Introduction to Market Structure
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Module 3: Perfectly Competitive Markets
Lecture 9
Optimal output and supply curve of a firm

Hello, welcome to my course Introduction to Market Structures. So, today we are going to start Perfectly Competitive Markets. So, from today actually we are starting the market structure. Before that we have done some preliminary things that is, those are required to do this analysis.

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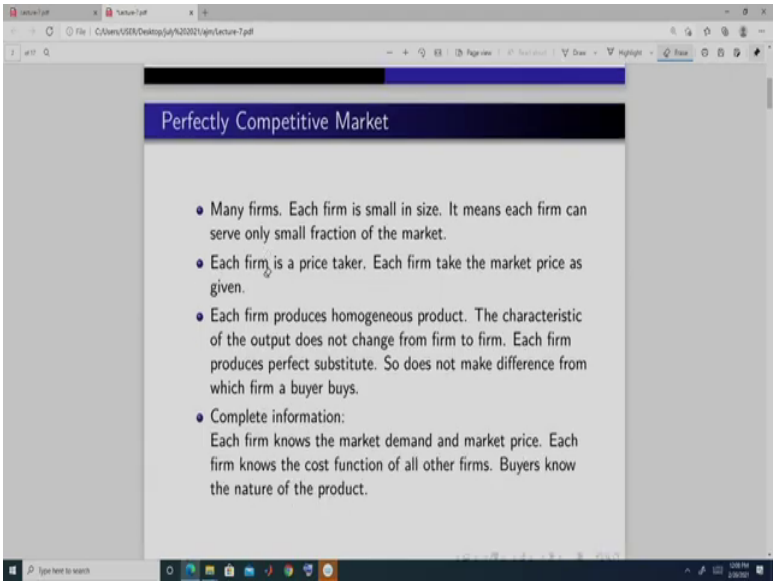

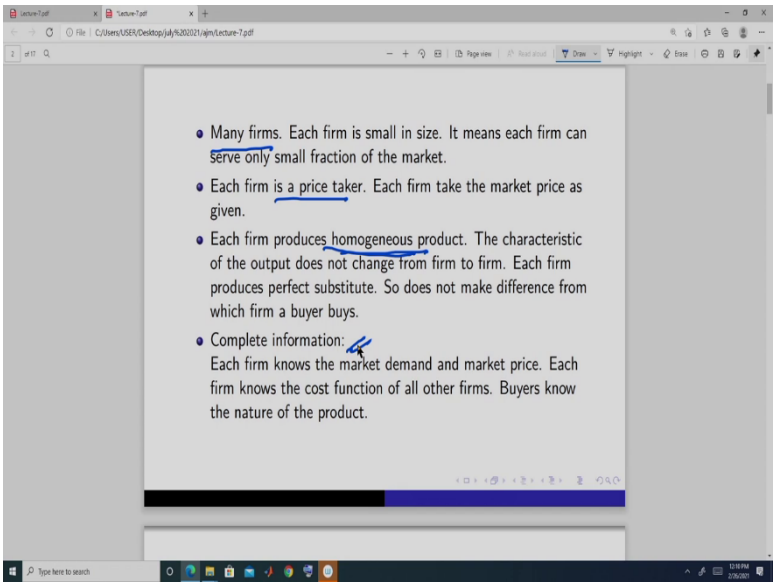

So first thing that we are going to do is what is Perfectly Competitive Market? In a Perfectly Competitive Market there are many firms. So, first characteristics is the many firms and each firm is small in size, it means that each firm can only serve a small fraction of the market, each firm cannot provide to a big chunk of the market.

Next each firm is a price taker. What do we mean by price taker? That the market price or the price at which a consumer is buying that good. that price is not determined by the firm, by an individual firm. Each firm takes that price as given and then it and only decides the output that is going to produce, okay. How that price is determined, we will do that later, okay.

So, first we assume that each firm takes the market price as given; that is the price at which consumers are buying that product. Next, the goods that are being produced by these firms are homogenous; that means that they are; suppose there are three firms, firm 1, firm 2, firm 3, output produced by each of these firms are going to be similar, 100 percent similar.

So, it means that whether I buy from a firm 1 or buy from firm 2 it does not matter. So this is the homogeneous product, okay. This assumption is very important. So, then what happens? So, actual identity of the firm does not matter because the products are homogeneous and next assumption is the complete information assumption.

What do we mean by complete information? It means that each firm knows the market price completely. If there is no uncertainty in the market price, so firm knows what is going to be the market price. Second, firm knows what is going to be its cost function, so if there is no uncertainty with respect to the cost function, like the input, price of the inputs are completely given and they are certain, okay.

So, the firm while deciding how much amount of output to produce, so it will decide how much amount of inputs to produce and doing that, in that decision there is no uncertainty involved, okay and the buyers also know the exact nature of the product, also know the price of the product, so there is also no uncertainty in that respect.

And each firm knows what are the types of firms they are there in the market; that is, the different production technology or the different product firms with different production function that are present in that firm market, okay if there are, so it may happen there are

some firms which are using a different technology and some firm may be using different technology, so that these two types have different production functions.

So, firm knows that there are these many of these types of real firm and there are these many of these many firms, okay. So, there is no uncertainty involved in this.

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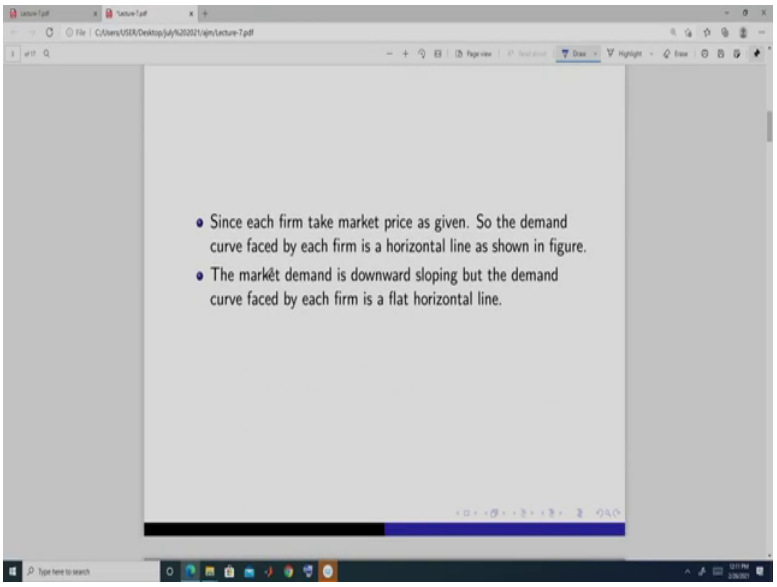

Now here, first the assumption that we have made, so these are the main important assumption , okay and there is another assumption, but we will specify that later, not now. It is regarding free entry and exit of firm and since we are not dealing with that right now, we are not specifying it, okay. Now the next is, that from the first assumption that the firms are always price takers, that means they cannot determine the market price. It means that the demand curve faced by each firm is a flat horizontal line, okay. So, you will see what do we mean by this.

