Decision Support System for Managers
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Week - 11
Module - 05
Lecture - 54
Decision Support Systems for Inventory Management (Contd.)

Hi! Welcome to our 5th module on 'Decision Support Systems for Inventory Management'! Today we are going to deliver it on two important inventory systems.

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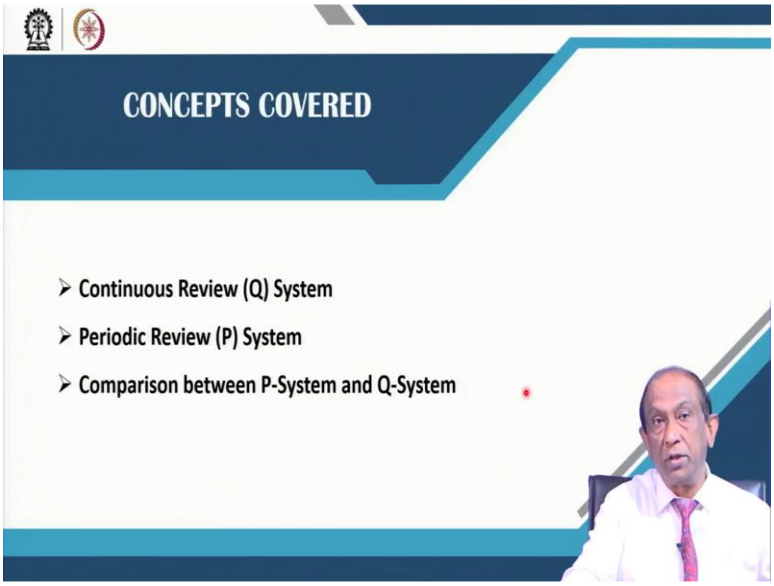

One is the continuous review system, that is also popularly known as the Q system of inventory control and the other one is the periodic review system, which is also known as the P system for inventory control. And then you will be doing some comparison between this P system and Q system. And these systems basically are fundamental systems used in various manufacturing industries and retail outlets and the all other inventory systems are certain variations of these two systems; ok.

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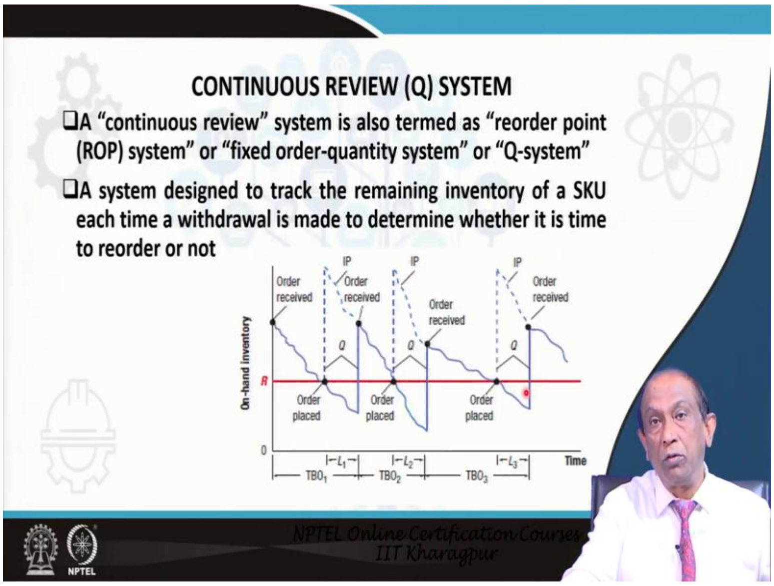

And, they are also embedded as part of decision support for materials management as well as for operational. A continuous review system is also termed as reorder point system or fixed order quantity system or Q system. Here a system is designed to track the remaining inventory of any item, whenever a withdrawal is made basically to determine whether it is time to reorder or not.

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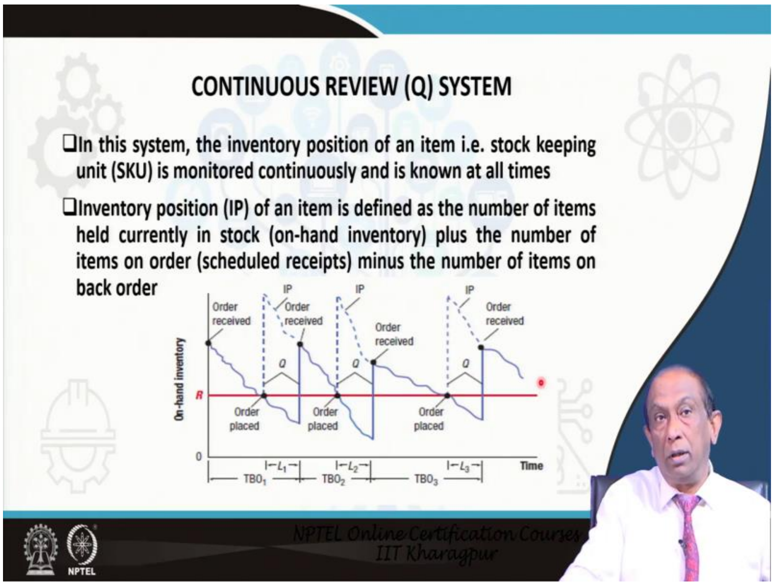

In this system, that is the Q system, the inventory position which is denoted by IP of an item is monitored continuously and this known at all times. So, basically these systems are implemented through computer control; without a computer base system, it is difficult to implement such systems.

So, what is inventory position? Inventory position of an item is defined as the number of items held currently in stock that is on hand inventory; basically in a factory environment, this is the stock at stores plus the number of items on order is basically the pipeline stock.

Purchase order have been placed on to the suppliers, but the materials have not yet been received; some materials are there in transit, that is why they are basically called pipeline stock minus the number of items on back order. Means in the previous cycle, there were certain demands from the customer; but since the factory did not have stock, they could not supply it to the customer.

But somewhat the customer agreed that, they can send them the required number of items during the next replenishment. So, those items which are yet to be delivered to the customers are basically called items on back order. So, those item whenever a fresh lot come from the supplier, those items need to be first delivered to the customer.

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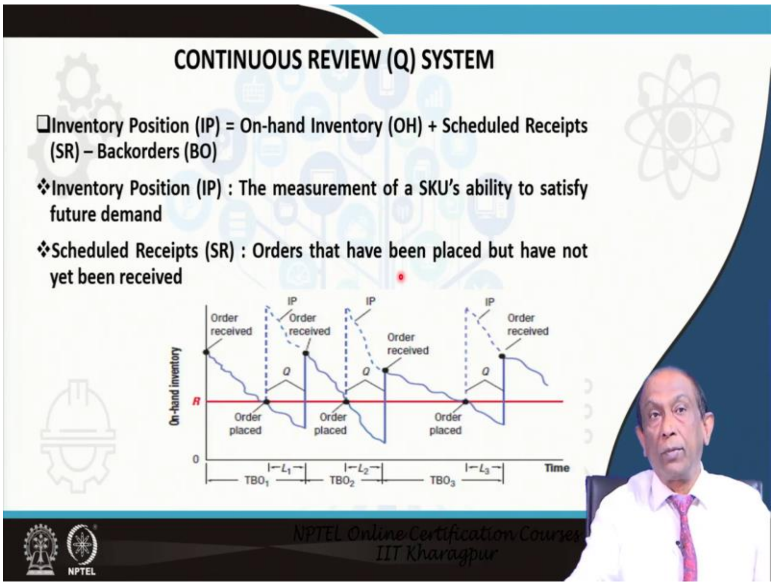

So, inventory position IP is basically on hand inventory plus the scheduled receipts which is SR minus the back orders BO. So, this inventory position is actually the measurement of an items ability to satisfy future demand. Scheduled receipts I have already explained; orders that have been placed, but have not yet been received.

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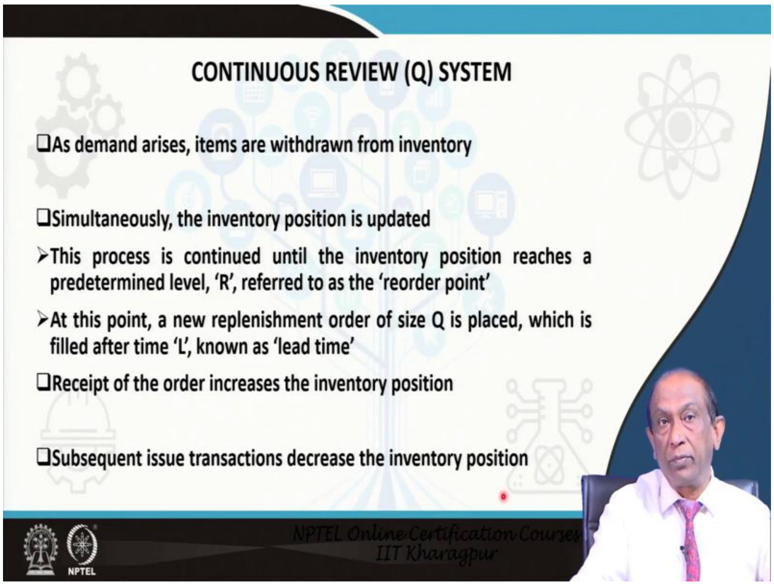

You see in the continuous review system, as demand arises, items are withdrawn from the inventory, which may be there in the stores or some other inside the premises. Simultaneously after withdrawal, the inventory position is updated. And this process is continued until the inventory position reaches a predetermined level which is abbreviated as R and referred to as the reorder point.

