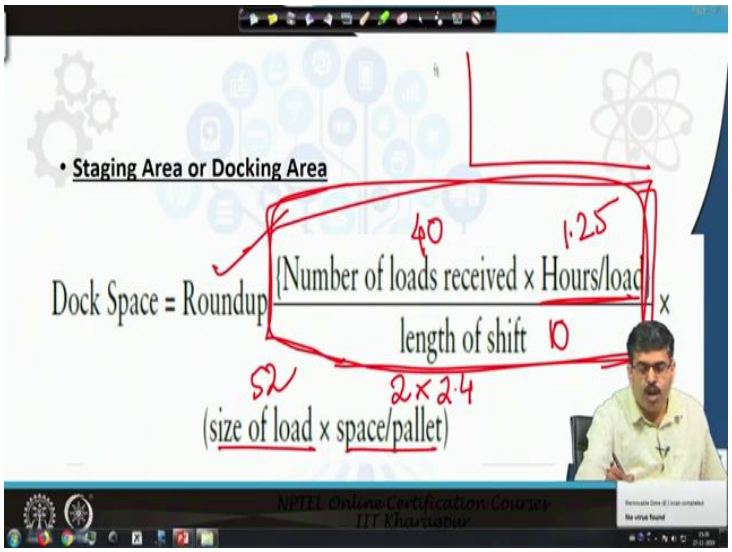

So, this is the problem, warehouse receives 40 vehicles or trucks per day each truck has 52 pallet, each pallet is 2 meter into 2.4 meter in area, it takes 45 minutes to unload a vehicle, it takes 30 minutes to stage prior to put away, the workers work 10 hour per shift. So, warehouse receives 40 vehicles a truck per day. Number of loads received, number of loads received 40, warehouse receives 40 vehicles per day into hours per load.

Let us see each it takes 45 minutes to unload and 30 minutes to stage, 45 minutes to unload and 30 minutes to stage, stage means taking it away because unless it is taken away this area for loading unloading that is not vacant so another truck cannot come, so 45 plus 30 it is 75 minutes, so basically it is 1.25 hours. So, 45 minutes 1.25 hours for loading unloading.

So, hours per load 1.25 hours, so we had number of trucks 40, 1.25 hours is required for every truck to load unload and move because the area to become empty, length of the shift was how much? 10 hours, length of the shift was 10 hours, size of the load and space per pallet, how many pallets was received? If you remember 52 pallets where received. And what is the space required per pallet? What is the space required per pallet? Each pallet is 52 pallet received and each pallet is 2 meter into 2.4 meter, so space per pallet is 2 into 2.4.

So, this is your formula, if you now multiply you will get the solution, only thing is you will have to finish this first, this part first, you have finish this part first, whatever the solution is, if it comes in decimals you will have to round it up. And with that result you will have to multiply 52 into 2 into 2.4, the first part is roundup, first part is roundup. So, this is what your calculation is all about.

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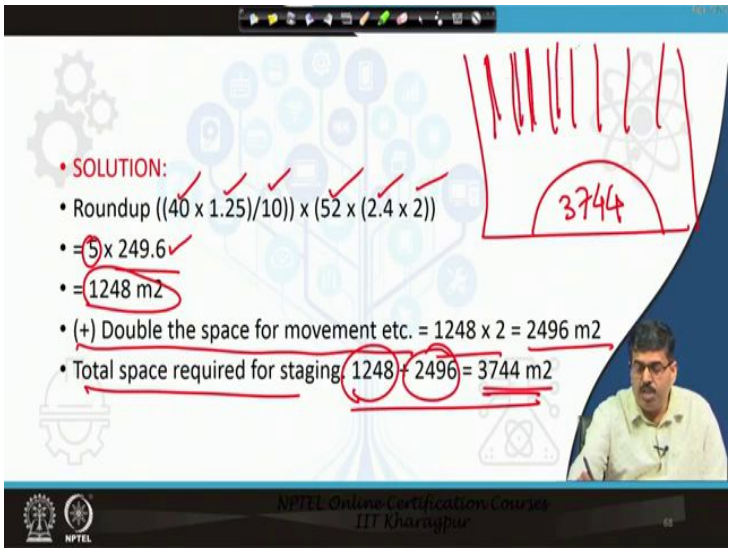