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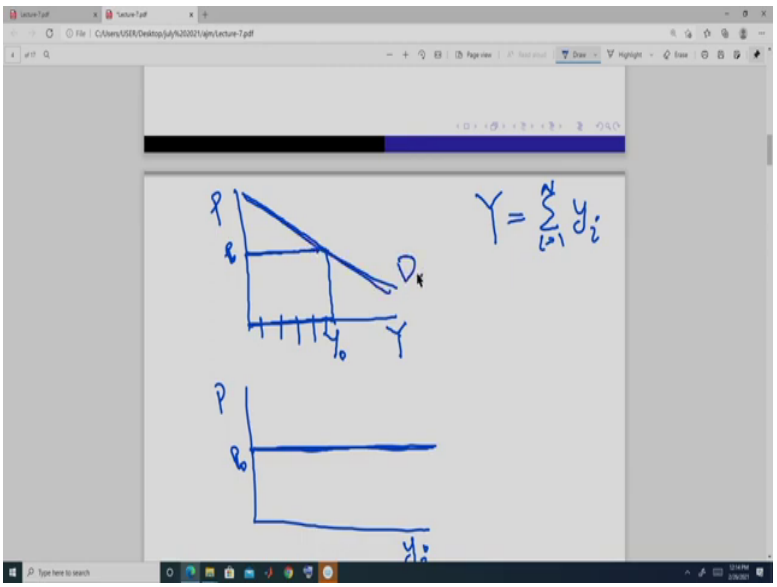

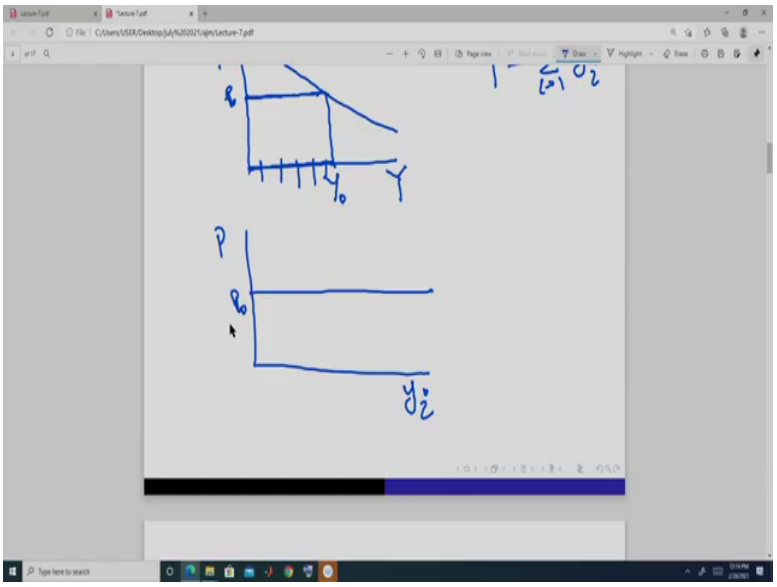

Suppose, this is the market output, okay and this is the price, so market output is actually sum of the output of each firm and we have not yet specified the number of firms present in this market but suppose there are n firms and this is, each firm is producing Y_i units of output, okay and this is the market output. And suppose this is the market demand curve. We know how to derive a market demand curve, it is horizontal summation of the individual demand curve, right?

And suppose it is like this. Now suppose market price is this p, okay, p naught suppose, then the total amount demanded in this market at this price is this much-Y_0, right, so each firm is going to produce some amount, suppose like this, some like this, some like this and then the sum is going to be this much. So, the market demand curve faced by each firm is simply this

horizontal line, so we take, suppose any firm Y_i and price here the market demand curve is like this at this price p naught, so it is flat.

Whatever amount of output it wants to produce it can produce and sell, that is the, because it cannot determine the price. And actually, their capacity is going to be so low or so that is why they will not be producing that much amount of output, okay, we will see that. So, the demand curve faced by each firm is this a horizontal line.

Although the market demand curve is this, this is the demand curve for that commodity, okay. Suppose, like take for example, the agricultural goods, so agricultural markets are in many times assumed to be perfectly competitive in the sense that the farmers when they are selling they cannot determine the price at which they are selling. So, they take the price as given, okay. So, whatever amount they want to sell they can sell at that price. So, the idea is this, okay.

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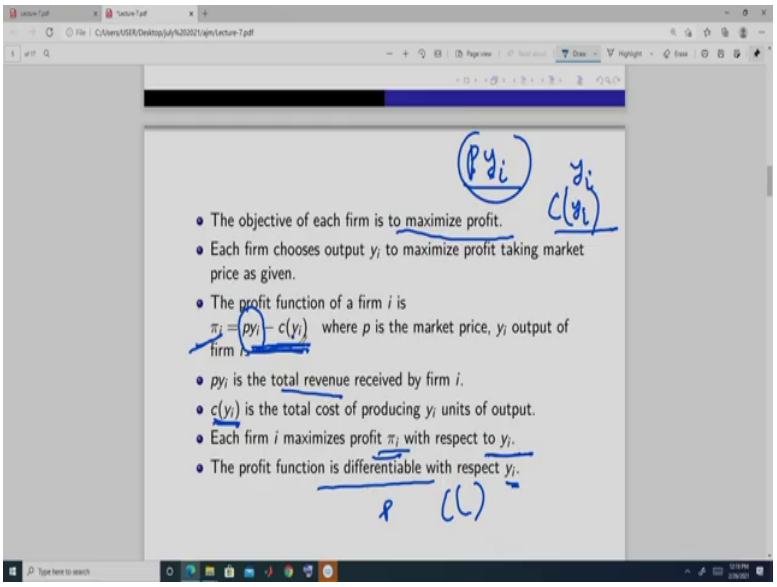

Now, we move to the objective of this firm. So, each firm wants to maximize profit that is their objective. Now, what is profit? Profit is while selling your output you will be selling at some price, so this price into the total amount of output you are selling will give you the total revenue minus the cost that you are going to incur while producing that much amount of output is your cost.

So, this is your profit- $\pi_i = py_i - c(y_i)$, where this term p into yi, this is the total revenue, this is the total revenue because this is price firm cannot decide the price, it takes it as a given, it only deciding the output, suppose it is a firm i is producing yi units of output, so this is the total revenue and there is a cost function, we have derived the cost function in the last class and this is the total cost suppose.

To produce yi units of output, the cost a firm incurs is suppose this- $c(y_i)$. Now, we are not going to specify what kind of cost function this firm has, we will come to it later on, okay. So, the profit function is actually total revenue minus total cost, okay. So, firm i or in fact any firm i wants to maximize this by choosing an appropriate y_i, okay. So, for this firm the p is given, the cost function is given and based on this, it has got a profit function which is price into quantity, it wants to sell that is the total revenue minus the total cost, okay and this is the total cost it is incurring for producing yi units of output.

Now, here firm wants to maximize this function, this is profit function with respect to yi- $\pi_i = py_i - c(y_i)$. Now, here we assume that this profit function is differentiable with respect to yi, okay. This is not that strong assumption because we know that the cost function are differentiable with respect to yi, right. We have done that in the last class. Why we have got it in that firm?

Because the inputs, that is labor and capital are continuously divisible and they can be employed at any level, so that is why or they can be changed continuously, so the cost function is actually a differentiable cost function, okay.