So, if you look at this picture you see, whenever a fresh lot comes in, the stock level goes up; then there is withdrawal, the stock level goes down. And whenever the stock level reaches this particular predetermined level R, which is called the reorder level or the reorder point, ok. Then fresh lot of order is been placed on to the suppliers and this new lot comes in at a time which is basically known as the lead time; from lead time is the this time gap between placement of an order and the fresh receipt of that lot.

So, from this point, after a time period of this lead time, which may be you know varying a new lot comes in, this is the cycle. Whenever the current stock level is less than or equals the reorder point, a fresh order with a size Q which we have already discussed, which is a fixed lot size equal to the economic order quantity is released on to the suppliers.

And after a time period of L which is denoted as the lead time, the new lot comes in and the stock again goes up. So, this is the pattern that is followed over the time. So, TBO 1 is the time between orders, here this is also the time between orders. So, this time between orders can also vary or fluctuate.

So, that is what this slide also we talk about; a new replenishment order of size Q is placed, which is filled after time L which is known as the lead time. And the receipt of this order increases the stock position or the inventory position; subsequent issue transactions will again deplete the level of stock.

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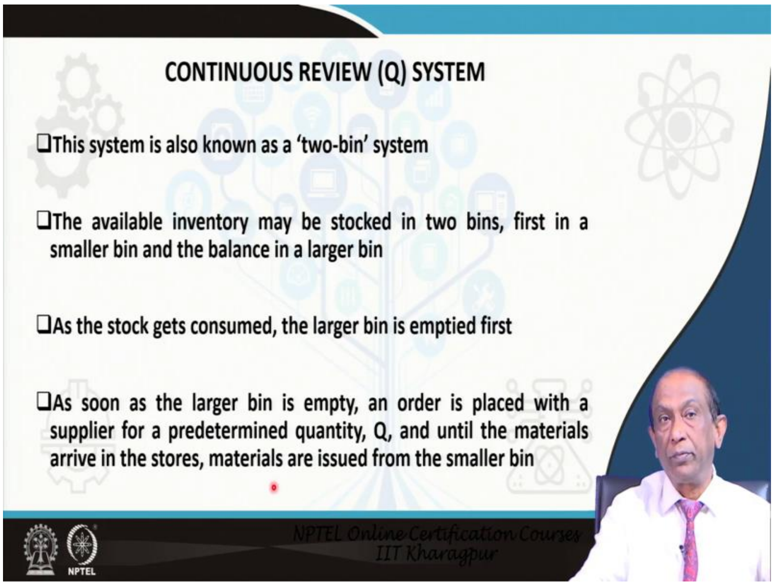

This system is also known as a two bin system. In many shops, they have implemented the two bin system; may be in our household kitchen for grocery items like rice, sugar, you know we can implement this two bin system. The available inventory in here may be stocked in two bins, first in a smaller bin and the balance in a larger bin.

As the stocks gets consumed, the larger bin is emptied first. And as soon as the larger bin is empty, a fresh order is placed with a supplier for a predetermined quantity Q, and until the materials arrive in the stores, materials are issued from the smaller bin. So, what you think, the smaller bin acts as a reorder level.

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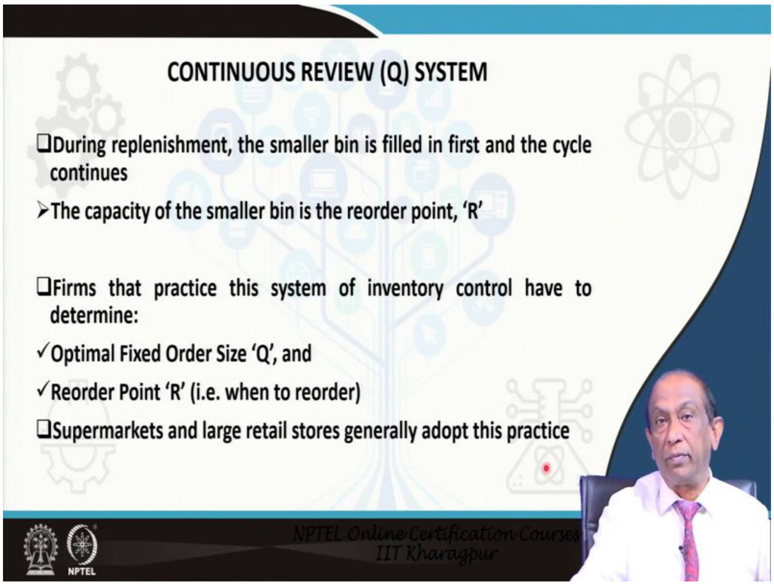

And during replenishment when the stock arrives from the supplier, the smaller bin is filled in first and the cycle continues. So, the capacity of the smaller bin is basically the reorder point R. Firms that practice this system of inventory control they have to determine; the optimal fixed order size Q, and the reorder point R, which will basically tell them when to reorder. Supermarkets, large retail stores generally adopt this practice.

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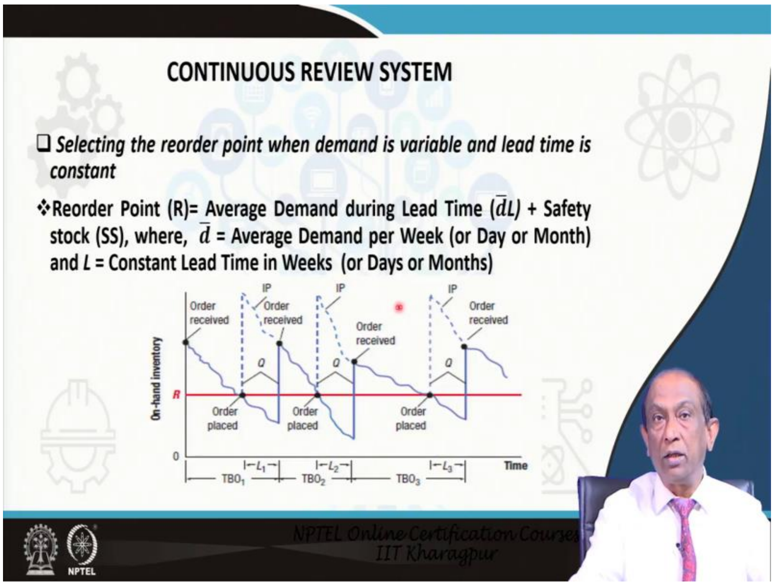

So, this is the, you know entire pattern of stock that fluctuates over time period. The reorder point R is basically the average consumption or average demand during the lead time, if the lead time is fixed; otherwise if the lead time is variable, then you have to take the average lead time. So, L basically can be the average lead time or if it is fixed, it is a constant value.

So, d bar is the average demand per week or it can be expressed as average demand per day or month whatever it may be. So, d bar denotes that average consumption level multiplied by; in this model we are assuming that lead time is constant and expressed in weeks or days or months. So, preorder point is d bar into L plus the safety stock, which we about which we have already you know deliberated at length.

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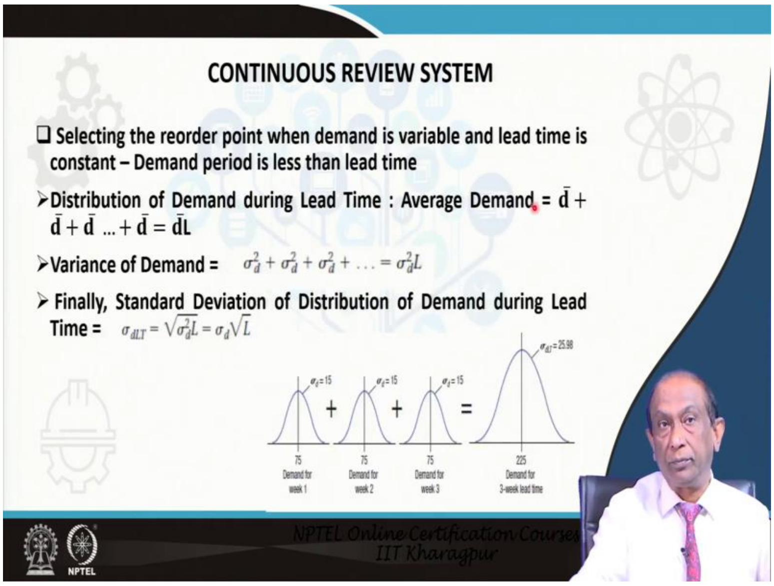

So, the most popular model that is used in practice is to select the reorder point when demand is variable; when demand is variable means, we know the average value or the mean value of demand and also we can determine the standard deviation of demand and lead time is constant. And the demand sometime it is, suppose it is expressed is in say demand per week. So, demand period is one week in this case, and suppose the lead time is three weeks. So, that is typically the case.

