**Chemical Reaction Engineering 1 (Homogeneous Reactors)**
**Professor R. Krishnaiah**
**Department of Chemical Engineering**
**Indian Institute of Technology Madras**
**Lecture No 34**
**Multiple Reactions Part 3**

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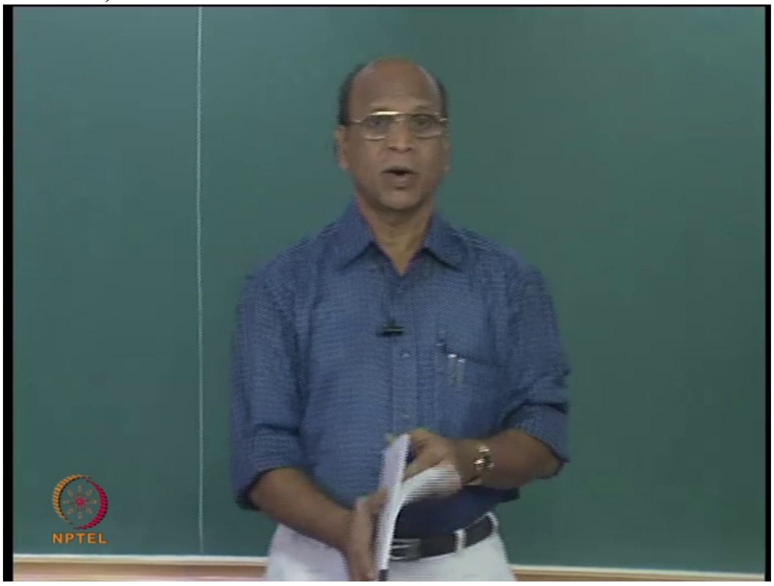

Ok, so now we have to start again multiple reactions and the definitions we have taken, multiple reactions definitions, Ok. And where we stopped yesterday

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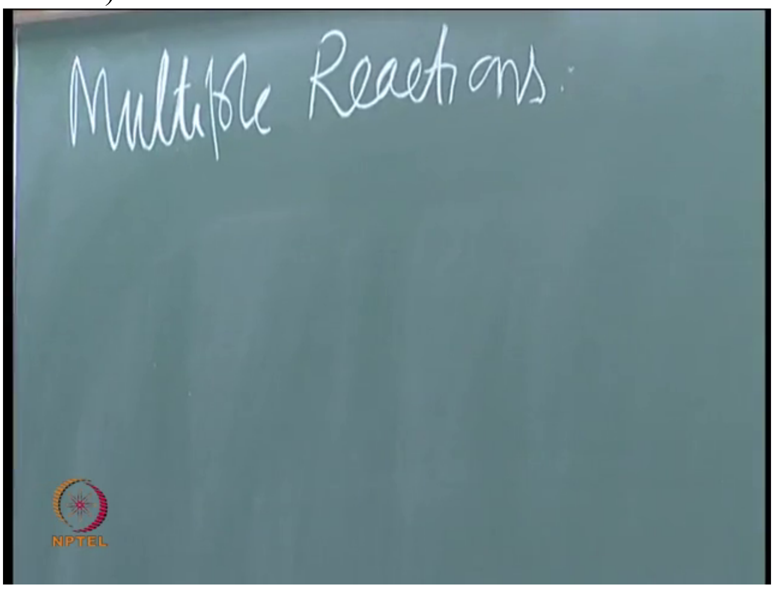


was that we

We found that for higher order reactions, if the desired reaction is higher order

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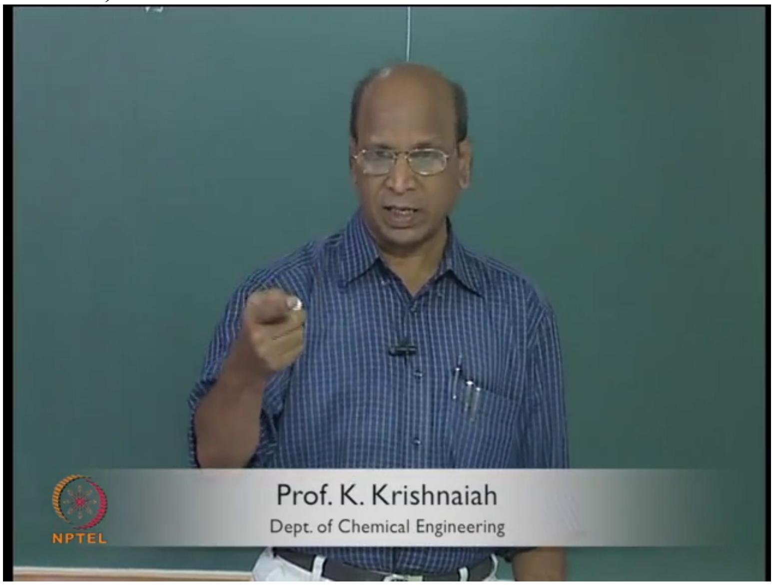


then maintain the concentrations as high as possible. Or if the desired reaction is lower order, maintain the concentrations as low as possible. And if temperature is also coming into picture, higher activation energy favors,

(Professor – student conversation starts)

Student: High temperature

Professor: At high temperature favors yeah, desired product if its activation energy is more, Ok. So these are the basic rules everywhere you have to use, right.

(Professor – student conversation ends)

Now the question is how do I maintain these high concentrations or low concentrations? Ok how do you keep C A or C B high or low? We are also imagining that

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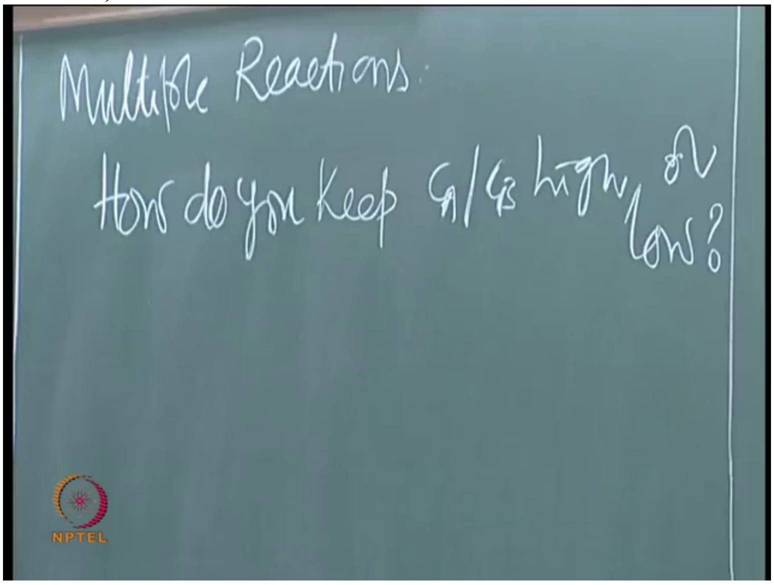


B is also one of the reactants. How do we keep that? And we know that, roughly when you have mixed flow, you will have high and all that. But what are the other possibilities?