So, just to show you, we mentioned 40 into 1.25 was a loading unloading time divided by length of the shift was 10 that has to be rounded up, so roundup value came 5 into 52 pallets, 2.4 into 2 was a dimensional of every pallet, 249.6 was this part of the solution, so 1248 meter square is the space required for exactly the pallets, not worker movement, this is the space required for the pallets, no worker movement space has been given plus double the space for movement et cetera.

So, 1248 into 2, 2496, so total space required for staging is 1248 for the pallets and the double the space for movement of workers, forklifts et cetera, so total space required is 3744 meter square. So, if you remember this was my warehouse diagram with the racks here, with the rack here and this was my staging area that is the loading unloading area.

What have we calculated? We have calculated the area required for loading unloading that is staging 3744. What are we left with? We are left with calculating the space for required for the racks.

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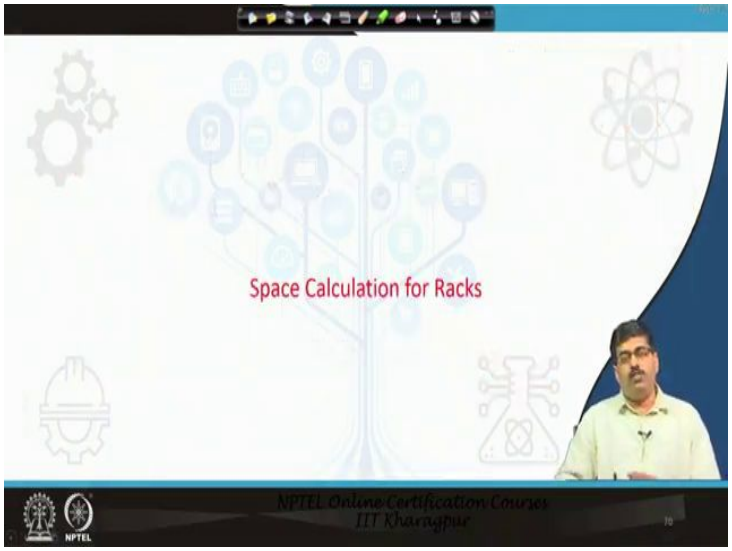

This brings us to the next part that is the space calculation for the rack. We just shown you the diagram in which you have to calculate space for loading unloading and then the space for the racks. A space calculation for the racks to know that we will have to look at 3 diagrams.

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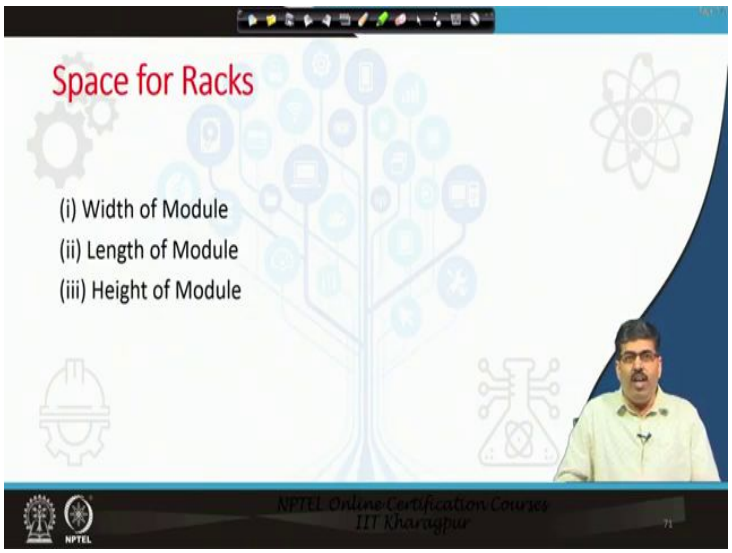

Width of the module, length of the module and height of the module.

