Welcome, friends. So, in our earlier sessions—the last two or three classes—we have discussed that for maximizing revenue, we can also use strategic pricing. We see that either by offering different types of pricing at different times or by applying some kind of promotional rules—when you are ready to reduce prices on special occasions. So that you can attract more customers; these customers may do forward buying. Or there may also be a possibility of market growth.

All these are possibilities through which you can maximize your revenue. In this particular session, we will focus on one more approach to maximizing revenue through pricing. This is known as an auction. And I hope most of you have already heard about this term, 'auction.' In our country, when the IPL started, the term 'auction' became very, very popular.

But in a large number of government sectors, auctions are very common—whether we discuss how licenses for spectrum communication are given or how licenses for mining activities are granted. All these are done through auctions because the government wants to maximize its revenue from limited available resources. But in the case of mining-related auctions or spectrum-related auctions, we have dual objectives. One, we want to maximize our revenue as a government, but in doing so, there may be a risk that the price for services offered through those resources may become excessively high for the common citizens of the country. So, therefore, these auctions are conducted very carefully—on one side, to generate more revenue for the government, and on the other, to

ensure that services made through these resources are not too expensive for the common man.

But then there are some other cases of auctions where we do not have these kinds of trade-offs, where only profit maximization or revenue maximization is the objective. For example, if I am auctioning a painting or some antique art, these are examples where we are looking to maximize revenue because there is no welfare angle associated with these kinds of auctions. So, in this particular class, in this particular video, we are going to discuss what the different types of auctions are. What is the significance of auctions in revenue maximization? And one or two important theories and examples we will be discussing in this particular session.

Now, the content, if we talk about it, we will cover the introduction of auctions, how auctions are used in practice, and types of auctions. Then we will discuss one interesting theorem, you could say, which is the independent private value theorem. We will also discuss some special cases like sealed bidding, first-price, and second-price auctions. And the equilibrium strategies for a second-price auction—all these we are going to discuss in this particular session. Now, when we start the process of an auction, technically, if I say that this is a mechanism for dynamically adjusting prices.

So, this is basically the definition, you could say, for an auction based on market conditions. If there are some customers who are ready to pay as per their paying capacity for availing the services, and therefore, you see how many customers there are and what they are likely to pay, you may keep increasing the price of your services to get more revenue from limited resources. So, that is the dynamic adjustment of prices. That is the dynamic adjustment of prices, where you see that there are still some customers who are ready to pay more, and to take advantage of their paying capacity, you will keep increasing the price. So, in this process, customers typically offer a bid price—the bid is basically the price a customer is willing to pay.

You must have seen in TV serials, in news items that how customers are ready and they are giving some kind of cards on which they keep writing the price they are ready to pay for a particular item. And then based on the highest bid available at a particular time, the

seller decides that which bid to accept. Some types of auctions are very close to posted pricing. What is this? Where the firm is giving a particular price and whether customers are willing to accept that price or not.

So, firm will say that okay 10 million. Now, if customers are there if they are willing to accept this price. So, you are posting the price or customer on their own may also give a suggested price where customer is giving their price that okay we are ready to give this much of bid to you and now it is up to the company the seller whether to accept that bid or not. Generally, you will see that the prices in auction depends on the number of customers bidding and their valuations for the item. If very few buyers are there for a particular product at the time of auction.

You will not get higher auction prices. So, for getting a higher value from the auction process, it is important that there should be sufficient number of large number of buyers then only the higher valuation will happen and then only you will get the higher revenue from this entire process of auctioning. Auctions are another important thing characteristic you should know about auction that auctions are considered price discovery mechanism. Because in the auction as we just said that it is a process of dynamically adjusting the prices. So, it is a price discovery mechanism that what is that price where the customer is giving maximum value to your product.

So, you on your own may not be able to suggest or find the suitable value for your price, but here, the customer themselves are suggesting the value they associate with your product. So, in this way, it becomes a price discovery process as well. We see auctions in a variety of cases, like in the stock exchange, which is very common. Now, some of you who operate in the stock exchange know that there are buyers and sellers, and the entire process happens with the help of auctioning. So, as a seller, I will place a bid stating that I have stocks of company X and am willing to sell them at, say, 200 rupees.