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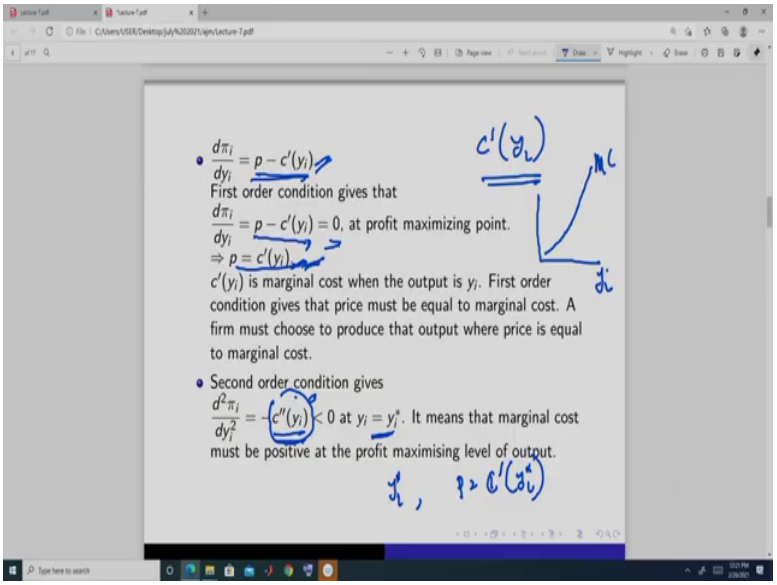

Now, what we are going to do? We are going to maximize this. Now, since this is a differentiable function so we take the derivative with respect to yi. So, each firm while choosing their output what they are going to do, they are going to take this derivative- $\frac{d\pi_i}{dy_i} = p - c'(y_i)$ and the first order condition gives that this should be equal to 0- $\frac{d\pi_i}{dy_i} = p - c'(y_i) = 0$, right? So, then this means that the price should be equal to this term. i.e $p = c'(y_i)$.

Now here, this $\{c'(y_i)\}$ is what?, this is the first derivative of the total cost, this is marginal cost, this is what, this is the changes in the total cost, right? at yi units of output. So, this first order condition gives us that when the profit is at a maximum point, then the price should be

equal to marginal cost, so a firm while choosing is profit maximizing output, it should ensure that the price that is taking as given must be equal to the marginal cost of producing that much amount of output, okay.

So, this is, okay, so this is the first order condition that the price should always be equal to marginal cost- $p = c'(y_i)$, okay. Now, we move to something called the second order condition, so we take the second derivative of this- $\frac{d\pi_i}{dy_i} = p - c'(y_i)$ with respect to yi that is the output of firm i and we get, since in this a or in this thing p is not a function of yi, it is given, it is fixed for this firm. So we get this term- $-c''(y_i)$ and this term should be negative at this, i.e $\frac{d^2\pi_i}{dy_i^2} = -c''(y_i) < 0 \; at \; y_i = y_i^*$.

So, we get this y star by solving this equation- $\frac{d\pi_i}{dy_i} = p - c'(y_i) = 0$. So, y star, yi star is such that p is equal to this- $P = c'(y_i^*)$, so when this is here, we get this y star and once we get this y star, what we do we take the second derivative and plug in y star here, then this, expression which is the changes in the marginal cost or the slope of the marginal cost function should be negative at that output.

So, this means that this term- $-c''(y_i)$, since there is a negative term, so this term should always be positive, right. Now, for this to be positive that means the marginal cost curve should be increasing like this, right.? We have done this in the last class when the marginal cost function is something like this, then it means that the production function is exhibiting decreasing returns to scale.

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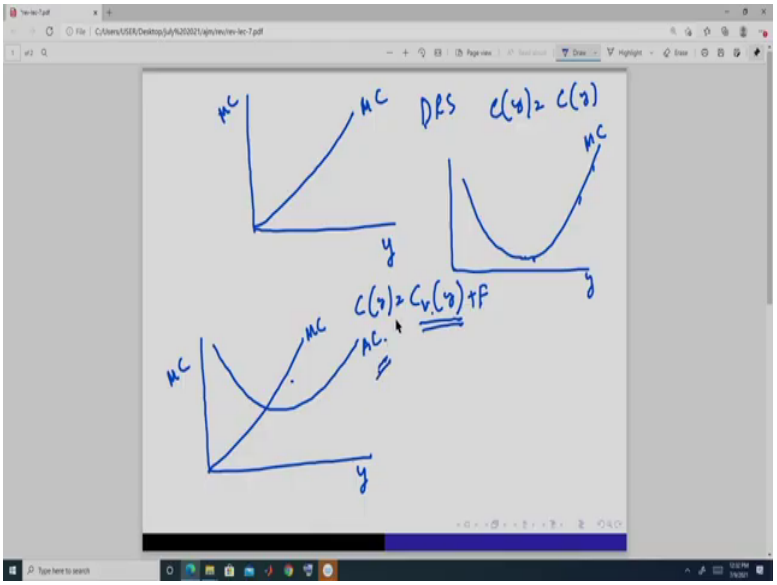

So, we have seen that when we have decreasing returns to scale, marginal cost is of this nature, this is y and this is mc, okay. So in this case our cost is, cost function is this- c(y)= c(y), so we do not have any fixed cost, okay. Or we may have a combination of increasing and decreasing returns and then also marginal cost can be of this. So, here we have economies of scale and then we have diseconomies of scale.

So, we have explained this in the cost function while doing the cost function. Now we may have another type of here also when, and we have discussed this in detail when we have done the costing. So, if we have a cost function like this- $C(y) = C_v(y) + F$ and this is a variable component it is giving you this kind of upward sloping marginal cost. So, here, this cost marginal cost is mainly due to law of diminishing marginal product, this.

So, we have discussed that if we have DRS, so in a competitive market we require decreasing returns to scale, but further even if we have, we do not have decreasing returns to scale, but we may have a situation like this, then we will get a marginal cost like this and in this situation we know the average cost is going to be of this nature, okay and you will see that we will use this case mostly in the perfectly competitive market.

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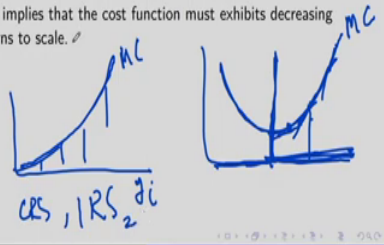
- When the profit function is differentiable, we get that for the profit maximising output to exist, the cost function must be such that marginal cost is increasing in output.
- This implies that the cost function must exhibits decreasing returns to scale.



- $\frac{d\pi_i}{dy_i} = p - c'(y_i)$

First order condition gives that $\frac{d\pi_i}{dy_i} = p - c'(y_i) = 0$, at profit maximizing point.
$\Rightarrow p = c'(y_i)$

$c'(y_i)$ is marginal cost when the output is y_i. First order condition gives that price must be equal to marginal cost. A firm must choose to produce that output where price is equal to marginal cost.

- Second order condition gives $\frac{d^2\pi_i}{dy_i^2} = -c''(y_i) < 0$ at $y_i = y_i^*$. It means that marginal cost must be positive at the profit maximising level of output.

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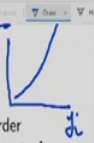

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So, what do we get? So, we get that the for profit maximizing output to exist, so that this point exists- $p - c'(y_i)$ and this is a profit maximizing point we require this point condition, i.e $-c''(y_i)$ and this ensures that the marginal cost function is of this nature, right? or the marginal cost function can be of this nature. But if marginal cost is of this nature then the profit maximizing output should be in this region, right? it cannot be in this region.

Here it will not, because then the marginal cost is downward sloping, it is going down as output, so then this violates this condition- $-c''(y_i) < 0$. So, if marginal cost is of this nature then the profit maximizing output should be in this, output should be greater than here. Because here if you take this point here, marginal cost is positive, here it is also positive, here it is, everywhere marginal cost is, the slope of marginal cost function is positive, right?