If I have batch system, batch, you can have, yeah, you can pour, Ok all this suddenly, yeah, Ok and then

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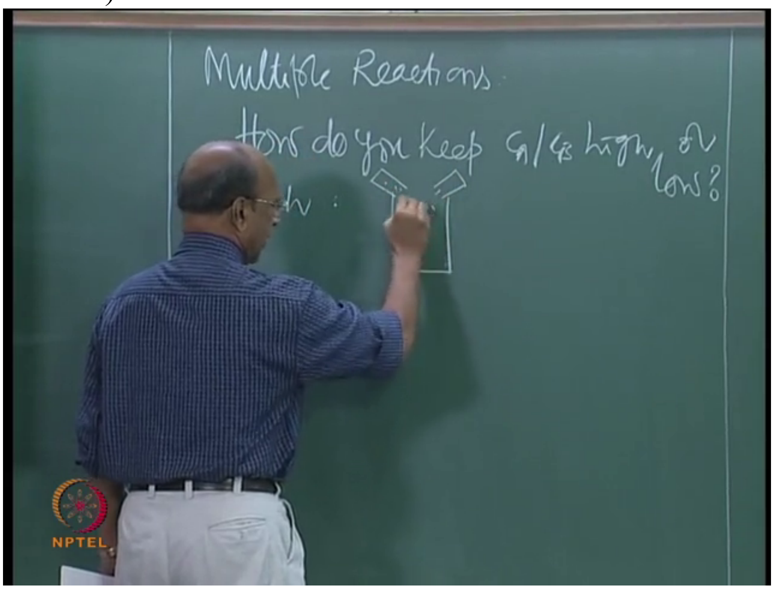


you may, anyway stirring is there. This is batch.

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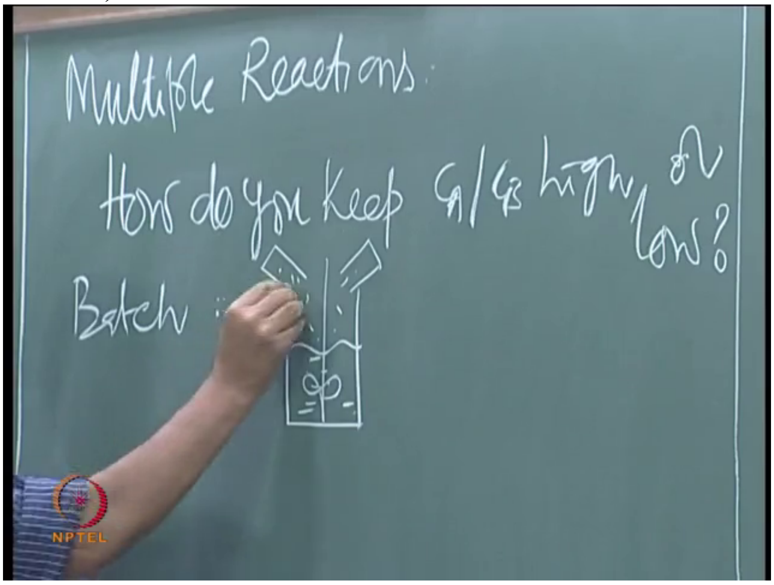


This is A, this is B. So this kind of system

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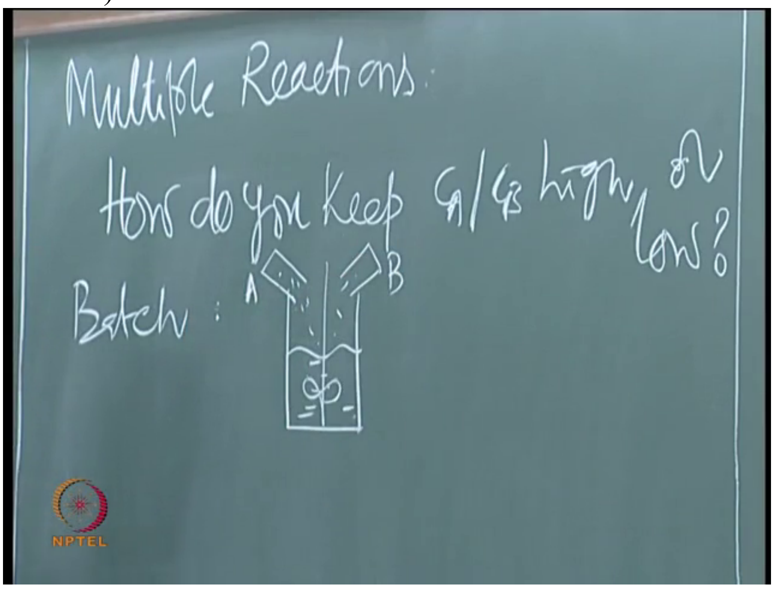


at time t equal to zero, you just put these two into the system, Ok and then start stirring.

So at that time you have C A, C B both high, if it is B, yeah right. Both high in this, yeah,

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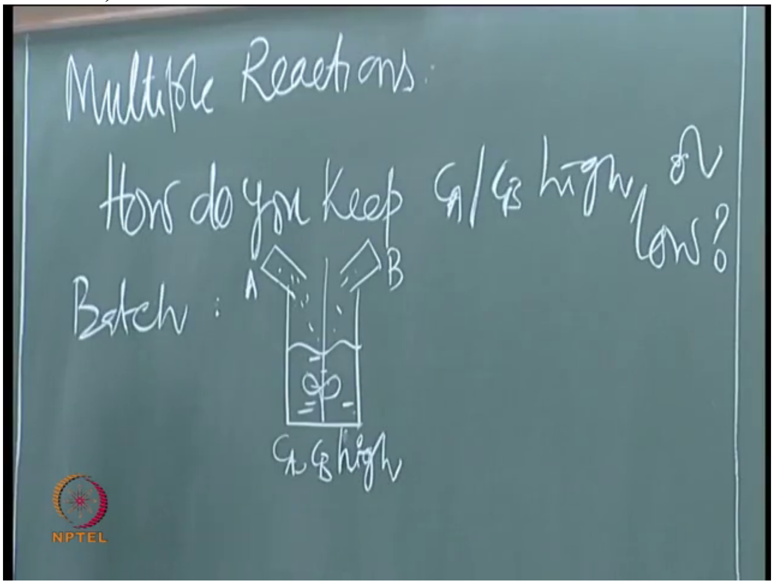


in this kind of, you know setup. That means suddenly you added both at time t equal to zero and started stirring. And if you are maintaining like that without any disturbance, then you maintain C A, C B high and slowly reaction is taking place.

And you know C A, C B will be converted to desired product, undesired product and everything, but when you maintain this

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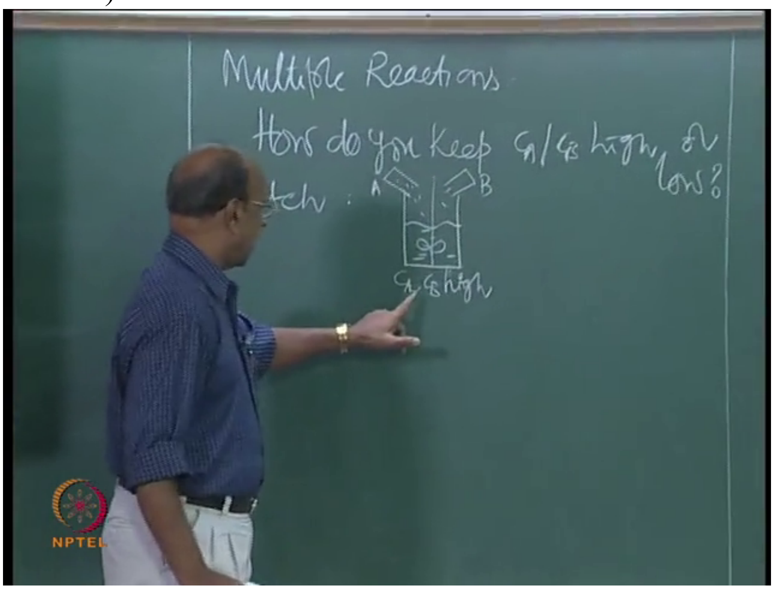


and if I have higher order for a desired reaction, so I will get definitely desired product more than undesired product, Ok, yeah, good. So that is the one.