Now, if there is a buyer willing to purchase at this rate, my bid succeeds, and the buyer pays that amount. But if no one is willing to buy at 200 rupees, my bid will be unsuccessful. The reverse is also possible: I may want to buy stocks of a company and offer, say, 190 rupees per share. If a seller agrees to 190 rupees, they will accept my offer

and sell their stocks at that rate. But if the seller expects their stock to be worth 225 rupees,

my offer of 190 rupees will not be accepted, as the seller expects a higher valuation. Thus, all stock market transactions occur through the auction process. Because there are many buyers and sellers in the stock market, the auctioning process happens very quickly. We may not even realize that it is an auction process. But the entire stock market system operates through auction mechanisms.

Then, there are various other examples like, in many cases, real estate may also follow the process of auctioning. Arts, paintings, interesting collections, some kinds of industrial procurements, public contracts, natural resource rights (like I mentioned mining, etc.), and the rights for communication spectrum—all these things happen through the process of auctioning. Nowadays, a lot of PPP activities are also happening. So, the involvement of private parties in public work is also happening through the process of auctioning. So, in a variety of activities, maybe in our daily lives, we may not encounter the process of auctioning, but in B2B activities, you will see the tremendous use of the process of auctioning.

So, this kind of pricing, I suggest, is more popular and used whenever we have B2B businesses or when our activities are related to other business activities. Now, when we see this process of auctioning from the point of view of revenue management, then you have near-perfect first-degree price discrimination because, in this kind of situation in auctioning, you give the customer the choice of what they are willing to pay for this particular service or resource. So, it becomes a kind of near-perfect price discrimination —that, okay, I am a customer, I am paying 200 rupees for the same service, and there is another customer. Let us say if there are 'N' number of products available. So, 'n' number of products are given to 'N' different types of customers, and it is quite possible in the process of auction that every customer may pay a different price for the same resource. And in that way, it becomes a kind of first-degree price discrimination where the same product is distributed to 'N' number of customers based on price discrimination.

Once we talk about types of auctions, this meaning of first-degree price discrimination will be further elaborated. The second is revenue benefits because, as discussed earlier, there are either single prices, two prices, or three prices for the entire inventory available to you. Maybe, like we discussed, the price for one period, the price for the second period, and the price for the third period. But here, you may give an individual price to each customer, and therefore, the process of auctioning may give the opportunity of 100% capacity utilization. So, that gives you maximum revenue benefits because you are ready to adjust the price as per the market condition, and it is a dynamic pricing system in that way.

Auctions are important because, in this case, customers are also involved in the process of pricing. So, it takes the proactive approach of the customer. In other kinds of pricing approaches, it is only the seller who dominates the pricing-related decisions. But in the process of an auction, you are giving the customer an opportunity to participate actively and strategically in pricing-related decisions. Another important thing in favor of auctioning is that auction theory can often be used to design optimal mechanisms. These maximize revenues among essentially all possible pricing mechanisms, as we have already discussed. Due to customer involvement, it provides revenue benefits by utilizing all available inventory and considering the purchasing power and the value a customer is willing to pay for your product.

You are able to get the maximum benefit in this particular case. Now, another thing is that auction theories provide convenient ways to compare the revenues produced by different pricing mechanisms. As we have discussed in our earlier sessions, there are different types of pricing systems possible. If you go to finance and economics classes, they also have certain types of pricing policies, such as pricing based on market value or a cost-plus approach, etc.

Out of all those pricing approaches, auction theory can help you compare how much better an auction performs, particularly for intangible or abstract things. Where it is very difficult to determine value from the seller's point of view, and value is more realized from the buyer's perspective, revenue is maximized using auction theory concepts. So, auction theory, as we are continuously discussing, is a strategic consumer model where

the consumer or customer proactively and strategically participates in the process of value generation through pricing. There are different types of auction practices, such as traditional auction houses. These traditional auction houses may not be very popular in our country, India.

But these are very popular; some of the most renowned traditional auction houses are in European and American countries, and they hold weekly or monthly auctions where a large number of their members participate in different types of auction activities. Generally, these are done for art and other kinds of collections to be auctioned. Then, financial market auctions—I just discussed stock exchanges. So, that is another type of auction activity which happens for financial products. Particularly these days, for stocks, electricity, and bullion markets—all these are places where financial market auctions occur.