So, demand period is less than lead time suppose. So, in that case, the standard deviation of demand during lead time is given by the standard deviation of demand per period into root over of L, where L is the number of periods denoting the lead time.

And we have already explained to you in previous modules that, why this root L is coming; because the variants of demand over the lead time period is given by the sum of this individual variances over demand per period. So, sigma d is the standard deviation of demand per demand period.

And since the demand period is less than the lead time period; so we will have several such small distributions over the lead time period and the resultant variance is nothing, but L into sigma d square. And hence the standard deviation of demand during lead time is sigma d multiplied by root L.

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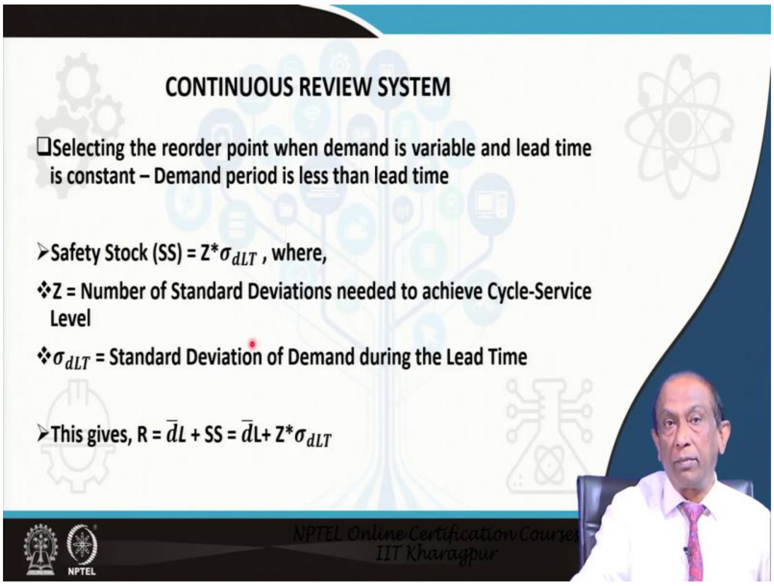

In that case, the safety stock will be given by Z multiplied by sigma of demand during lead time and Z we have already explained in the last module that is the number of standard deviations needed to achieve cycle service level. So, the expression for the reorder level in that case becomes d bar multiplied by L plus the safety stock, which is nothing, but d bar into L plus Z times sigma d L T.

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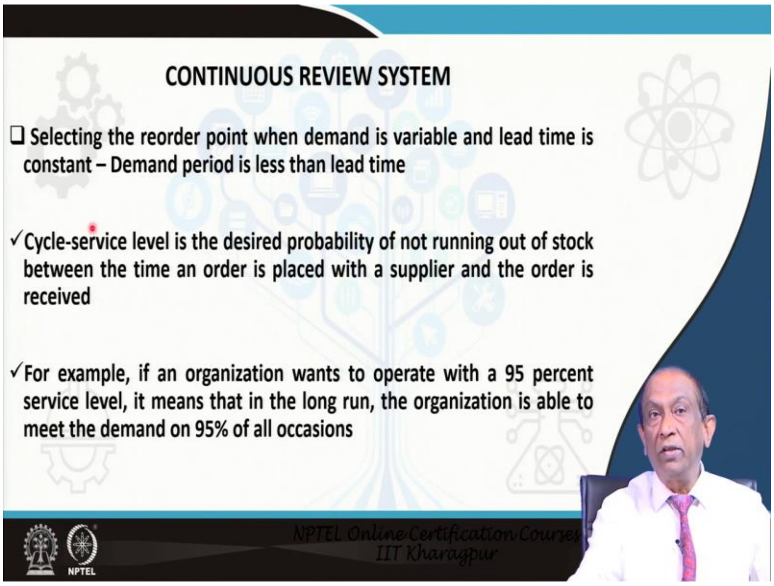

Cycle service level is the desired probability or chance of not running out of stock between the time an order is placed with a supplier and the order is received. That means, it is the probability of not running out of stock during one replenishment cycle. For example, if an organization wants to operate with 95 percent service level; it implies that in the long run, the organization is able to meet the demand on 95 percent of all occasions, there is the chance of stock out in that case is only 5 percent.

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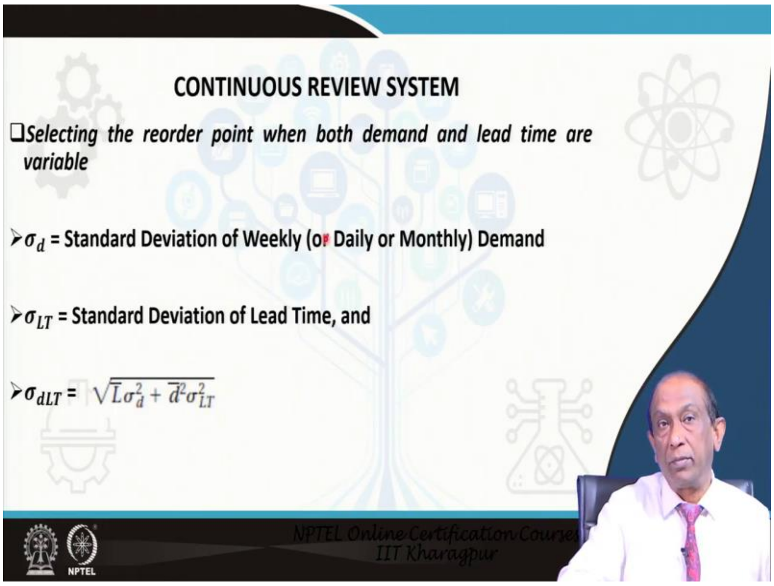

And the other commonly used case is that, when both demand and lead times are variable. In that case, the standard deviation of demand during lead time is given by this expression which we have discussed in the last module. This L bar becomes the average lead time and d bar is the average consumption per period. Sigma d is the standard deviation of demand per period, sigma L T is the standard deviation of lead time.

And just to express, sigma L T is expressed in days; we multiply it by average consumption per period to get how much quantity to express the standard deviation in quantity term, because this particular expression will be in terms of quantity. So, directly the units of the sigma d L T will be so many units or items per period.

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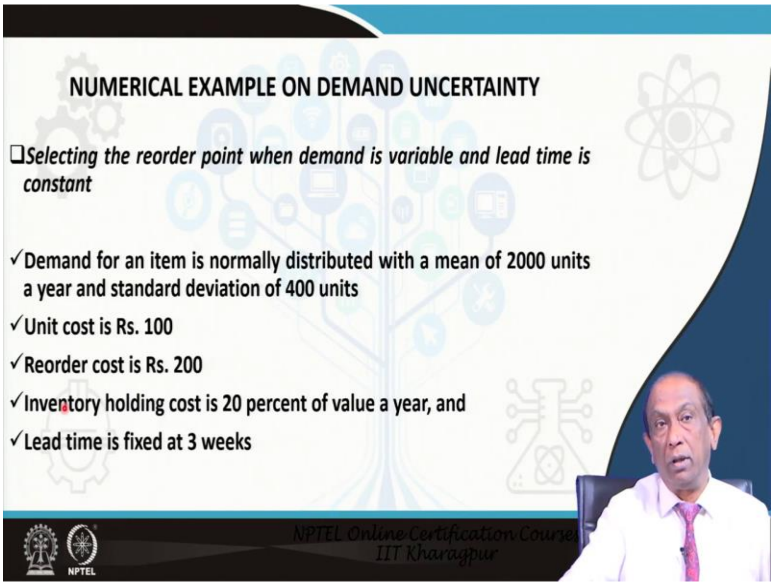

Let us look at some example. So, demand for an item is normally distributed with a mean of 2000 units a year and standard deviation is also given as 400 units per year. You need cost suppose is given as rupees 100, the reorder cost is given as rupees 200; the inventory holding cost is 20 percent of the value a year, may be the interest rate also. Lead time is fixed at 3 weeks; because we are going to discuss an example where the lead time is constant, only demand is variable, which is the commonly practiced case.