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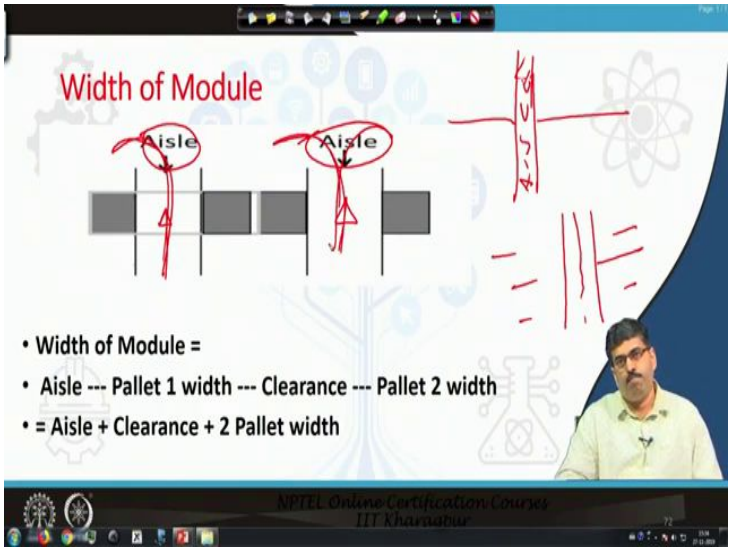

What is width of the module? Here is something called an aisle, some people say it is aisle some people say it is aisle, whatever the spelling remains the same aisle, what is this? All you have been on local trains or long distance express trains, between 2 rows of seats there is a space through which passengers walkers and everybody goes, this is the aisle, aisle, if you have been on aircrafts you know that again in the middle there is a place through which the passengers and the airline staff moves and both the sides there are seats, that is an aisle.

So, in warehouse also there is a space between the racks, in warehouse also there is a space between the racks for materials to be taken forklifts will move, materials will be put in racks et cetera. So, this is basically the diagram of what we call as a width of a module.

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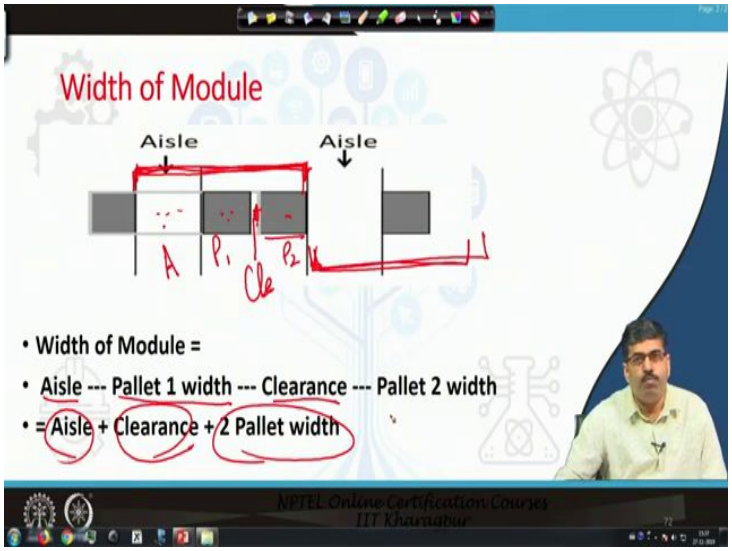

So, there will be a space, there will be space through which the forklift will go on both the sides there will be space for keeping the pallets, for keeping the goods. Normally this is the space for goods movement on a forklift or a trolley, so 1 pallet will be kept here, one pallet will be kept here, there will be a small gap in between and another pallet will be kept beside it. And again there will be an aisle on this side, what is the idea? A forklift can go pick up the pallet from this side and again move out.

Again if this pallet has to be picked up if forklift will go pick up the pallet from this side and move out. So, there is no need to brings out this pallet and then again pick up this pallet and go, this pallet can be picked put from this side, this pallet will be picked up from this side, that is why there are only 2 pallet spaces, 2 pallets spaces between the aisles.