Government auctions, like various government services, also come through the auction process, where bidding occurs. In some cases, the person who is ready to offer the services at the lowest rate wins. Or, in other cases, where revenue maximization is the goal—like with natural resources—you grant services or contracts. So, in government auctions, it is generally the allotment of contracts to the buyers. Industrial procurement auctions—for example, crude oil is a very interesting case, which is an industrial procurement activity that also happens through the auction process. So, there are markets that actually deal in these kinds of commodities, and a lot of industrial procurement happens for crude, steel, coal, etc., which are industrial procurement activities.

Nowadays, because it is the time of e-commerce—particularly if I remember companies like eBay— They have pioneered online auctioning activities, and following eBay's lead, many other organizations are conducting online auctions. I have seen that online auctions are also happening in the travel industry, where different airlines offer online auction activities for securing a particular seat. So, that is a very new phenomenon in the process of auctioning in our practice. Now, let us see what the different types of auctions are that you can do.

So, there are different types of categories in which we will discuss types of auctions. So, in the first category, which we call standard auction types. So, there is a system of English auction, an open ascending auction. Here, we consider that there is a product, and for that product, you have a particular price. At this price, all those buyers who are ready to give value for this product will raise their hands. After this, the price will be increased, and for the next higher price, let us say two buyers are raising their hands.

Then, the price will be further raised, and the buyer who is ready to pay the highest price —because that customer still values the product at that high price—the product will be given to that customer. This is the most common type of auction process, also known as the English auction process. Just opposite to that is the descending auction process. Now, in the descending auction process, it is interesting that we have, let us say, N products. Now, in the N product, we have—let us say N equals 3 in our case—I keep a particular price, and at that particular price, there are some customers who are ready to give value to the product at that price. Now, let us say at N equals—sorry, at P_1 equals something—N equals the customers who are ready to give value. These are just one customer who is ready to give value at that high price.

Now, I am reducing the price to P_2. Now, two customers are ready to give value at this lower price. I will further lower the price to P_3, and now exactly three customers are considering the value at this lower price. So, I will give this product at this lower price to these three customers. Because I have three products, and now exactly three customers are ready to pay at this lower price.

So, I will give my product at this lower price to these number of customers. So, this is known as Dutch auction. So, Dutch auction is more popular when you have more number of products and you want to see that optimal price at which exactly that number of customers who are ready to give value at that particular price that is your optimal auction price. Now, another system of bidding is there, bidding means here we as a customer we offer a particular price and this bid is given in a confidential sealed envelope and when the bid is opened. So, the seller will put all the bids in some kind of descending order and the bid which is having the highest value or top bid that bid is given the product that bid is given the contract.

Generally, this is done in the government contract systems. So, we just discussed that there is a government auction happening and in that government auction we generally use this sealed bid first price auction system that all the possible customers they are giving their bids and the highest bid is given the order. Then another interesting type of sealed bid process is here you are giving your bids, you are giving a bid of V_1, somebody is giving V_2, somebody is giving V_3 etc. So, if there are N bids coming, so these are the different values which are offered by the possible customers in their envelopes. Now, again in this case you are going to give order to the person who is giving you highest bid.

You are going to give the order to the V_1 bidder, but he will pay this is the pay. He will not pay what he is bidding by bidding the highest he is able to get the contract, but he will pay the second highest bid V_2. So, actually his own price is helping him to get the order, but the price which he will be paying for getting this resource that is the second highest bid. So, this is another type of auctioning process and the difference if the difference is more it appears that you have unnecessarily increased your price because of that but in this case generally the because all these bidders they are independent and mostly the sealed bid process happens in a confidential environment. So, they all behave in their own rational manner and in that rational manner this person V_2, if he is not willing to do the work on his own, but he will increase his bid in such a manner that it should be just slightly lesser than V_1.

So, that if V_1 gets the order he has to pay sufficiently high price if the gap is high between V_1 to V_2 this higher gap is actually benefiting the customer V_1. But if the gap is narrow, this you can term as loss to customer one because he has to pay almost the same price for which he has bid. So, all these things are the important type of auction types. Now, here one or two important things we will like to tell you. One is the reserve price.