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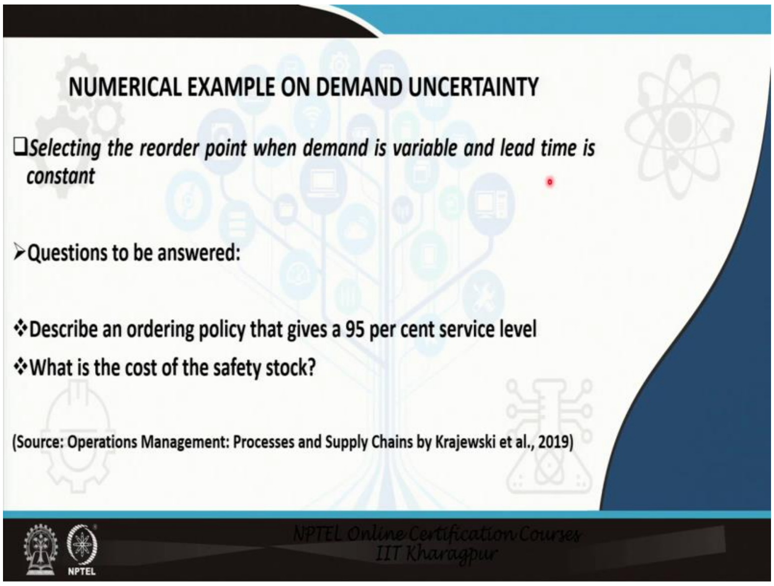

Questions to be answered, describe an ordering policy that gives a 95 percent service level. And under this condition, what is the cost of the safety stock?

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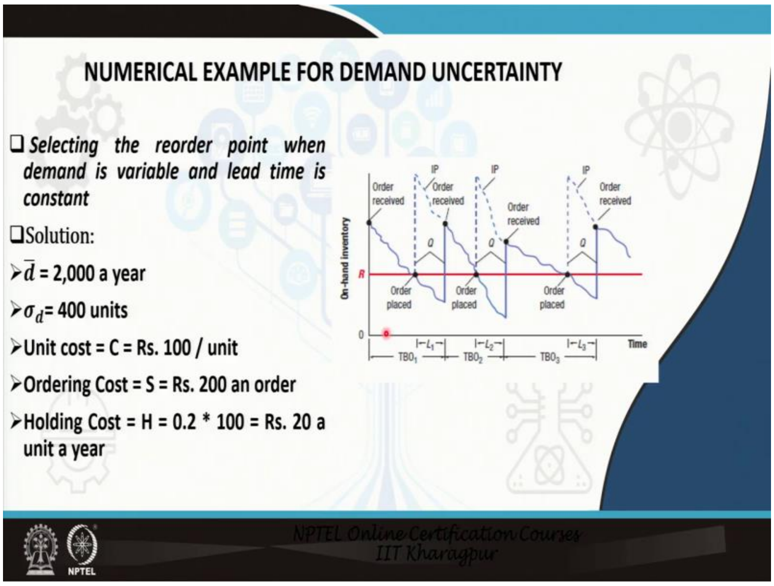

So, typical solution is the average demand is 2000 units a year, standard deviation of demand is 400 units per year; unit cost is given, rupees 100 per unit. The ordering cost is given as rupees 200 per order; holding cost is the interest rate or the holding rate multiplied by the unit cost of the item, which works out to be in this case rupees 20 a unit a year.

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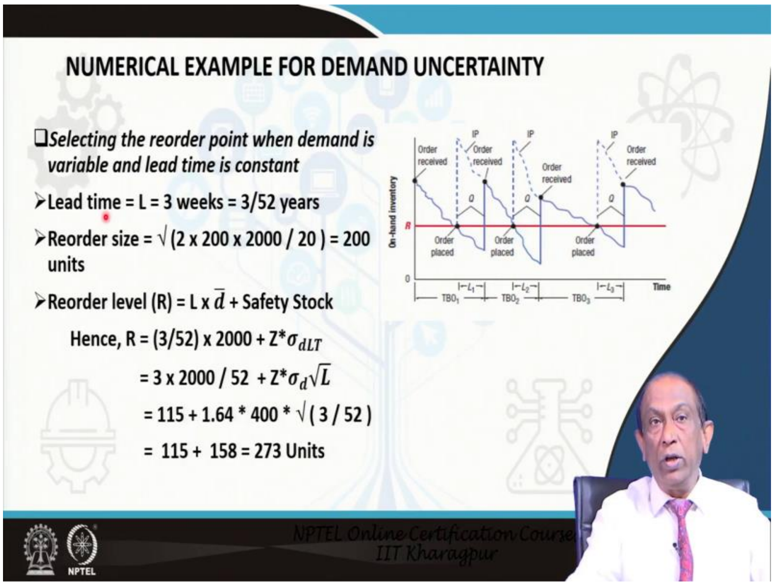

Now, lead time is 3 by 3 weeks and in a year there are 52 weeks. So, the reorder size that is economic order quantity using the expression for that, it works out to be 200 units and the reorder level works out to be this much. So, we substitute all the values; so works out to be 273 units.

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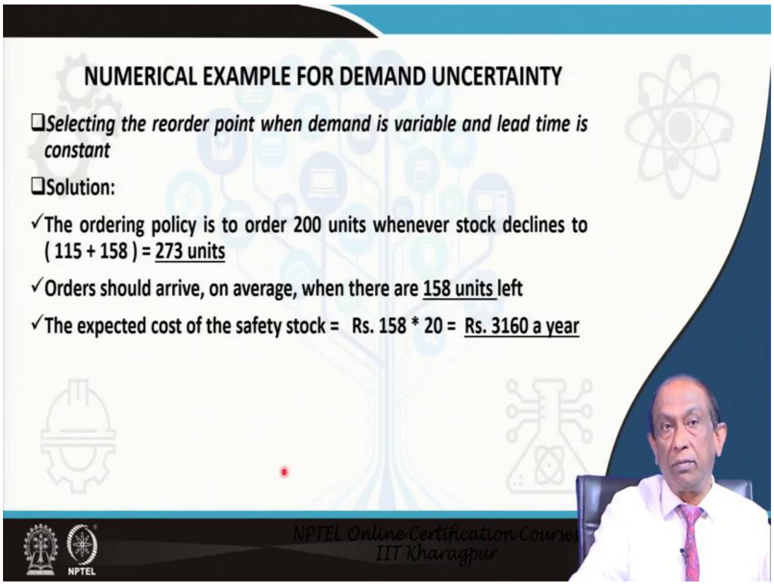

So, the ordering policy is then, to order 200 units, whenever the stock declines to this level of 273 units. So, in that case order should arrive on an average, when there are 150 units, 58 units left and the expected cost of the safety stock is this much.

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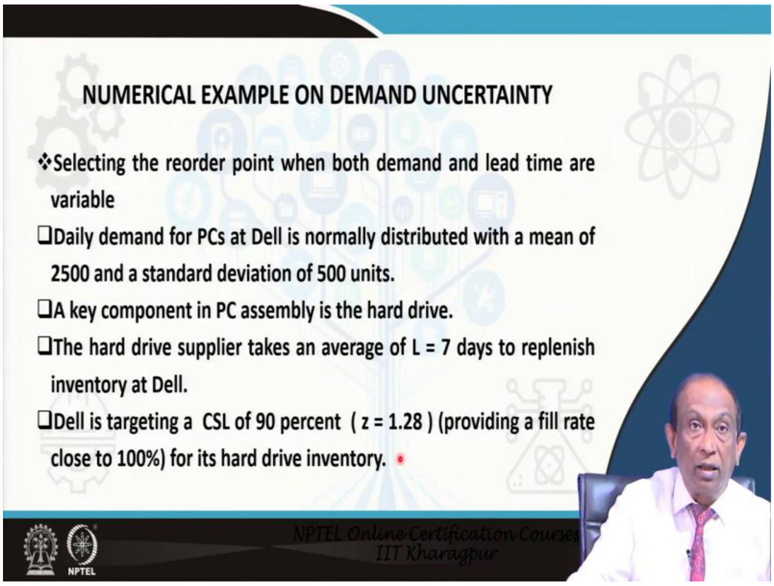

Now, we move on to another example; selecting the reorder point when both demand and lead time are variable. Very simple, this is also a normal case and we you know work out, let us work out one example. This example is very commonly you know illustrated, in various books it is there; daily demand for PCs at Dell is normally distributed with a mean of 2500 units and a standard deviation of 500 units. A key component in PC assembly is the hard drive.