For this kind of marginal cost, we will always have any point, any output is going to be a profit maximum, can be depending on the price, okay. So, this portion here, we know it is exhibiting decreasing returns to scale and here the whole, it is exhibiting decreasing returns to scale throughout, so here till this output it is increasing returns to scale and after that it is decreasing.

So, this means that we will never have something called a CRS or IRS production function in this type of market. We will show later why we should not have such type of production function, okay or if we have such kind of production function then what is going to be the outcome, okay.

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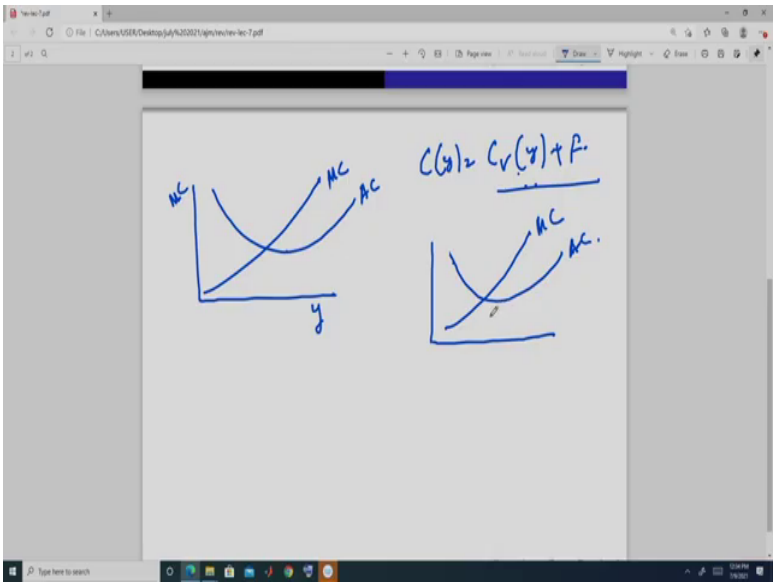

Now, let us do this profit maximizing thing which we have solved algebraically in a graphical way. So, our cost function can again be of this nature- $C(y) = C_v(y) + F$, right? and when it is this, we know that one factor is fixed and the another factor is varying, so we have law of diminishing marginal product it is operating and so that is why our marginal cost is of this nature, right?, and the average cost you will get is of this nature.

So, this should be at the minimum point, okay, intersect at the minimum point. But further we may have a situation when we have, we can vary both machine and the labor but our plant size is fixed or the land is fixed, so in that case we fix, get the fixed cost from that land or that rent is giving us a fixed cost but main inputs like capital and machine, labor those are varying, then we may have a situation of decreasing returns to scale where we have got decreasing returns to scale by varying both labor and capital but our land or the plant size is fixed.

So, then we again may get, this kind of can thing, right? so these two are, it maybe although they look same, but maybe different. In the sense here only law of diminishing, one factor is fixed machine is fixed, only labor is varying, here both labor and machine are varying, labor and capital are varying but the land is fixed, okay and the moment we have this kind of marginal cost function, we will get the optimal point in a perfectly competitive outcome.

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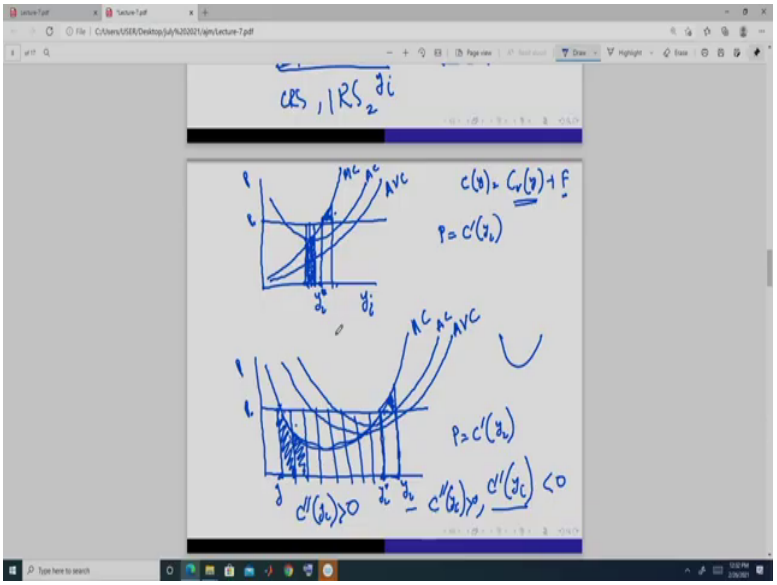

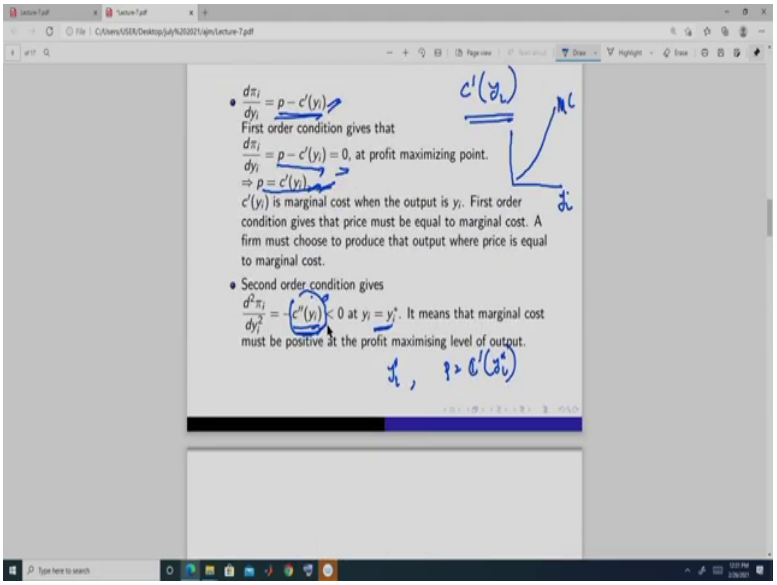

So, let us take any firm yi, output of that firm is given in this axis and the price is here and suppose the market price is this, okay. Initial market price is this p naught, okay. And the marginal cost function is something like this, okay if the marginal cost is like this it is throughout increasing, then we know that the average variable cost is going to be like this and the variable cost function, sorry, the average cost function is suppose something like this.

So, if we have taken this firm, then it means that our cost function is of this nature- $C(y) = C_v(y) + F$, right? and this is such that the marginal cost is always increasing, right?

If we did not have this part- F, then average cost would have been same as average variable cost and it will be something like this, okay. Now, here what do we see? We get that this is

the profit maximizing output. Why? Because at this output, price is equal to marginal cost because these two curves intersect at this point.

Now, suppose take any other output here, if we take this output then it means what? Marginal cost at this point and revenue or the price is there. Now, if we increase the output slightly from here to here, here, what we are doing? We are total cost; that is the region under the marginal cost is this much extra cost we are bearing, but this whole region we are adding as the total revenue because this into this.

This is the difference in the output and this is the price, this whole region, so we are adding some additional part to the total profit, this is the profit, right. So, what is happening? So, I have a tendency to increase output. Now, from here if I do further like this, what I am doing? Marginal cost curve is this, so this region is the total increase in the cost but total additional revenue profit is given by this region.