So if I want to maintain only both low for example, C A low, so what we do is, Ok, so you, this is A, this is B but

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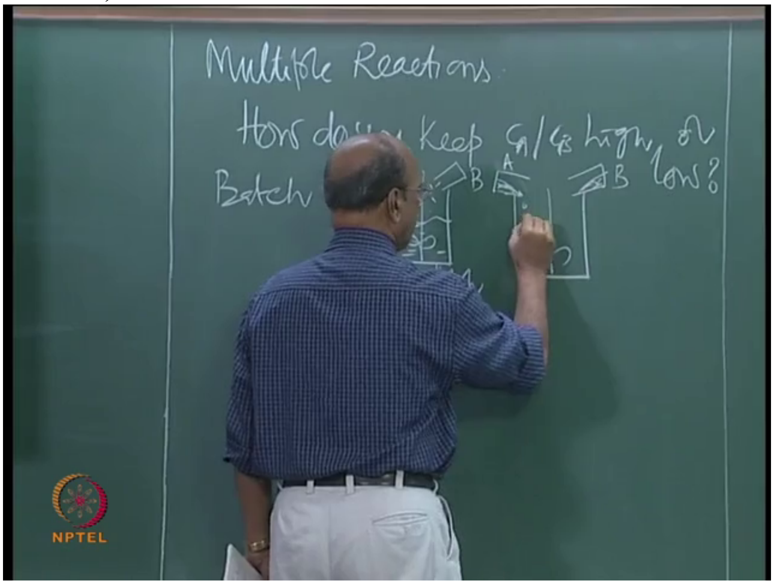


add drop by drop,

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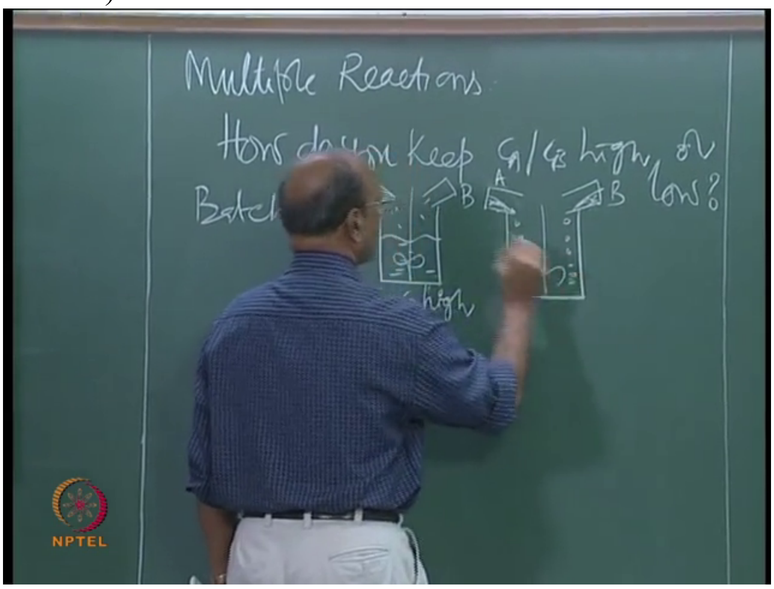


Ok so that it will be,

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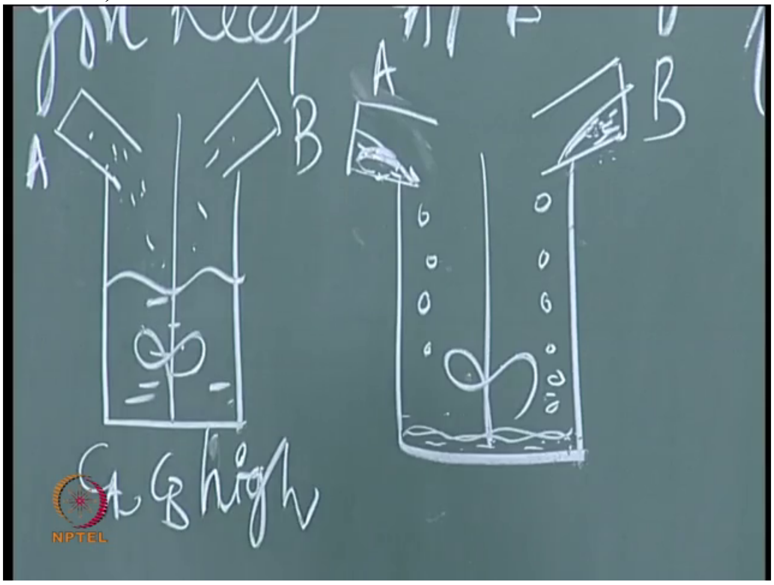


yeah, you will be adding drop by drop, our idea is to maintain C A low, C B low.
So by adding drop by drop what happens is

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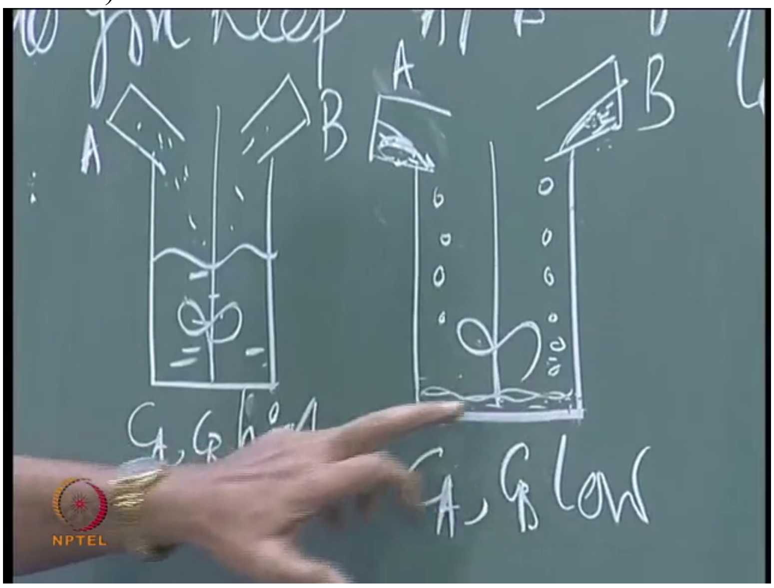


that always you are keeping, you know you are also adding drop by drop slowly and reaction is taking place, then C A will be low, C B will be low, right and we have not taken any reversible reactions, right, for reversible reaction also, rule would be the same only. It will not change.

So then you can maintain C A, C B low if you have first order, I mean if you have a batch system. Another possibility is you can either, you have to maintain sometimes either C A low or C B low, one of them. So again this situation is same, that is I will take, if I want to maintain C A low, C B high, what do I do?