The hard drive supplier takes an average of 7 days, which is basically the lead time to replenish inventory at Dell. Dell is targeting a cycle service level of say 90 percent for which the z value is 1.28 providing a fill rate close to 100 percent for its hard drive inventory that is the target; all this data are hypothetical; ok.

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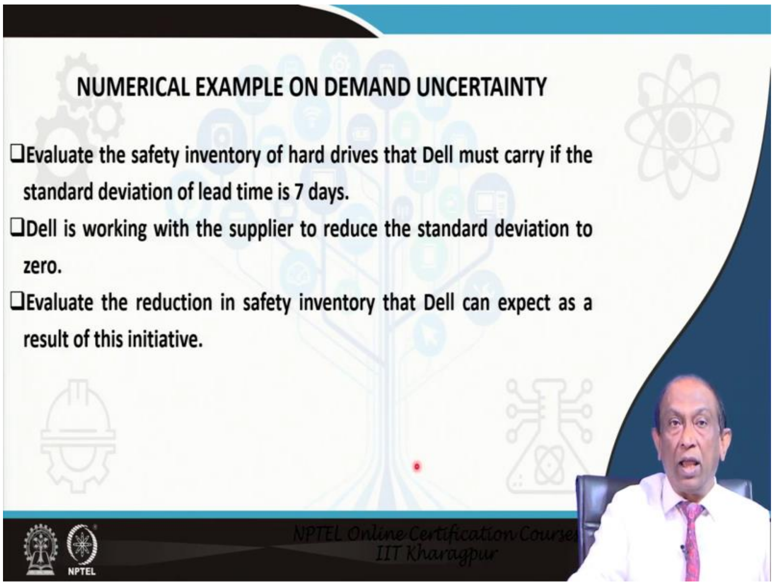

The problem is evaluate the safety inventory of hard drives that Dell must carry, if the standard deviation of lead time is 7 days. So, you see lead time is also varying with a mean of 7 days and standard deviation is also 7 days. The company is working with the supplier to reduce the standard deviation to zero.

In that case, evaluate the reduction in safety inventory that Dell can expect as a result of this initiative. This is a standard problem ok, used in almost all the books. So, once you determine the safety stock in such condition, then reorder level is nothing but you multiply the average consumption per period into average lead time plus that safety stock.

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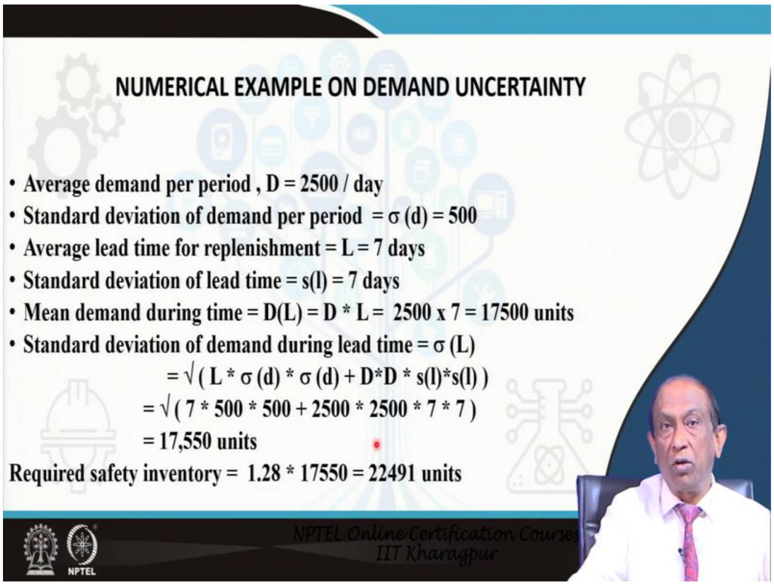

So, for this case, the average demand per period is this much; the standard deviation of demand per period is this much 500 units per day, average lead time for replenishment that is mean of the lead time is 7 days, standard deviation of lead time is also given as 7 days.

So, mean demand during this average lead time, average consumption during average lead time is 17500 units. And standard deviation of demand during lead time using the expression that, we had just talked about works out to be 17550 units. So, required safety inventory in this case is 22491 for a 90 percent service level.

If you look at the problem, Dell is targeting a cycle service level of 90 percent. So, that is the required safety inventory, ok. In that case, currently they have more safety stock. And once you determine the safety stock in this manner ok; then computing the reorder level is extremely easy and when the other parameters needed for computing the order size are given, computation of economic order quantity is also very simple.

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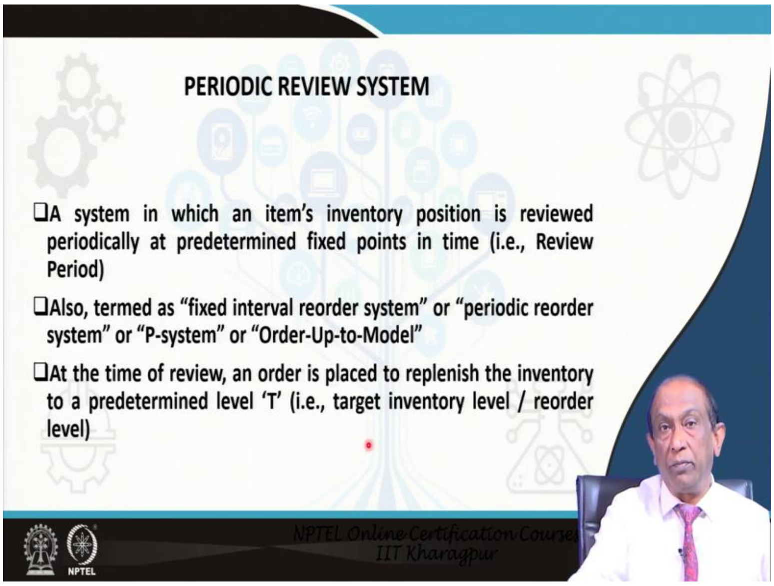

Next let us move on to the periodic review system, also known as P system, is also sometimes known as order up to model. In this case, an items inventory position IP is reviewed periodically, not on a continuous basis. So, at predetermined fixed in points in time say after 3 weeks or after say 4 weeks; at the time of review an order is placed on to the supplier to replenish the stock to a predetermined level, which is basically called the target inventory level or in some parlor it is used as reorder level.

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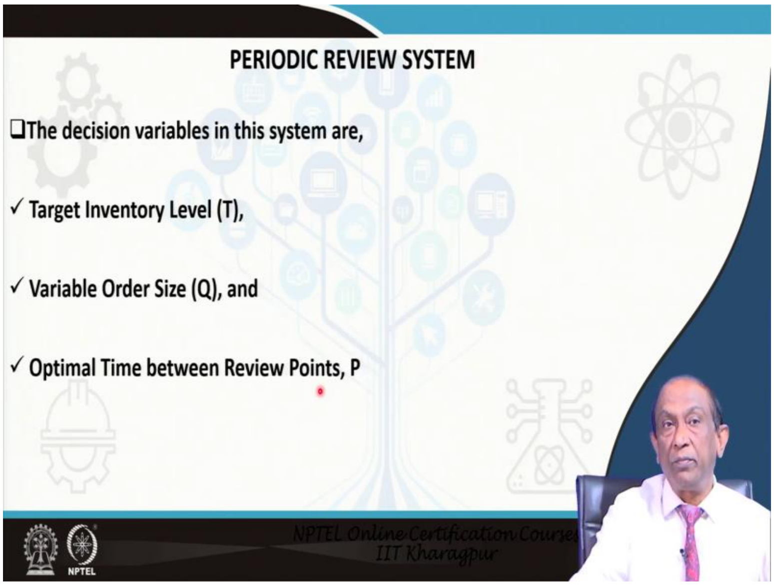

So, the decision variables in this system are what is the target inventory level, what is the variable order size, and optimal time between review points P; that means what is that interval after which we should review the stock position.

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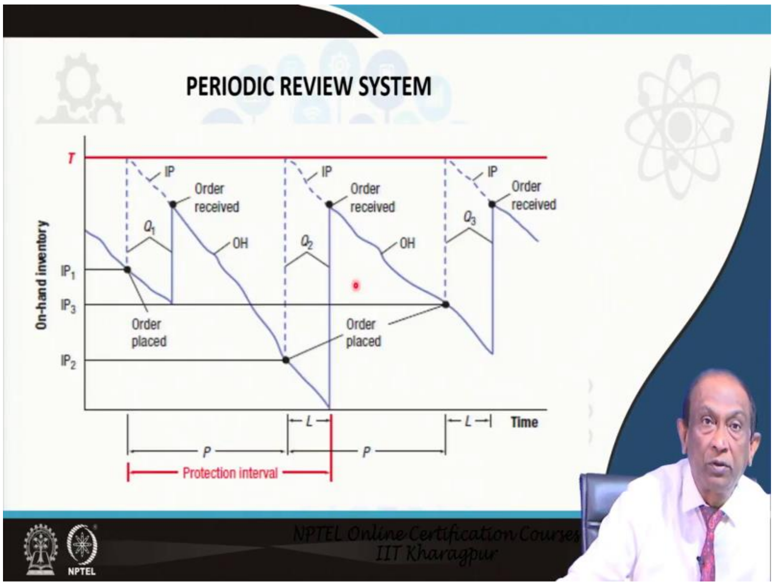

This T is the target inventory level; that means whenever see, this blue line represents the stock position. The y axis represents either on hand inventory or inventory position and you know how to calculate inventory position.