So, I will again further increase. So like this I will go on like this y star unit of output, but if I move beyond this, like if I move to this portion, what I am doing? total revenue that I am getting, additional total revenue is this, right? this rectangle, but the total cost is this portion, so here this much is the additional cost we are earning, which is more than the revenue, so this much amount of loss I am making.

So, I will not have any tendency to produce output more than y star. So, that is why we get a condition that the price should always be equal to marginal cost, okay. Now, here when this is the price and this is the marginal cost so, and suppose the average cost is like this and the average variable cost is like this optimal point is like this, okay and here you see that since the marginal cost is throughout increasing, so the second order condition is always true.

Now, when second order condition is going to be binding, we will see that now. Suppose let us take this a price in this axis and suppose this is the market price, okay at this level and suppose the marginal cost is of this nature, okay. Okay, marginal cost and this is suppose average variable cost and suppose this is the AC, average cost, okay. In this case we have, in two points we have this condition, p is equal to marginal cost.

At this point and another point is this, out of this point we will always choose this y because now if we are at this point price is equal to marginal cost, but if I increase output a little bit like this, what is happening, my additional cost is given by this region and my additional

revenue is this rectangle, so I am making a profit of this region. So, that is why I will produce this much not this, I will not stop at this point, so this is not going to be an optimal point.

Now, if I produce further, here the additional cost is this much, additional revenue is this rectangle, so this much is the addition to the profit, so I will go on producing output till this point and then I will continue like this because this region is giving me the additional profits, right? and further I will this way reach this point. If I produce more than this, suppose I produce here, then what is happening?

My additional cost is given by this region, but my revenue is only this so I am making a loss of this portion. So, that is why I will not produce beyond this y star unit. So, in this situation when marginal cost curve is u-shaped that is, it has both increasing returns to scale component and also decreasing returns to scale component, then we see that this second order condition this is a very important. Why?

Because if you look at the marginal cost here you will see that its slope is downward sloping that means this second order condition this is negative, so then it means if we take negative of this, if we take negative it becomes positive, so that is why it is not a and also from the argument that I have given you it is clear.

But at this point it is clear that the slope is positive, so slope of marginal cost is positive. So, this term is negative at this point, not at this point, okay. Now, let us look at one more thing that suppose we, so we now know what is going to be the optimal point here and what is going to be the optimal point in this case of marginal cost, okay, so only this type of marginal cost we get an optimal point, okay.

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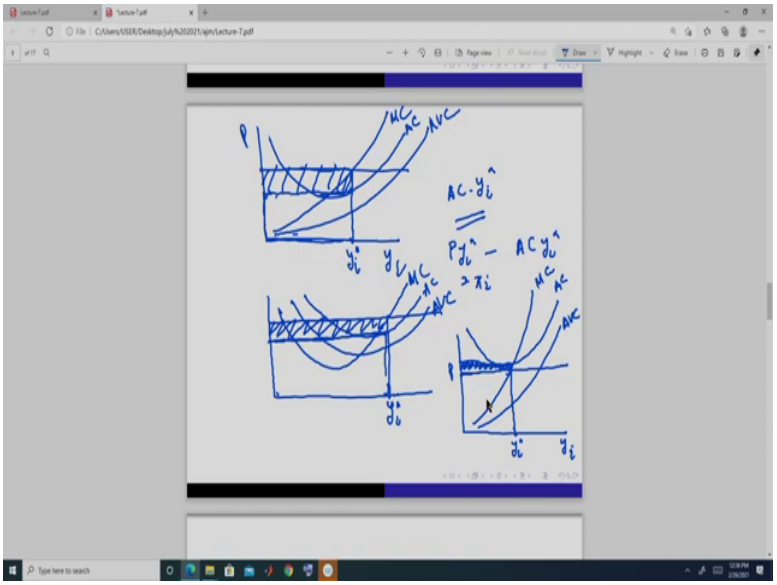

Now, suppose again take this is the price and suppose the marginal cost curve is this, then the average variable cost is this and suppose the average cost is this, okay. So, the optimal output is given by this point yi star (y_i^*). Now, here what is the profit that the firm is going, is making? So, this is the, when I produce this much amount of output, average cost is this much.

So, this region average cost, this rectangle gives me I can say average cost into height is the average cost into yi, yi star so this region is the total cost, this is the total cost. Total revenue, this height is the price into this quantity, so this gives me the total revenue, right? So, price minus you can say AC is going to give me the profit. So, profit is this rectangle, total profit, okay.

We get this. And when we are in this situation, suppose marginal cost is like this, so average variable cost is this, average cost is this and suppose the price is this. So, we know the optimal output is given by this much level of output. Now here total profit the firm is making is given by this rectangle because at this level of output average cost is this much and when the average cost is this, total cost is this rectangle.

And total revenue is this rectangle so this shaded portion is the profit, okay. So, in this case we see that there is a profit there and a positive profit. Now, suppose the situation is something like this, okay. So, optimal output is this, right? at this profit price is equal to marginal cost, right? suppose the price is this. But at this a output, this output total cost is this

much. So, here in this case firm is making a loss of this much amount because total cost is given by this bigger rectangle.

And the total revenue is given by this smaller rectangle. So, it is possible that the firm may make some loss in the short run, okay. We will define what do we mean by short run, now just take it as a term. Here, then this question comes that these two condition that or you can say if we look at this graph and suppose the price is somewhere here, then from this marginal cost and this is intersecting here so optimal output is this much.

But the average cost is this much, so the firm is making a loss of this much amount in this case, so this gives rise to another question, whether a firm is going to produce when they are making loss or they are not going to? That means whether they are going to produce any positive amount of output when price is quite low. So, from this what do we get, that when the price is low then the firm makes a loss and when the price is high the firms are making positive profit, okay.

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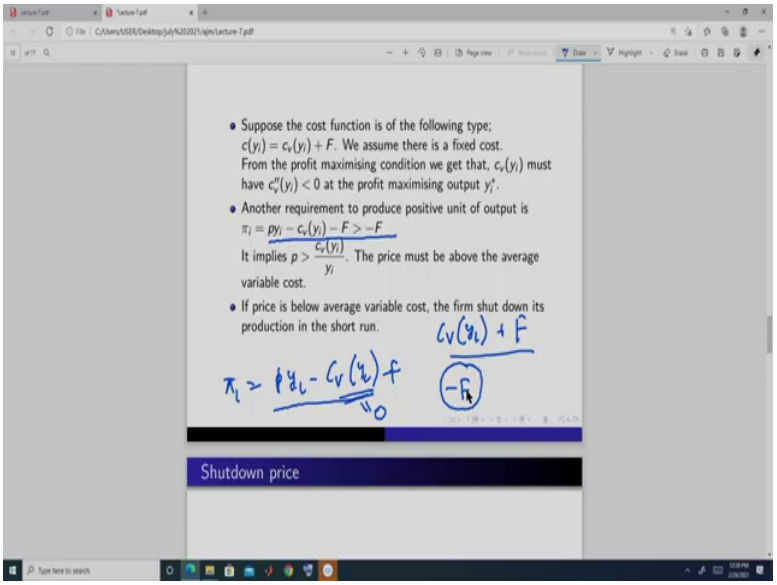