Though in the process of auctioning, We say that the prices are adjusted as per the market condition this is the dynamic pricing system but in many cases seller may keep a reserve price also that okay I will sell my product not below this particular price. So, that is a reserve price and in many times you must have heard about IPL auctions also that there is a base price for every player. So, that base price is basically the reserve price. Similarly, in the government services also government may keep a base price that okay we are

going to give you services at this minimal price. Similarly, one more important thing is reverse auction and in the reverse auction what we are going to do that we are going to follow the system of how by increasing the value you are going to get more and more revenue, but at the same time you have to see that more value if you are extracting from the contractor.

For example, if I am looking for mining of coals and if I am looking to give the contract of coal mining to a contractor, I will expect that as a owner of the resource Government of India, I should get maximum revenue from this coal mines. But if mining prices are so high, the electricity produced from that expensive coal will also be very very expensive and the burden of this high coal price will go to the consumers ultimately because then the higher prices of electricity will create a burden on the public. So, we want that price of the electricity should also not go beyond a particular limit and we should also be able to maximize our benefit in that case. So, on one side you want to maximize the value and on the other side you want to keep the cost of ultimate product in check also. So, therefore, this becomes a kind of a reverse auction system that we are moving in two different directions and then we look for one optimal balance where you get the appropriate cost at a particular level of value.

So, you see the benefit from both angles, and that becomes your optimal price for the auction purpose. Then there are other kinds of auction activities, like multi-unit auctions. Multi-unit auctions are where you have N number of products, and for these N number of products, you have different auction rates for different types of units. There are also combinatorial auctions, where contributions come from different types of auction activities. So, these are not very popular types of auctions.

The first four, along with conditions like reserve pricing and reverse auctions, are the ones that generally follow in any standard auction process. Now, let us look at a very important theorem in auction theory, known as the independent private value theorem. In this independent private value theorem, the focus is on the revenue generation property of auctions, largely ignoring the welfare aspect, which was discussed during our reverse auction process, and its allocative efficiency properties. Now, how do we do it? We consider an auction where we are selling to, say, N types of customers.

All of them have the same objective and the same kind of product, with no difference in the product. For example, in the IPL, we are not selling homogeneous products because there are many players with different skill sets. So, the IPL auction is an example of heterogeneous objectives. But if I talk about coal mines or different types of cars, etc. These are examples of more homogeneous auctions.

Out of N customers, ith customer is giving the value at V_i. Now, this value that how much value I am giving to a particular objective that is a very confidential information and different customers are giving different value like first customer giving V_1, second customer V_2, ith customer Vi and the last customer N is giving value V_N. Now, there is no order that V_1 is greater than V_2 and V_I is greater than V_N. But you can easily understand that there may be and all these information is confidential. So, that distribution through which these values which are given by customers that we are calling as F distribution.

Now, we consider that as new customer is giving a value in this system that is a higher value. If a previous customer has given some value V_A. So, if V_B is the next value this next value will be higher value. So, F distribution is strictly increasing with a continuous density function F and has bounded support on the interval [0, $\underline{v}$]. So, that $F_{(0)}$ is 0 and $F(\underline{v})$ is 1.

Now, customers have different valuations and all know that F is not equivalent to saying all customers are same. So, all the customers are giving even though the product is same, but all these customers are giving different valuation to the same objective because of value they are perceiving in that particular objective. Now, that was our independent private value theorem. Now, another type of interesting analysis which you can do in informal analysis of sealed bid and second price auctions. However, let me tell you that we generally do not find many cases of this second price option.

Mostly, we do the sealed bid first kind of analysis. Because in that case, the customers are giving their bids in a sealed envelope, and they are charged on the basis of the highest bid, whoever is giving. So, you need to see what your bidding strategy is, and the bidding strategy requires that you should be able to understand the strategy of your other competitors also. We see that all the players who are going to put their bids in that sealed

envelope are equally rational. They have complete information about their other participating customers, and in light of that available information, here comes the interesting concept of game theory also in application—applying the principles of game theory, we can actually decide our optimal bidding strategy.

And those who are interested can read about game theory and game strategies, in which the Nash equilibrium comes into play for deciding our optimal bidding strategy. So, with this, we have discussed the different types of auction strategies, and we saw how we need to decide our optimal strategy whenever we are in the process of getting the maximum revenue using the principles of auction. That is the end of this particular session. Thank you very much.