Periodically we review the inventory position and suppose at this point in time one review takes place; at that point in time, we place an order equivalent to the difference between the target inventory level and the inventory position. The next what we do? Again after a fixed period of time P, we review the stock position. And then place an order; since P is the fixed period and L is the lead time.

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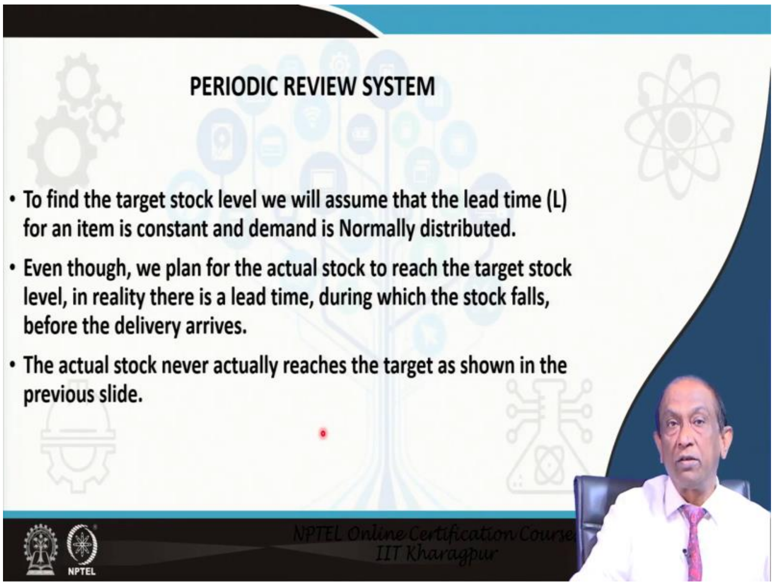

So, in this case you see, the protection interval is P plus L and that is why the safety stock under such situation is more than what we carry in a similar Q system. Since the periodic review system, the objective is to find the target stock level that is T. And in doing that, for sake of simplicity; we will be assuming that the lead time L for an item is constant and the consumption pattern or the demand can be described by a normal distribution.

So, here even though, we plan for the actual stock to reach the target stock level; because when we are placing an order, you have must have seen that the order size Q 1 is basically the difference between the target level and the inventory position. So, we are targeting that, whenever the fresh order comes in the stock will reach the target inventory position or the maximum inventory position whatever we call it.

But in reality, there is a lead time, during which the stock falls before the delivery arrives. So, the actual stock never actually reaches the target as shown in that previous slide.

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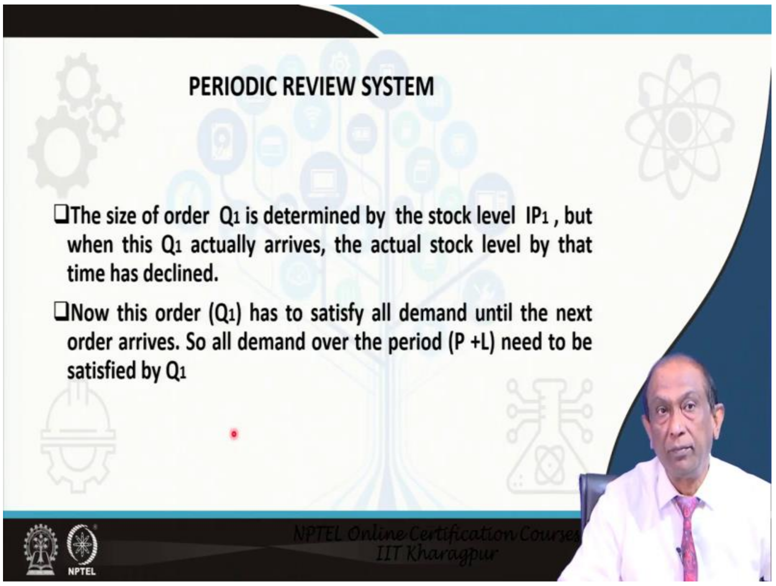

The size of the order Q 1 as I have already discussed is determined by the stock level IP 1; this difference actually the difference between the target stock level and IP 1 is of the size Q 1. But when this Q 1 actually arrives, the actual stock level by that time has declined. Now, this order Q 1 has to satisfy all demand until the next order arrives. So, all demand over the period P plus L need to be satisfied by Q 1.

This is the only point where you need to be slightly attentive that, you have placed an order; but you are receiving that order at this point in time. So, that protection that you have to provide for is basically should cover the consumption during the time period P plus L that is why this is the protection interval.

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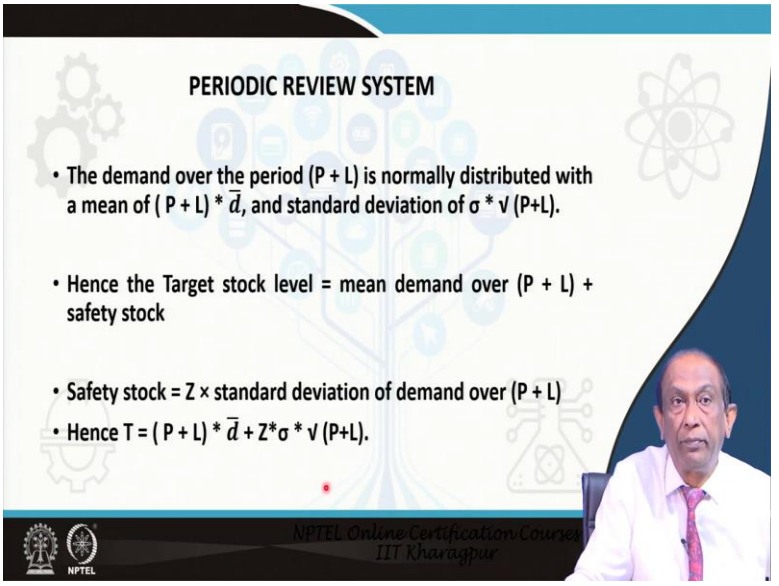

The demand over this period P plus L is normally distributed with a mean of d bar into P plus L and standard deviation of sigma multiplied by root over P plus L. So, you see, in the Q system it was only root over L; here it is root over P plus L. Hence the target stock level in this case is the mean demand over the time period P plus L plus the safety stock.

And the safety stock is equals Z that is the standard normal random variate, whose value will depend on the cycle service level multiplied by the standard deviation of demand over the period P plus L. Hence, the target stock level T is given by P plus L into d bar plus Z into sigma into root over of P plus L. This is the cycle that is followed in a periodic review system.

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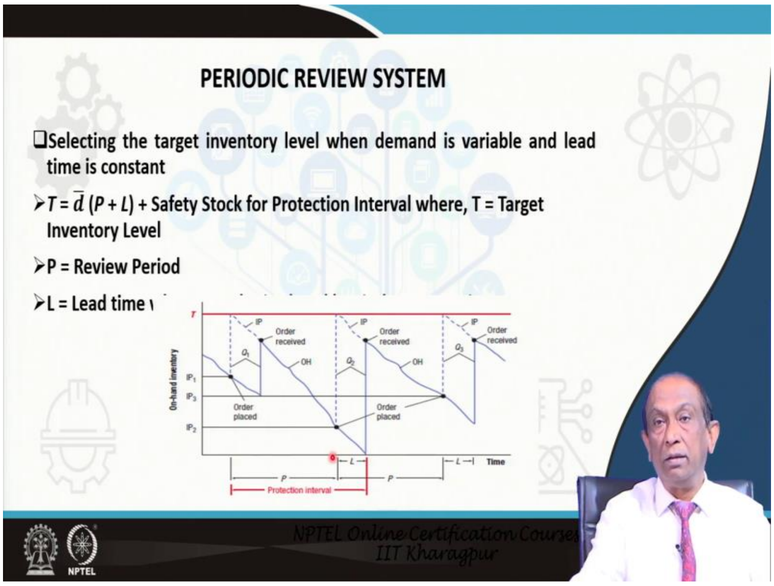