Yeah, C B is first poured, this is B and then add, this is A, this is A, add A drop by drop.

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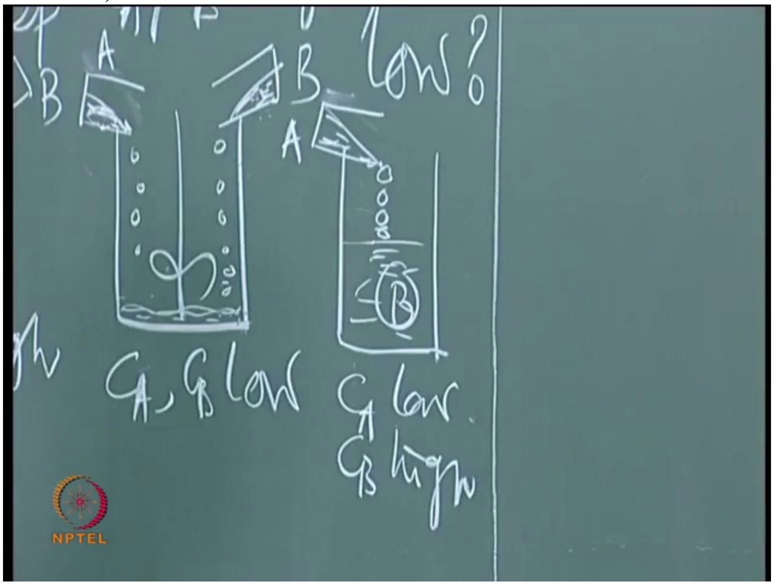


Ok. So these are all the things. You know. That is why the contacting patterns what we have discussed there, Ok so now for multiple reactions we have to choose what are the possible contacting patterns where our conditions are fulfilled, either C A is low, C B is low or both are low, or both are high, right? Or temperature is high, temperature is low, right.

So temperature is not that kind of problem because temperature high means I will put here a jacket and then maintain high temperatures. Right, but stirring and all that is there, right good.

Similarly temperature is not a big problem in choosing these kind of things but once you choose this, how do you give the temperature, either outside jacket or sometimes inside coils you will have to put, heat will be in direct touch with the reactants. So then you can also have high temperatures, Ok if it is required.

If it is low temperatures again you have to cool it, all kinds of things we can do, right. So if I have a continuous system what are the possibilities to keep the concentration as high as possible, in continuous system, right? So let me write here continuous.

In this system, C A C B high. In other system we will have C B, C A C B low. These two we will just try to find out, Ok. So

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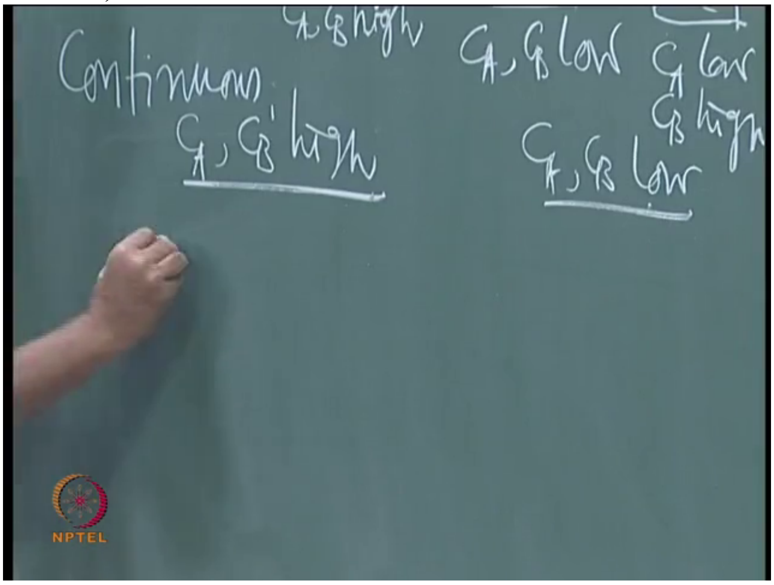


this I do not have to give much information because when you maintain, this is A and B, this is P F, then

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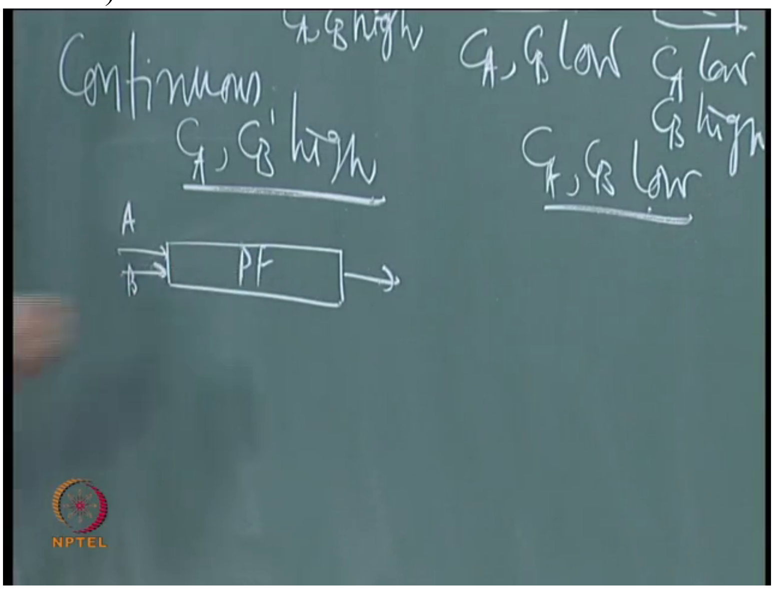


we know that definitely we can maintain high C A and high C B if I have this, Ok, good.

So then for C A, C B low we have A, B, this is coming here,0:06:47.9, right here in mixed flow normally we can always maintain. Here

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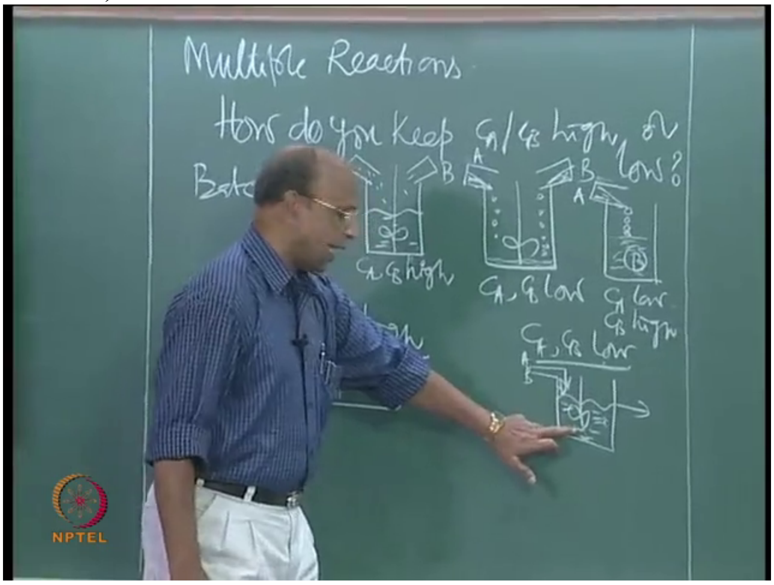


I can definitely maintain C A, C B low because that low also corresponding to the outlet concentrations, right.