What is the gap in between for? This gap in between is for workers to climb the pallets and pull it outside, workers to climb the pallet and pull it outside that is why this gap, so this section, this section, this section, this section is called a width, I am repeating this section is called a module width, module width.

Aisle plus pallet 1, aisle plus pallet 1 width, pallet 1 width plus clearance this is the clearance, plus pallet 2 width this is width of 1 module, aisle pallet 1 width, clearance pallet 2 width, aisle pallet 1 width, clearance, pallet 2 width, this is 1 width of 1 module. Next this will be another module, this will be another module, so 1 module is aisle pallet 1 clearance pallet 2.

So, in simple words aisle plus clearance plus 2 pallet width, this is 1 aisle, aisle plus clearance plus 2 pallet width, aisle plus clearance sorry aisle plus clearance plus 2 pallet width, this is the width if a module.

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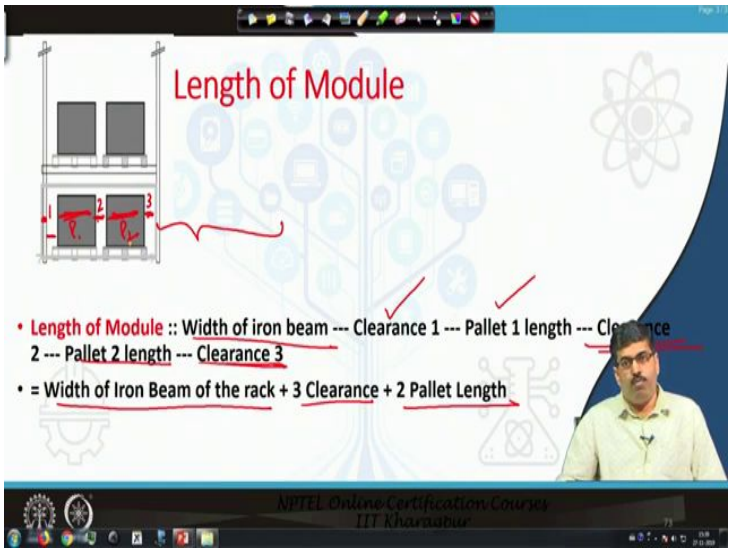

Next comes the length of the module, length of the module this is from the other side of the racks if you see, 2 carton 2 pallets have kept side by side, so what is the length of the module and there are racks, so length of the module is if you see, length of the module is the width of this rack it may be 10 centimetres width this much of thickness, this much of thickness, it maybe 10 centimetre width.

So, width of the iron beam, width of the iron beam clearance between the iron beam and the pallet to bring put the pallets from inside clearance to bring out the pallets from inside, so width of the iron beam plus clearance 1, pallet 1 length plus clearance 2, clearance 2, so repeat width of the iron beam clearance 1 pallet 1 length clearance 2 pallet 2 length pallet 2 length, pallet 2 length plus clearance 3, plus clearance 3.

So, width of the iron beam clearance pallet 1 length again clearance pallet 2 length again clearance, we are not considering the width of this iron beam, why? Because this will be taken for calculation for the next module length, this would be taken for calculation for the next module length, so in summary width of the iron beam 3 clearances, clearance 1, clearance 2, clearance 3, 3 clearances, 2 pallet length, pallet 1, pallet 2. So, this is my length of the module.

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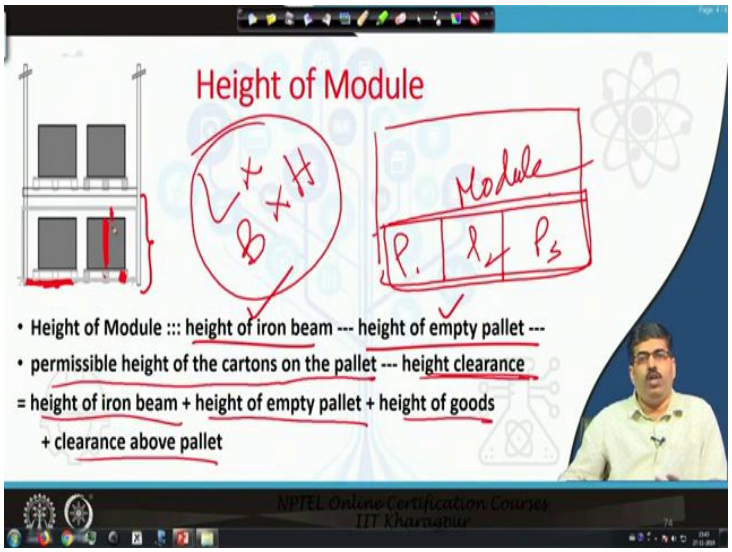