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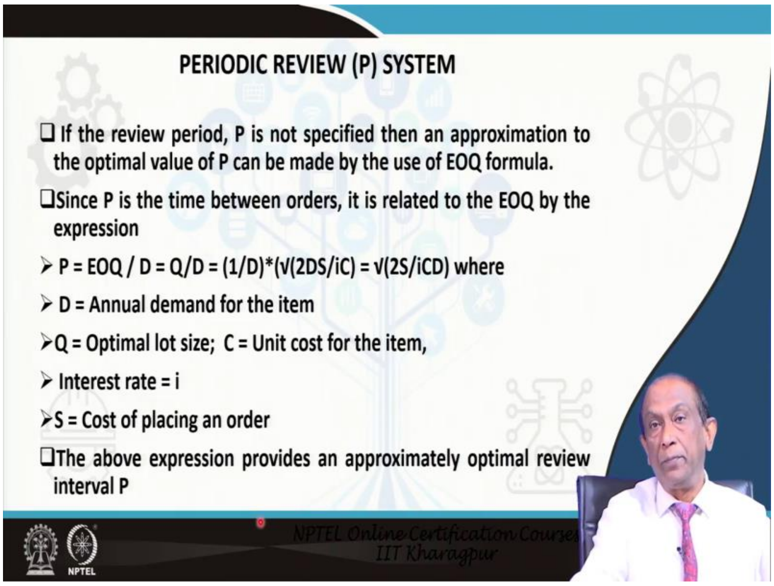

Now, in any problem, if the review period P is not specified; in some problems or in a real life situation, the management might dictate that the stock position be reviewed after a period of one month, but sometimes it may be necessary to determine the optimal review period. So, if the review P is not specified, then an approximation to this optimal value of review period P can be made by the use of economic order quantity formula. So, what do we do?

Since P is the time between orders, it is related to the EOQ by the expression POQ; P equals EOQ divided by D that means it is Q by D. And we know the formula for Q, so you just substitute. So, this becomes the expression for finding out the optimal review period or optimal review interval P.

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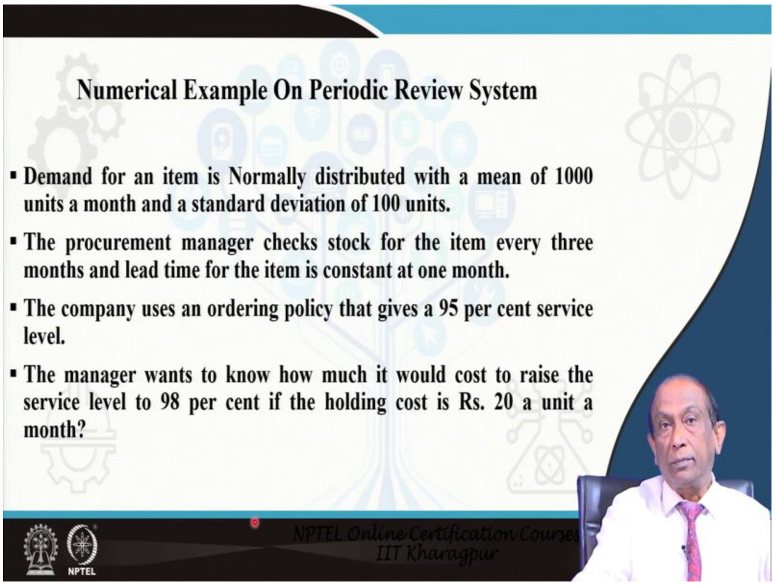

Let us look at one simple example demand for an item is normally distributed with a mean of 1000 units a month and a standard deviation of 100 units per time period; that means in the 100 units per month. The procurement manager checks stock for the item every three months; that means the review period is here three months.

And the lead time for the item is constant at one month. The company uses an ordering policy that gives a 95 percent service level. The manager wants to know how much it would cost to raise the service level to 98 percent if the holding cost is rupees 20 a unit a month?.

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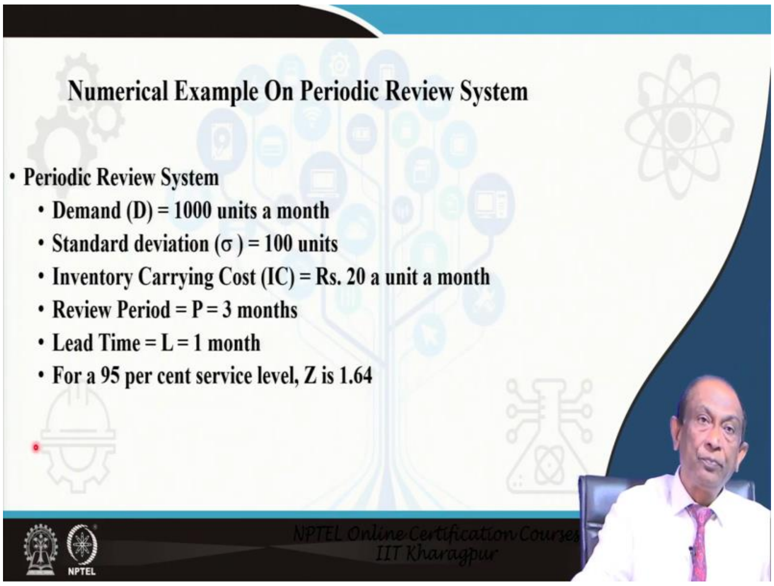

So, again a very simple, periodic review system; demand is given, standard deviation of demand is given, inventory carrying cost is computed, review period is given, lead time is given and the Z value corresponding to a 95 percent cycle service level is 1.64.

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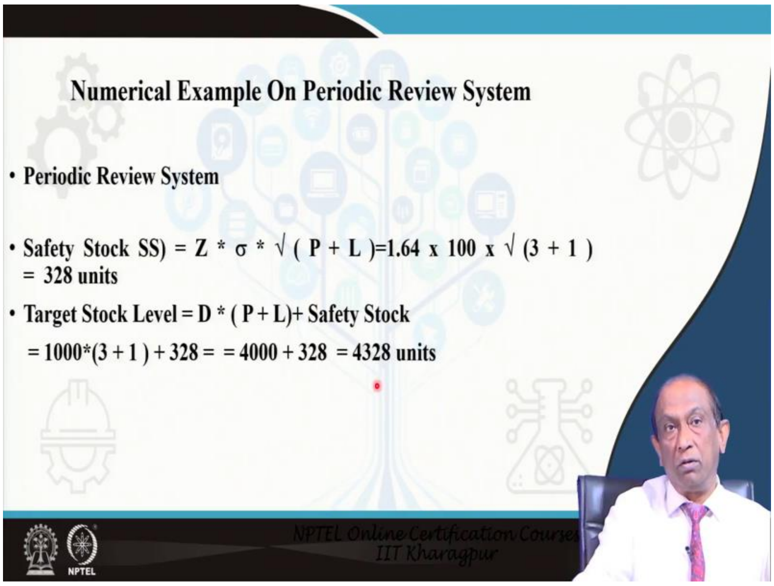

We just simply substitute these values in the expression for safety stock, which works out to be 328 units. Then the target stock level works out to be 1000 into 3 plus 1; this is the review period plus one month lead time plus the safety stock, which works out to be 4328 units.

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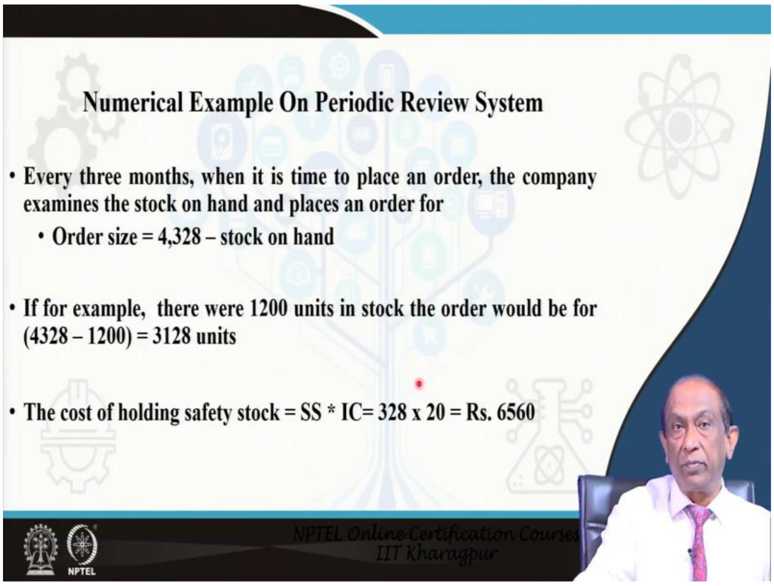

So, every three months, when it is time to place an order, the company examines the stock on hand and places an order for an order size which is the target stock level of 4328 units minus the stock on hand. For example, if there were 1200 units in stock; the order would be for 3128 units. The cost of holding the safety stock becomes this multiplied by this.