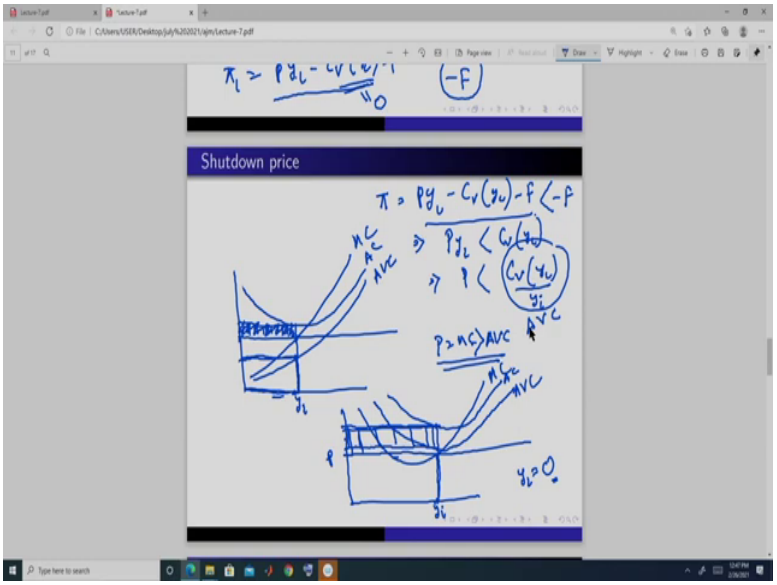

So, we defined something called a shutdown condition, okay. How do we define that? We define it based on this criteria- $\pi_i = py_i - c_v(y_i) - F > -F$. So, we have got that our cost function is of this, going to be of this nature-$c_v(y_i) + F$, right? Now, profit is this as given, so this profit can be negative when we are making loss, now it should be that much, now what is happening? It can be negative. Now see firm is, if it produces zero amount of output then this part is going to be equal to 0, i.e$c_v(y_i) = 0$.

But this part is there, fixed cost it is always, it is independent of the level of output, right? so if it produces 0 output, it is also equal to 0, right. So, this portion is 0, i.e

$py_i - c_v(y_i) - F = 0$, right? So, the profit is minus F, so firm is making a loss of F amount, okay. So, the whole fixed cost is going as a loss. So, if a firm makes a profit which is negative that is if a firm makes a loss and that amount of loss is the whole fixed cost that is F, then a firm should, it is better to produce 0 amount of output. Because if firm produce any positive amount of output, okay.

So, here suppose firm makes a positive amount of output and this is this- $\pi_i = py_i - c_v(y_i) - F$ and they are making a loss and this loss is suppose less than this loss, i.e $\pi_i = py_i - c_v(y_i) - F <- F$, okay, then this implies what, this implies, this implies what, this is what?, this is average variable cost- $c_v(y_i)/y_i$, when the price is below average variable cost we get that the loss is going to be more than the fixed cost, okay, and so it is better not to produce any output, because if we produce any output and we sell it at a price which is less than the average variable cost then our profit is going to be negative.

So, that means we are going to make loss and that loss amount is going to be more than the fixed cost. So, it means by producing we are increasing our loss, so it is better not to produce. So, that is why we get the shutdown condition as this- $\pi_i = py_i - c_v(y_i) - F >- F$, okay. So, the shutdown condition it means that the firms are not going to produce any output whenever price is below the average variable cost. So, for a firm to stay in the market or to produce some positive amount of output, the price should always be greater than the average variable cost.

What does this mean now? So that means that if we are given like this, suppose the marginal cost is like this then the average variable cost is like this and suppose this is the average cost and suppose the price is here, okay, then this is going to be the optimal output. So, firm is making a loss of this much amount, right. Now, if firm suppose does not produce, because see if you look at this curve, this much is the average variable cost.

Average variable cost into output is going to give you the total variable cost, so this rectangle is the total fixed cost, right. Now, if it does not produce then the loss it is going to make is this, because it has already incurred the fixed cost because it is in the market right? so it has already bought the machines. So, now if it does not produce then the machines are going to

be lying idle, so it means that he has to pay for this machines and they are not going to and this entrepreneur is not going to get any return on this payment.

Why? Because it is not producing and so then the loss it is going to make is this whole rectangle. But if it produces then this loss, it is still making a loss but this loss is this much only, so it is better to produce, so because the loss is now less amount, if it produces, so that is why a firm is always going to produce in this situation, right? So, when the marginal cost is always increasing, we know that the average variable cost is always going to lie below it.

And the moment average variable cost lies below it, then it means what? from this a the optimal point or the profit maximizing output is given by price is equal to marginal cost and since marginal cost is always greater than average variable cost, here, so this condition is satisfied, this shutdown condition automatically gets satisfied. So, for this kind of marginal cost curve if the technology is such that we get a marginal cost curve of this nature then this problem of shutdown will never arise.

So, firms are always going to produce some amount of positive amount of output because if it does not produce then the loss it is going to make is more than when it produces some positive amount of output and so it will always produce the optimal amount of output, okay, which is given by this point. Now, suppose consider this case, okay, marginal cost is this, average variable cost is this and average cost is this and suppose price is here, okay.

So, the optimal output from the first order condition if it is maximizing, when it is maximizing profit is this, at this output, total loss it is making is this much, right. This whole rectangle because this is the average cost when it produces this much amount of output, so the total cost is this big rectangle. Total revenue is, because this is the price is this, so the total loss is this rectangle.

Now, average variable cost is this much, is this, so if it does not produce any output then its loss is going to be only this smaller rectangle, right, but if it produces then it sells at this price and this price is less than the average variable cost, so it is making a higher loss. So, in this situation a firm is never going to produce output.

So, it is going to produce y optimal output is 0 and because the shutdown condition is not being satisfied that is the price is below the average. So, we get this that this shutdown condition is binding when we have a u-shaped marginal cost curve. When the marginal cost

curve is always increasing then this is not going to bind, we will always, shut down condition is always going to be satisfied.

So price is always going to be higher than the average variable cost, but when we have a marginal cost which is u-shaped then it is possible that the price may go below the average variable cost and so the optimal output is such that at that price marginal cost is less than the average variable cost, okay and when the marginal cost is less than the average variable cost then what we will get?

We will get that when it produces it makes a more loss then when it is not producing anything so the optimal output is, optimal decision is going to be not to produce any output, okay. So, from here what do we get? We get that when a firm is going to produce, firm is always going to produce when the price is greater than average variable cost, right. When price is always greater than average variable cost?

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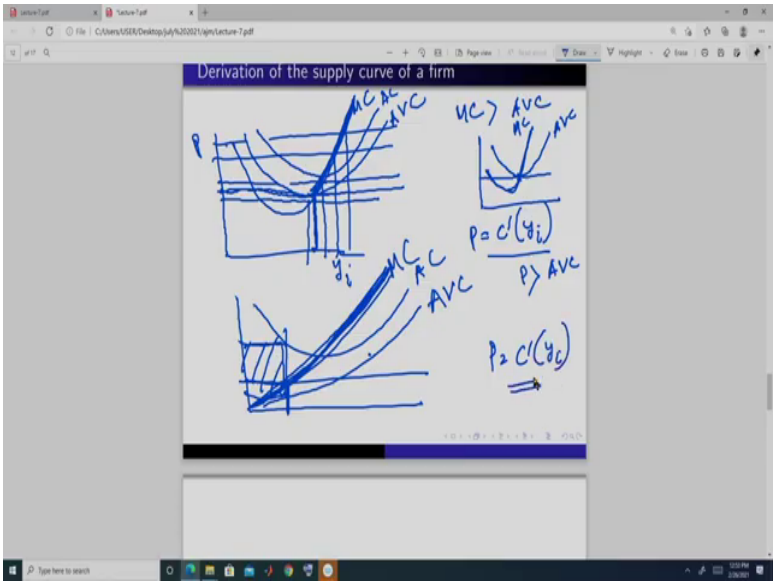

We know that a condition that, we have a condition that whenever marginal cost is greater than average variable cost, whenever average variable cost is increasing, right? so we know this thing. So, this intersection, this is the marginal cost and this is, this curve is suppose marginal cost and this curve is suppose average variable cost then this intersection takes place at the minimum of average variable cost, right?