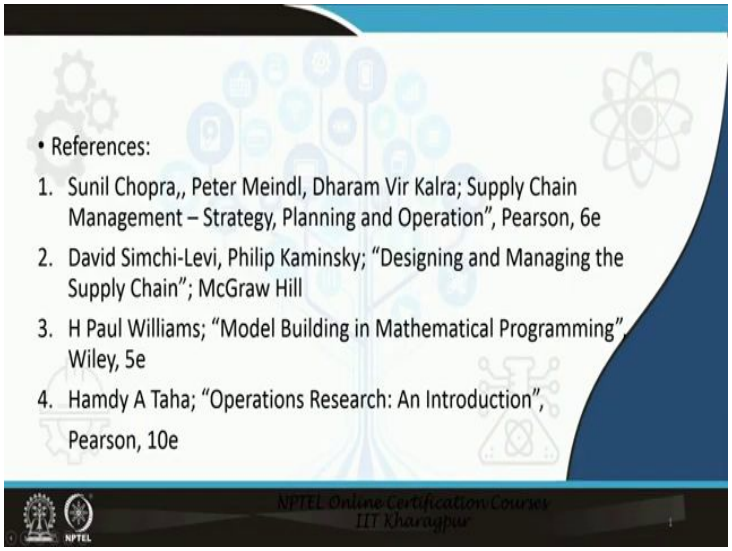

Then we move on to the 3rd one that is the height of the module, now what is the height of the module? The height of the module is basically this, what is this? Height of the iron beam bottom also, at the bottom of your warehouse the products are not kept on the flower, so they are on some iron racks.

So, the rack the iron rack also has a height of the iron beam which is basically the support for the racks. So, height of the iron beam if you see this is the height of the iron beam, height of the empty pallet, the pallet is also a has a height, for those of you have not been into a warehouse earlier you will be wondering what is a pallet, many of us who have studied in schools where they were painting class, you would have heard about the word pallet.

In pallet what was there? There was water, there was colour and you were take some water and some colour and then you will paint, but that pallet is not this pallet, those of you have not been into warehouses a simple way to understand what a pallet is, is you know in our home, we have refrigerator that is the fridge the common word that we say your refrigerators.

Now, refrigerator is on a stand, refrigerator is not on the floor, we take a plastic rectangular piece of stand and put the refrigerator on top of the stand you can take that stand as an example of a pallet, stand is an example of a pallet. So, that stand has a height, so that is what is called as height of the iron beam, sorry and height of the empty pallet, sorry that is not the height.

So, that stand has a height and so that is the height of the empty pallet, iron beam is the rack, height of the iron beam that stand height is the height of the empty pallet plus permissible height plus permissible height of the cartons on the pallet this height, this permissible height of the cartons on the pallet, plus clearance above the pallet there will be some clearance above the pallet there will be some clearance, to bring the pallet out to bring the pallet outside, height clearance.

So, in summary what is it? Height of the iron beam, height of the empty pallet, height of goods plus clearance above pallet same thing, so height of the iron beam height of the empty pallet permissible height of the pallet plus clearance, this is 1 module. So, basically if you look at it if you look at a warehouse between 2 racks there are multiple pallets, pallet 1, pallet 2, pallet 3 this is basically called as a module, this is called as a module.

In many warehouses there will be 3 pallets, so accordingly your formulas will expand, so this is what is called as a module. So, in a module what have we learnt the length of the module, breath of the module or the width of the module and the height of the module. So, basically we get the space required for 1 module. In the next session, we will do a mathematical calculation using this formula. Thank you.