And if you would like to increase the cycle service level to 98 percent; find out the corresponding Z value for that, recalculate the safety stock and find out the difference between cost of holding that stock and this stock to find out how much additional cost will be incurred, if the cycle service level has to be increased?

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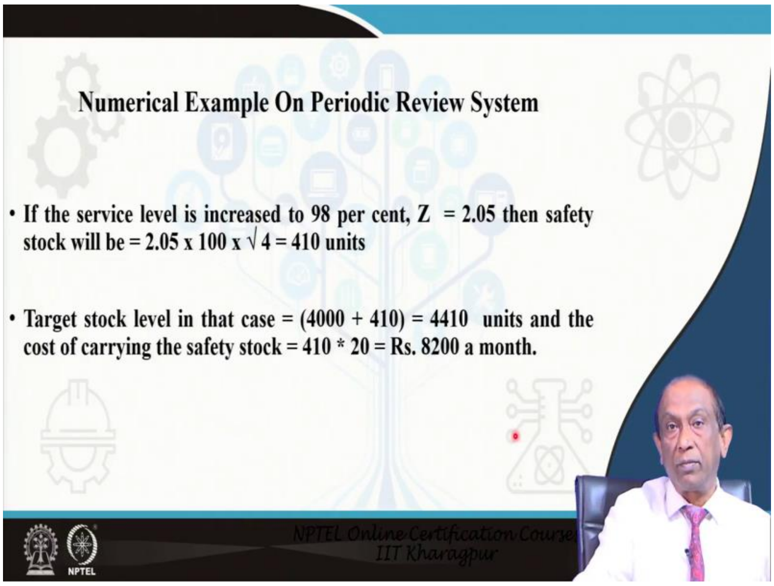

So, if the cycle service level is increased to 98 percent, the value of Z becomes 2.05; then safety stock works out to be 410 units. So, target stock level in that case becomes this much and the cost of carrying the safety stock will be this much. And the difference between this safety cost of carrying this stock and the previous one will give you the additional cost that the company management has to incur.

So, these kind of you know simple models can be embedded in a computerized systems and then shown to the materials manager. They can change the safety stock; they can change the target stock level based on their experience, judgment and other things; because mathematical models cannot take care of all the factors that governed the reality.

So, human interaction between the models, the system which are the components of decision support systems, they play a very important role. And also you see there is a physiological effect also; see if managers they feel that, if models are going to dictate everything in life, then what for we are here.

So, in order to give them some assurance that, their judgment or experience is also very important; the decision support system, the philosophy of DSS is that the user interface should be built in such a way that, this managers can play around with different parameter values and see the implications of that and then finally, choose that one which basically they feel will give them the best results.

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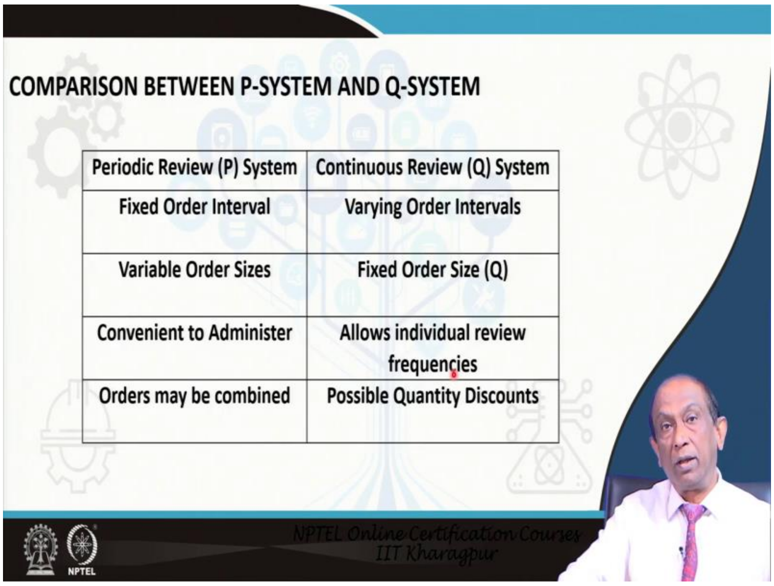

Sometimes for our own knowledge and experience, we need to know the difference between the P system and the Q system. The periodic review system is basically a fixed order interval, the review period is fixed; whereas in a continuous review system Q system, the order interval is varying; because you never know when the stock will touch the reorder point.

As we have seen that in the periodic review system, the order size is variable; but in a continuous review system, the order size is fixed, which is equal to the economic order quantity. Periodic review system is very easy and convenient to administer. Continuous review system allows individual review frequencies and hence it is best that you deploy a computerized systems for implementation of Q systems.

And in the periodic review system, you may combine several orders related to several items. In continues review systems, there is one advantage that you can you know take into consideration possible quantity discounts.

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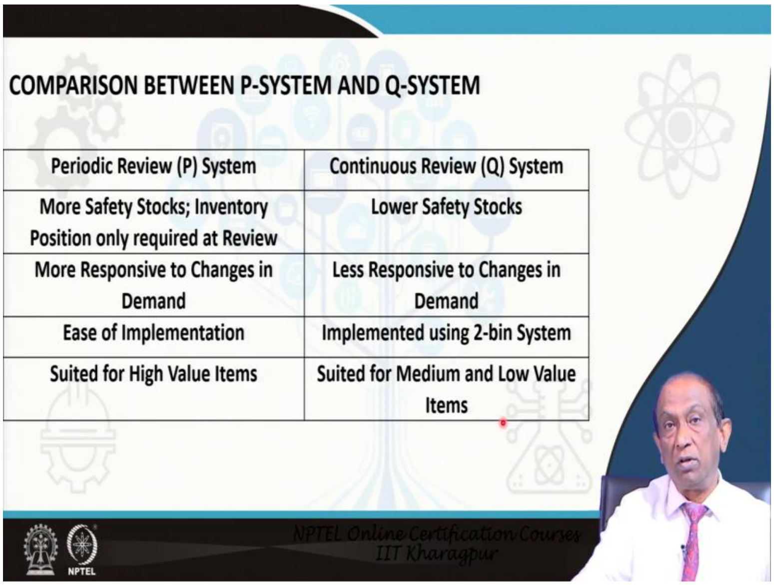

Periodic review system we require more safety stocks as we have shown; because the protection we have to give, keep the safety stock to you know provide protection over a period of P plus L, whereas in the Q system it is only over the lead time period. So, lower safety stock in Q system.

Periodic review systems more responsive to changes in demand; whereas in a Q system, it is less responsive to changes in demand. It is very easy to implement P system; Q system we have given the example of implementation using two bin system. Periodic review systems are suited for high value items; continuous review systems are suited for medium and low value items.

So, with all this knowledge, a DSS designer after interacting with the operating managers to find out their actual requirement and with his domain knowledge; can design the system such that the systems can be made flexible, wherein the initial output of the models can be modified based on the interactions that the managers they carry out with the computerized system. This is the way decision support system operates.

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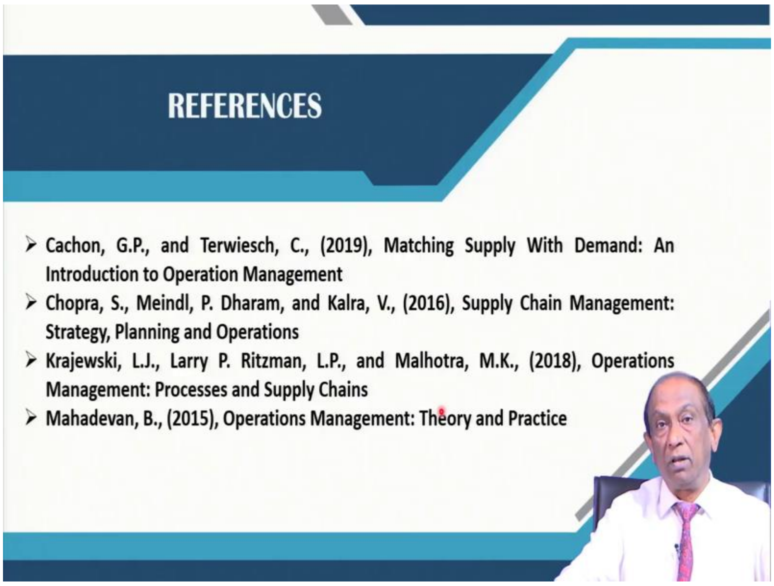

Thank you all! These are the references that we have used for this particular lecture.

Thanks a lot!