So if you want to still keep it very low, then you have to increase the reactor size and then maintain the concentrations as low as possible and then automatically whatever concentration you put that will be instantaneously mixing through that

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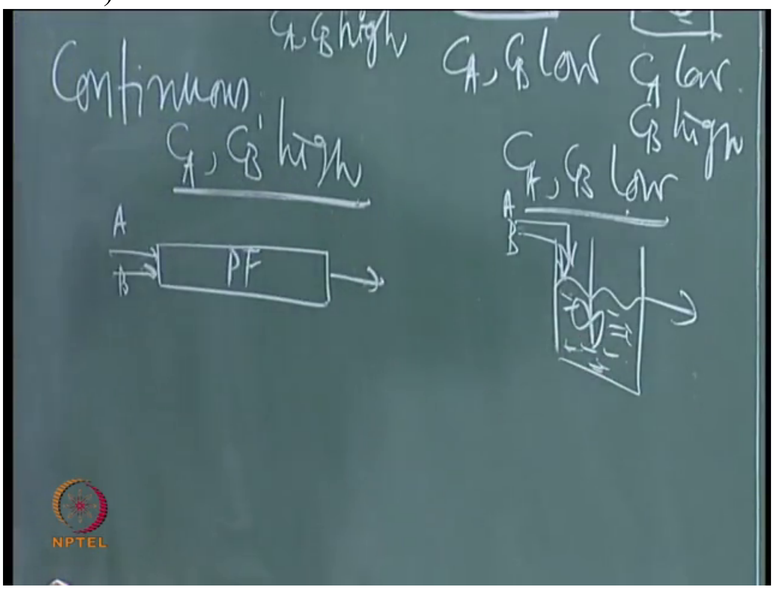


concentrations and you will get corresponding steady state conversions, right? This is one.

And we also have other possibility. You know this is not new. That means how do I replace that P F with tanks? I may put more number of tanks. And we have also seen 6 tanks are enough to get almost P F. Ok, only may be 1 percent, 2 percent, 3 percent is left from sixth to, or seventh to infinite number of tanks, right?

So that is why to maintain high concentrations we can also put, yeah so this kind of arrangement, yeah again put here A and B, and anyway it will come out as the product. This is another way of

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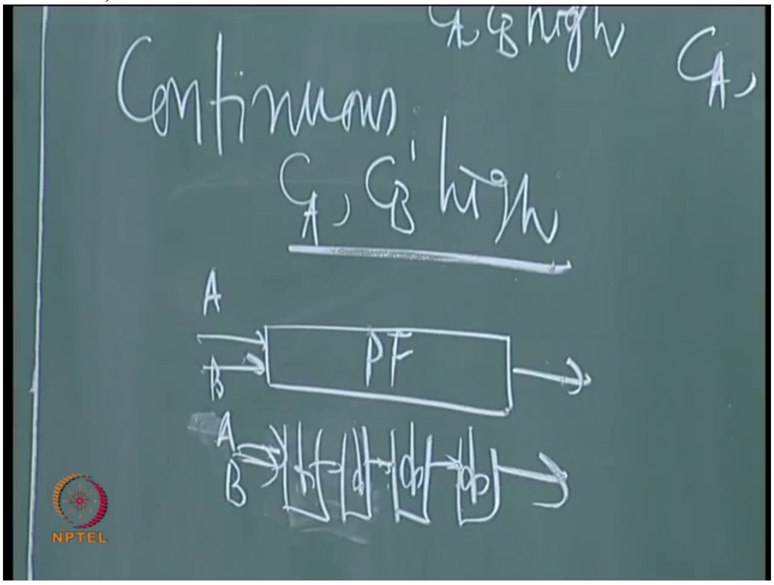


maintaining high concentrations. This is Ok.

Now if you want to maintain for example, C A high and C B low what do you do? C A high, this is continuous system again, I will write. C A high and C B low, for this situation what do we do? Not bypass. Bypass alone will not help you. This is P F. You know, C B low I have to put, A

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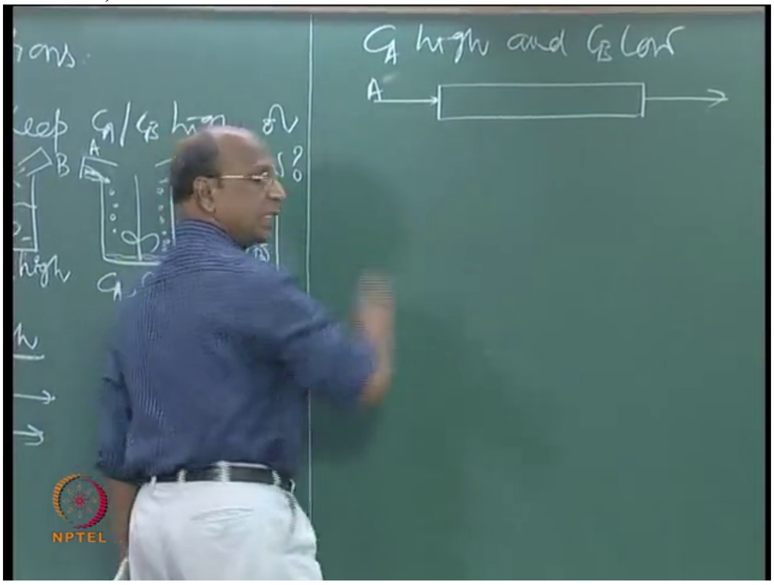


I will send here but B I distribute.

This is one of the challenging problems for chemical engineers, Ok. Yeah. This

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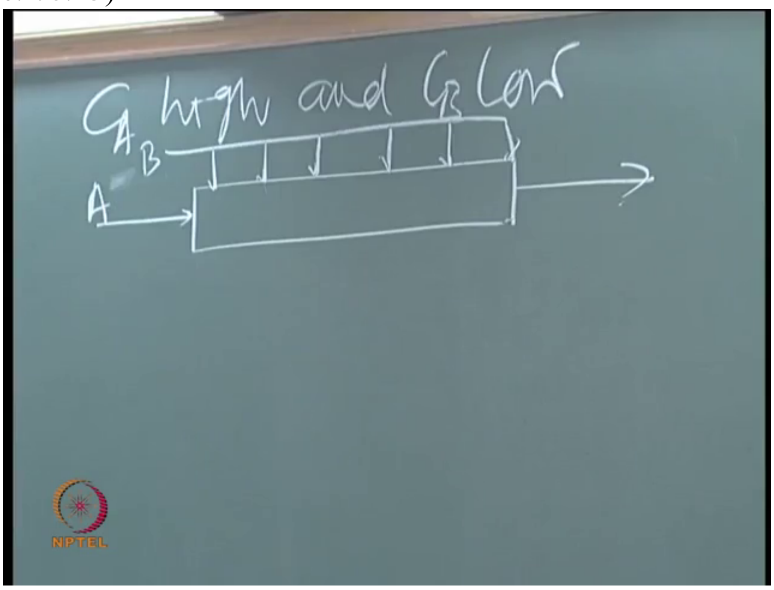


is really wonderful problem. Definitely you can question how do you maintain plug flow and still do it. It is not that easy. But still things will work, right.

That means if I, when you are introducing this, there will be some disturbance, hydrodynamic disturbance. So that will definitely create some kind of mixing, right when it is entering. You have the vertical tube or horizontal also, and then you are putting various streams at various places and open the tap.