So, whenever price is above this minimum, then firm is always going to produce. If price is below this minimum, then it is not going to produce. So, from this we can derive something

called a supply curve of a function, supply curve of a firm, so if the output is like this, okay, so price is like this, marginal cost is suppose this, this is average variable cost, this is average cost and suppose price is here.

In that case this is the optimal approach, so firm is not going to produce. So, price should always be above this level, right, this much output. So, a firm is always going to produce this much amount of output and then as the price increases like this, here, optimal output is this, if price is here, the optimal output is like this, if price is here the optimal output is this, so from this position this, this is the supply curve of a firm.

So, price here and the amount of output it is going to produce is this, **this** much, it is not going to produce anything below this because if the price is below this then it is possible that they may produce, but then while producing that it makes more losses then while not producing any output. So, that is why it is not going to produce. So, the supply curve is this. So, its output is going to start like that.

So, it is that portion of marginal cost curve which is lying above the average variable cost, so the supply function of a firm can be written like this. This condition is giving me the supply curve, where the price is greater than average variable cost or you can say it is when the price is greater than minimum of the average variable cost, okay.

So, in this situation we will get a like this, but suppose the marginal cost curve is of this nature, then we know the average variable cost is always going to lie below it and suppose the average cost is this, then this whole marginal cost is the supply curve, because if we produce, suppose the price is here, then optimal amount of output is this and it is lying above the average variable cost, so if it does not produce its loss is this much.

And if it produces its loss is this, so it is better to produce, right? So, this whole the marginal cost is the supply curve, in this situation the supply curve is actually this of any firm. Now, why do we need this supply curve? Because from this supply curve we will get the market supply curve because it is going to be the horizontal summation of each supply curve of its firm and then that will give us something. It will allow us to derive the market demand, okay. We will do that later.

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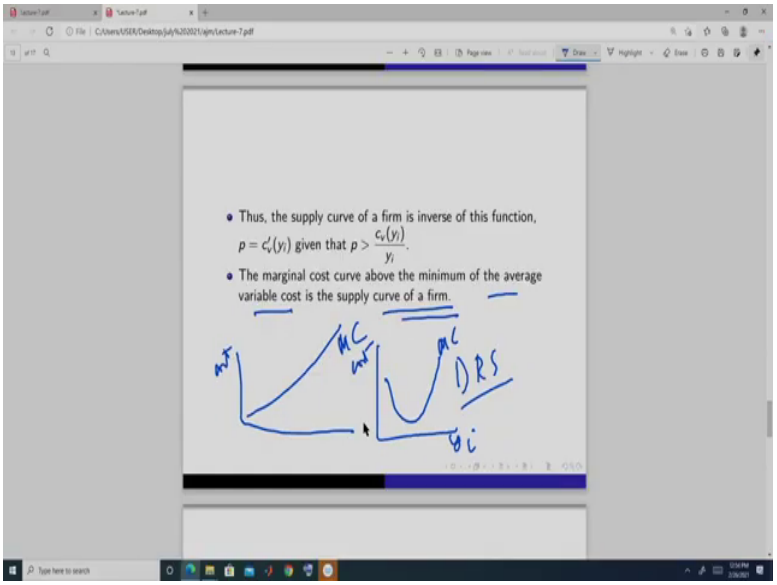

So, marginal cost curve which lies above the average variable cost is the supply curve of a firm, so we have got that. Now the thing is in this whole whatever we have done till now, we require the cost function to satisfy decreasing returns to scale at least partially, so the cost function can be either like this, marginal cost function can be like this or the marginal cost function can be of this nature, right?

So, this is when we have decreasing returns to scale we know marginal cost is always going to be like this, okay and if we have one fixed component of cost and suppose all, suppose labor and capital is variable, but the fixed component is coming from the rent that we pay from for the building that we have hired or for the land, then also we can have a decreasing returns to scale and we may get a this kind of u-shaped marginal cost.

Another reason when we can have this kind of marginal cost is when we have law of diminishing marginal product, which is operating, that means suppose land is, capital is fixed, it is fixed at some a and it is lumpy, you have to buy this much and a is variable, labor is variable then we have seen that we will get a marginal cost curve, which is always increasing of this nature and but fixed cost is coming, will be there. So, together we will get this. So, due to law of diminishing marginal product, we will also get this kind of marginal cost and so the average cost curve will be of this nature, okay.

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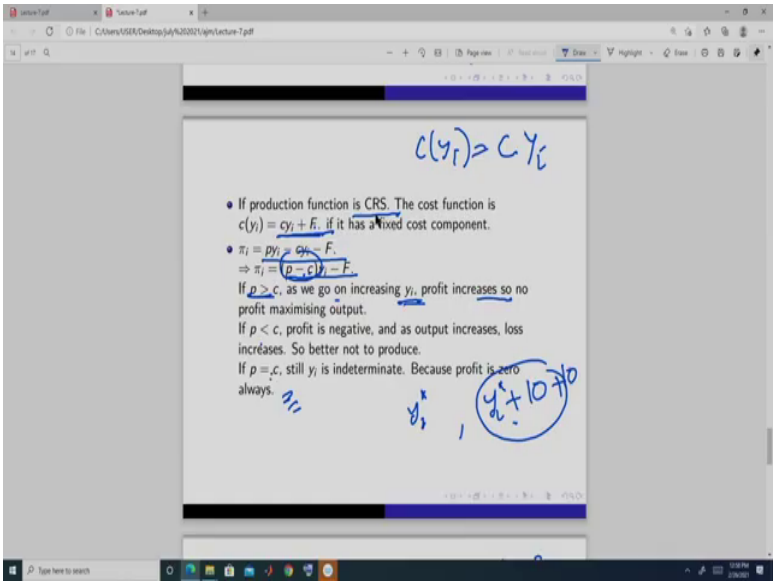

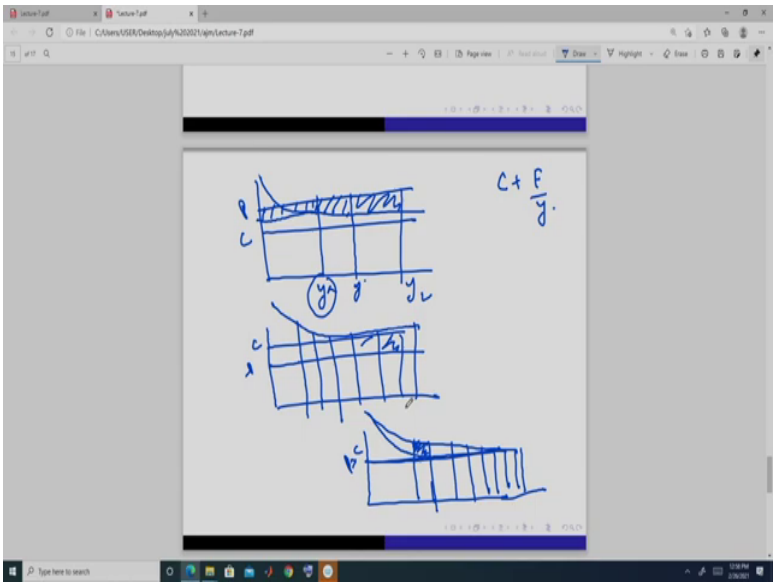

Now, what happens if we have suppose Constant Returns to Scale – CRS? We know one form of a CRS can be this kind of cost function- $c(y_i) = cy_i + F$ where we are multiplying the output with a constant number, fixed number, real number plus a fixed cost component, it is like this. So, if it is like this or the another form it can take is going to be only this- $c(y_i) = cy_i$, whatever form it takes here we get the profit function in this form- $\pi_i = py_i - cy_i - F$.