When it is entering, definitely there will be, overall flow is from top to the bottom. It is going like this. So definitely you will have some disturbances. But if you take sufficiently lengthy things I think you know, we are almost near plug flow but still you will get some kind of small disturbance but you get good amount of yields.

Ok, that can be done beautifully. But mathematically it is not that easy. Ok. A and then B distributed over so that at any time I will choose my C B. in fact this is again an optimization problem.

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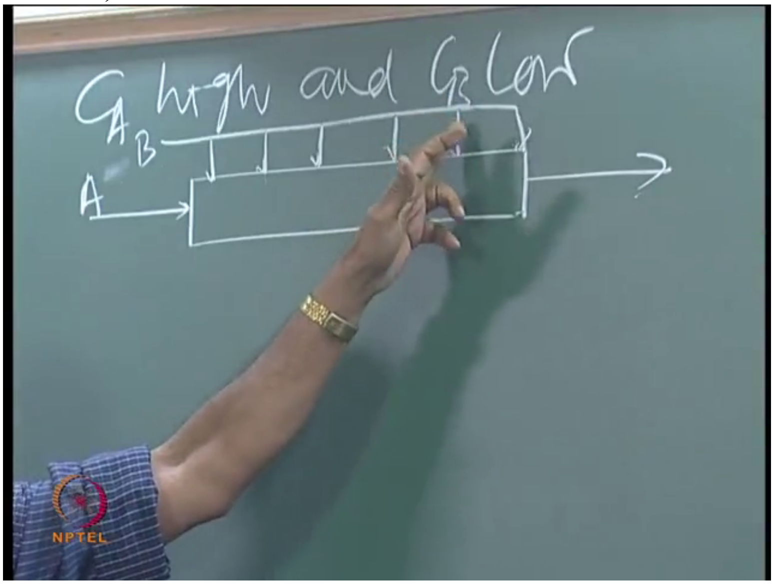


Which C B that means what is the concentration of C B and what will be the flow rates of C B?

(Professor – student conversation starts)

Student: Distribution. C A high flow rate, B lower flow rate. We can maintain...

Professor: But I cannot maintain

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no, because again stoichiometrically I have to do that.

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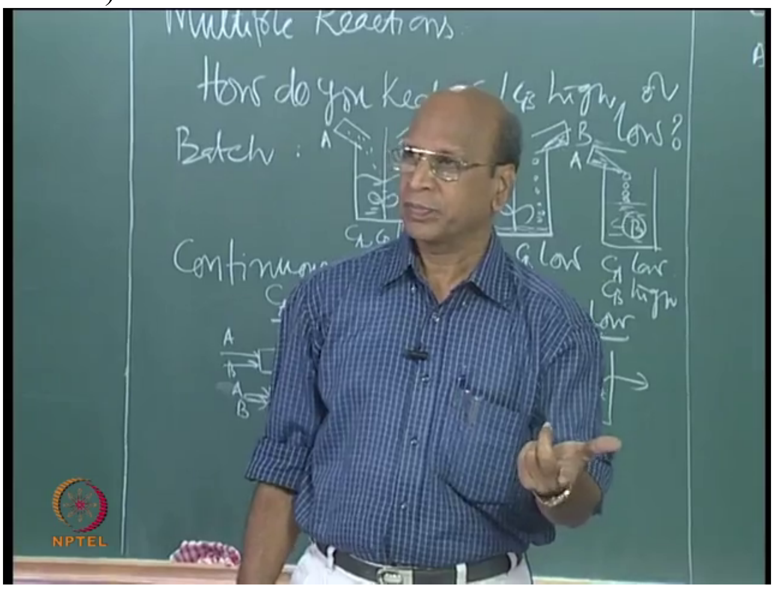


Yeah, exactly. That will be limiting reactant. So I do not get the desired products. So that is why.

Student: C B will be high in this case.

Professor: No

Student: C A will be high.

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Professor: A is maintaining throughout, , you have

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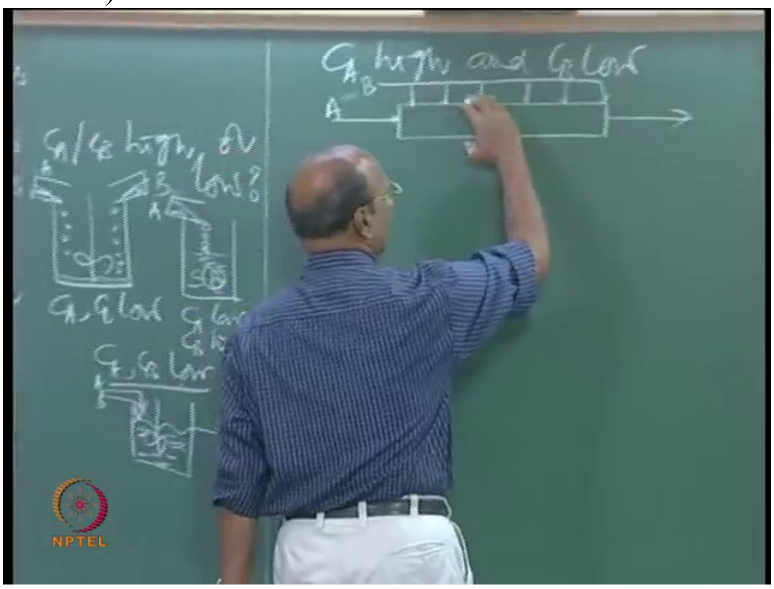

high concentrations. And B you are introducing wherever you want, you know throughout that means at any point of time when I look at that, at this position for example A should be high, B should be low.

Student: 0:10:26.5

Professor: So similarly, A should be high, B should be low concentrations.

Student: After some time A will be reacted.

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And only still you are adding B. Means B is higher, A is low.

Professor: Yeah, but here you see I am taking 25 moles or 30 moles

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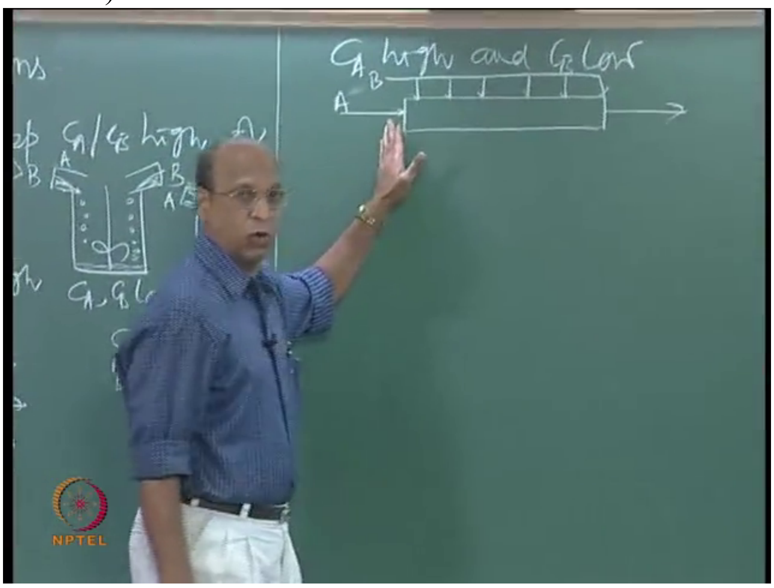


and here I am adding only 1 mole.

Student: You are adding more B,

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high concentration of B

Professor: Yeah, but that I have to find out

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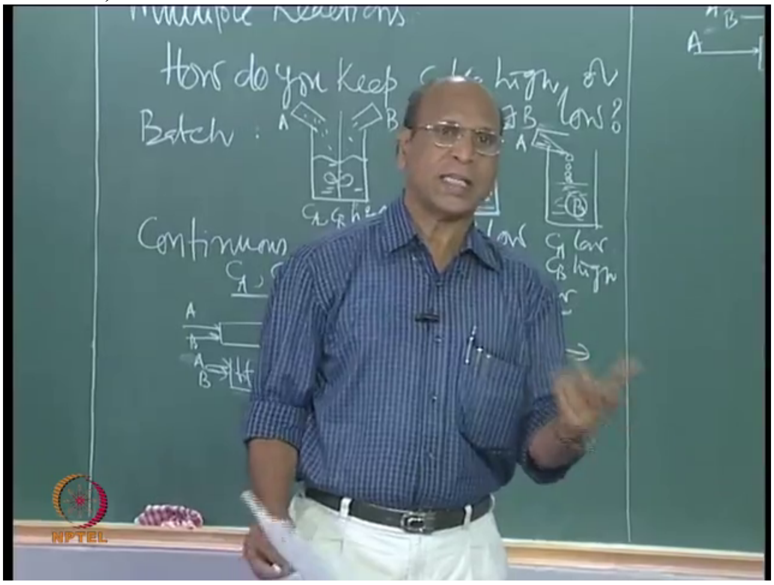


what are the concentrations which I have to use so that I will maximize my product? So here this mathematics will be very, very complicated. Concentration I have to choose, flow rates also I have to choose. So these two I have to choose. I mean this is really a challenging problem.

Student: I mean when you are pouring C B at different cross-sections, Sir, there might be a probability of mixing.

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Professor: That is what I just told you, no. That is what exactly I told.

(Professor – student conversation ends)

You know

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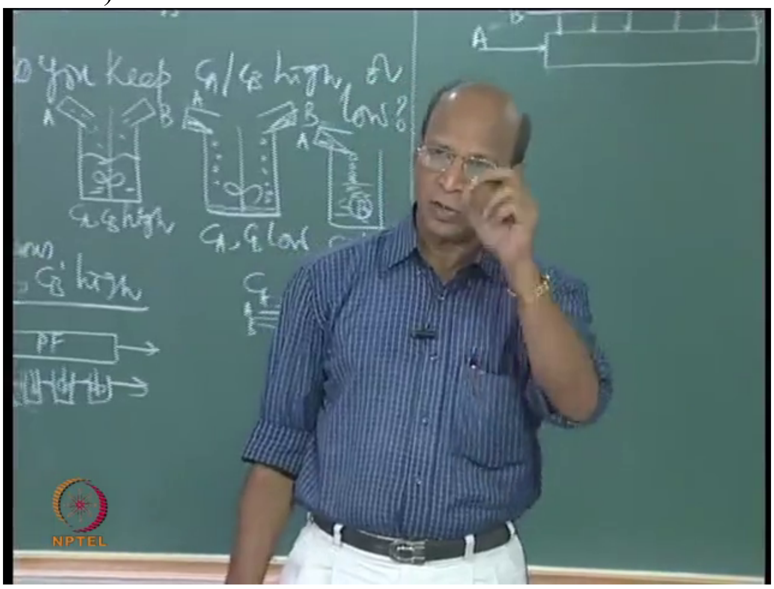


that hydrodynamic disturbance is there when you are introducing the streams at any cross-section, right. So due to that, you will have some kind of disturbance.

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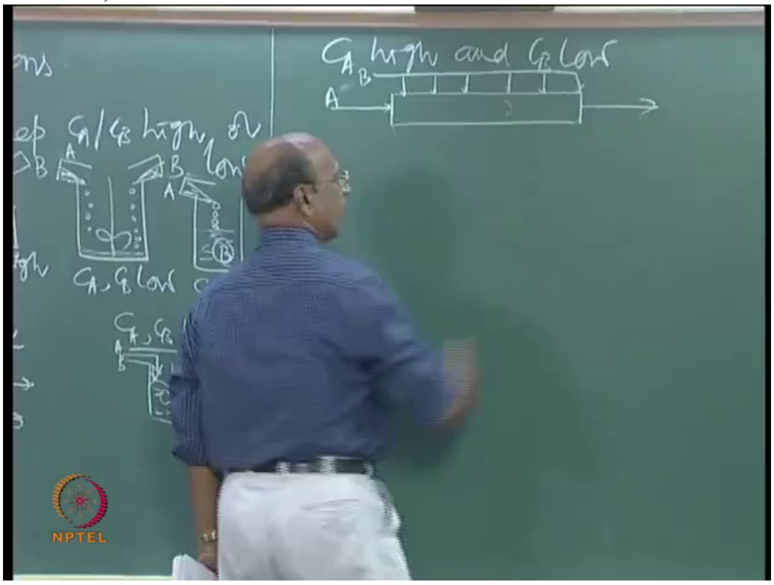

But overall if I look, still I may not get 100 percent perfect plug flow.

By the way there is no 100 percent plug flow except for conveyor belts, right? So that is why that disturbance is there. But in spite of that disturbance I will still get more desired product if I use this system, if I have to maintain C A high and C B low, Ok and also we have another nice thing, the same thing.

Can you just imagine what is the next alternative? Because plug flow is generally is difficult and then you know, yeah

(Professor – student conversation starts)

Student: C S T Rs

Professor: Yeah, that also, C S T Rs you can put, let us take 6 you can take and introduce in everything separately. That is in fact is much easier, but only thing is you have to handle 6 reactors in industry. But where as you have to use only 1 pipe I mean when you are trying plug, right?

(Professor – student conversation ends)

Because again, you know, in industry many people hate maintenance. The more number of pieces they have then definitely

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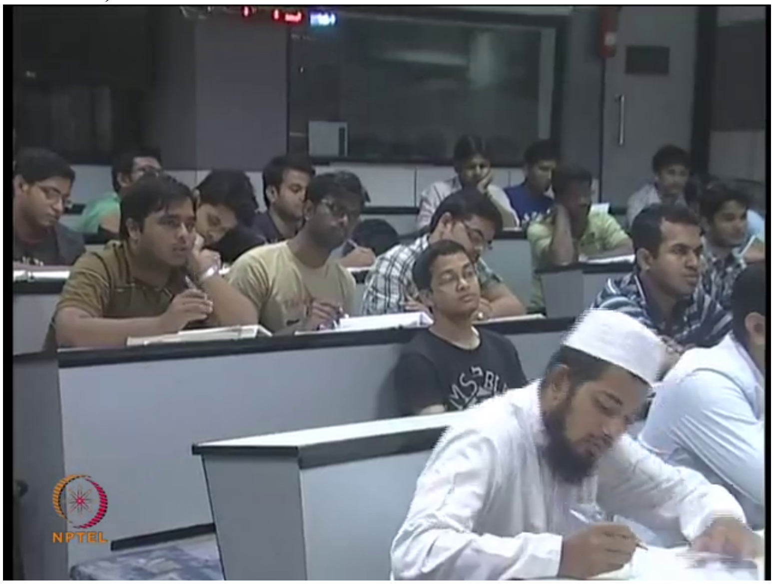

the maintenance also will be high. So that is why they would like to go normally for equipment which is not moving that means moving parts are not there.