So, here we can take it in this a- $\pi_i = (p - c)y_i - F$., so it means what? Now, here you can see the price minus this marginal cost into output. Now, see we will use this kind of cost function a lot in later in this course, okay, as of now we are not using it. Now, here if suppose

price is greater than c, if in this case, so what is happening, this is taking a positive number. Now, if we go on increasing output this profit is going on increasing.

So, if you produce suppose y star units of output and then instead of that if you produce y star plus some more suppose 10 units, then this will give you a more profit. So, if you produce this then plus suppose 10 more, it will give you more unit profit because it is something, diagrammatically we can do it like suppose the price is this fixed and c is fixed, so if I produce output of this much, then the profit that I get and suppose this is the average.

Suppose this is the average cost, we know the average cost curve is going to be like this, right, so it is like this. So, if we produce this much amount of output, then I am making this much amount of profit, right. If I produce this much amount of output, I am adding this much amount of profit, so I will not produce this instead this, but if I produce this I am adding more, so what is going to happen, so I will not be able to determine what is the optimal amount of output, right?

As we increase output profit goes on increasing so we do not have any profit maximizing output. In this case suppose the price is less than the marginal cost, okay, so this is suppose c and this is p and this is our average cost, right, so what is happening? We are always going to make losses, if we go on increasing, so these are losses, right, output our losses are increasing. So, we will not produce any output here in this case, okay.

Now, in this situation if price is equal to the marginal cost, so if we are at this, price is also equal to, now profit is always, so it will be like this, average cost is going to intersect, right? so we will go on producing output, right. If we produce here loss is, this much is going to be the loss, right. So, in this situation also we do not get because as we, a output is indeterminate. So, what do we get? If we take CRS, then actually we cannot determine the optimal amount of output, okay.

So, that is why we generally do not take CRS in competitive outcome. Now, when we do the market demand curve and when we do the derivation of the market price then I will again discuss this CRS, okay but as of now for each firm they cannot determine their optimal amount of output okay. Now, what happens we when we have an increasing returns to scale?

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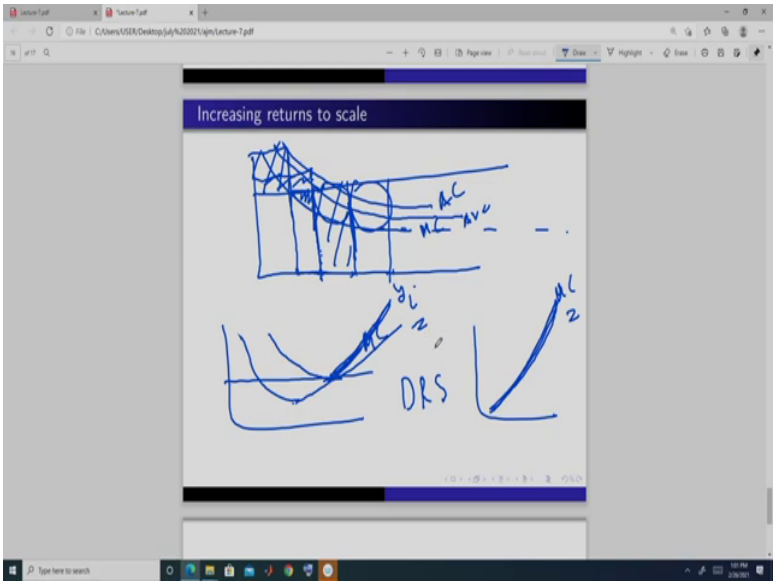

When we have increasing returns to scale we know marginal cost curve is something like this, right? if marginal cost is something like this, average cost is going to be like this, okay and suppose average variable cost is also like this. So, at this price we get price is equal to marginal cost, but if I increase output, this much is the revenue and this much is the additional cost. So, I make some additional profit.

Although I am making a loss in aggregate amount, but that loss has gone down. Earlier the loss is of this whole amount, now the loss is only of this amount, so instead of this if I produce, here my profit increases by this region, if I produce here profit increases by this region, so I will go on producing, so here again when we have increasing returns to scale, we find that the, it is not, we cannot determine the optimal amount of output of each firm.

So, that is why for in a perfectly competitive market we always assume that the technology or production is always decreasing returns to scale or it may have initially some increasing returns and then again decreasing return. So, marginal cost curve should always be of this nature or the marginal cost curve should be of this nature, okay.

And based on these two type of marginal cost curve what we can do we can find out the optimal amount of output a firm is going to produce at any price and we know in this case, the whole marginal cost curve is going to be the supply curve and in this case, only suppose this is average variable cost is like this, then the supply curve is going to be this for the firm, okay.

So, we end today's lecture at this point and in the next class what we will do from this supply curve of each firm, we will move to market supply curve and then at market we will determine the price and then we will see what happens, what is the dynamics here, we will not do explicit dynamics, but we will simply describe the function here, how, what happens when the price is below average cost and when the price is above the average cost, okay.

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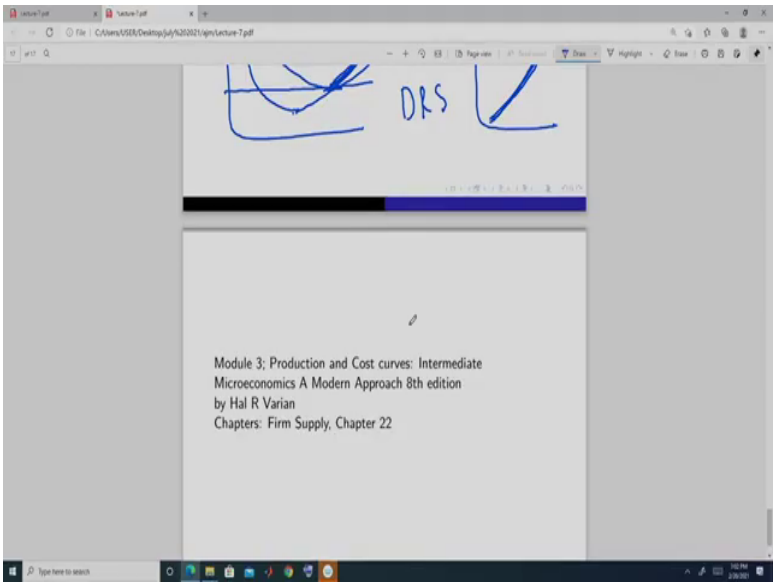

And you can start reading chapter 22 of this book Hal R Varian Intermediate Microeconomics A Modern Approach, that is Firm Supply or this class notes is going sufficient, I have covered exhaustively, okay. Thank you very much!