If you are able to mix without

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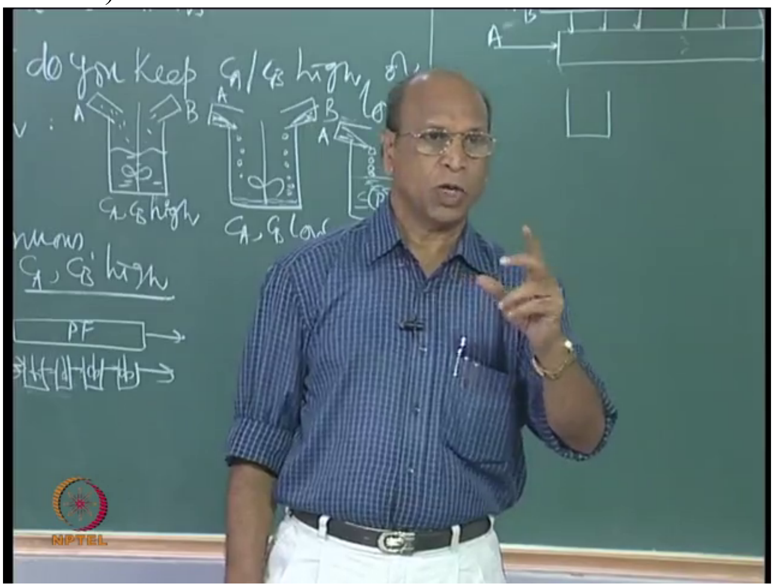


even external stirrer it is excellent. You know there was some, think there are many, many wonderful things I say if you are open for knowledge, Ok. Many people I think in 70s tried to design motionless mixers, static mixers. Another name for that is static mixers, and motionless mixers.

So the fluid will move itself and then there is no external mechanism where the stirring is occurring and then mixing is taking place. See, human mind is excellent. I think there is no limitation for thinking. Only thing is you are not thinking. I mean, you may be thinking other things. Thinking about chemical engineering, that is what my worry is, Ok.

So that is why all those possibilities are there but this one is easy for me to handle but except again in industry you know I have to maintain 6 stirrers, 6 different tanks, tanks may be same size, Ok and again if I have, each tank has a coolant, that means if it is exothermic reaction you have to remove or add heat, right, you have to maintain some temperatures. So all these problems will be there. Yeah

(Professor – student conversation starts)
Student: Magnetic stirrer will work

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Professor: Magnetic stirrer means L K G,

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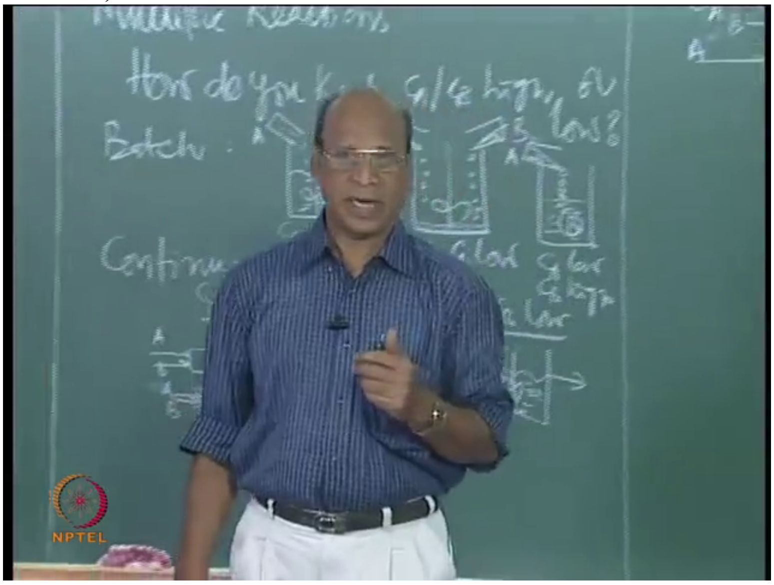

right. Because in magnetic stirrer, how can you can in industry where I have 2 tons, 3 tons of liquid in a reactor, right? Yeah I mean that is not possible, no. So that is why you go to, I mean, I think if you know also, I do not know in Fluid Mechanics you have studied what kind of stirrers we have.

(Professor – student conversation ends)

You will tell only the turbine type and the other is paddle time, propeller type, only these three but if you go to actual suppliers shop you know Google and then ask for, yeah, different kinds of stirrers, thousands you will get. Thousands, I am not joking really. I mean so many you can get, right?

So that is why stirring itself is one of the again areas where lot of chemical engineering and lot fluid mechanics all this went in. Ok, good. But I think theoretically when you are discussing, yes, I can put some 5, 6 tanks in series and now again you put B here, A here.

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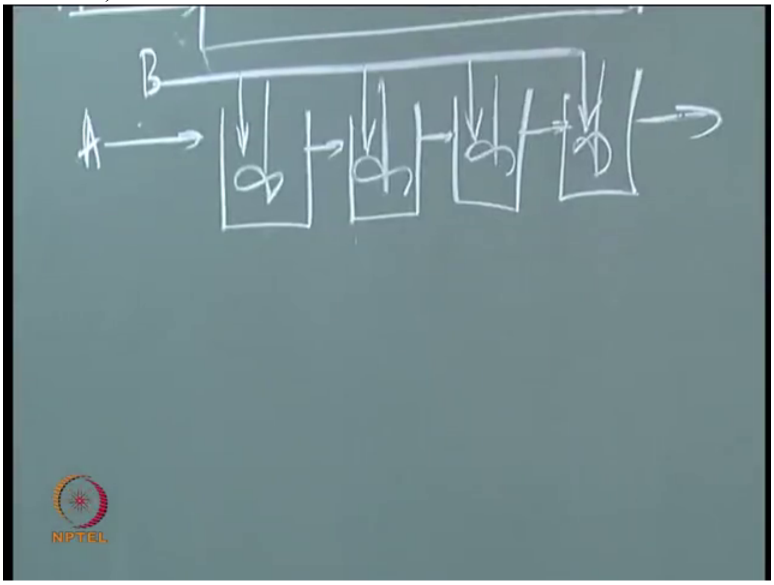


This is easy to solve, this is easy to solve also.

And again, for optimization I have to now try to find out what will be the, you know the flow rates and concentrations, concentration of A we know but concentration of B, so that overall you will get here at this end, the maximum yield. Ok.

Yeah, this will be quite interesting, I say, yeah because I told you, you could have had and I am not trying to pointing out any bad things about you, you know I am not trying to say anything bad about you but you know if the sufficient information was there when you come here for M Tech or P h D, we could have discussed actually these kind of problems.

Ok, that means I do not have to explain again what is plug flow. I do not have to explain again what is differential method, what is, you know integral method. So straightaway go to multiple reactions and multiple reactors, from there you can go to temperatures, non-isothermal systems and also R T D and all, right?

But now I have to bring to that level and then try to say. Ok or otherwise whatever you have the knowledge, if I start only with this kind of complicated things I am sure 90 percent of the brains will be switched off. Battery loss. So this is the problem. That is why again we have to do all this, Ok.

So now this is another way of operating, for C A low, C A high and C B low and vice versa also what we can do, good? Ok so now. Let us take an example here. Then you tell me which kind of

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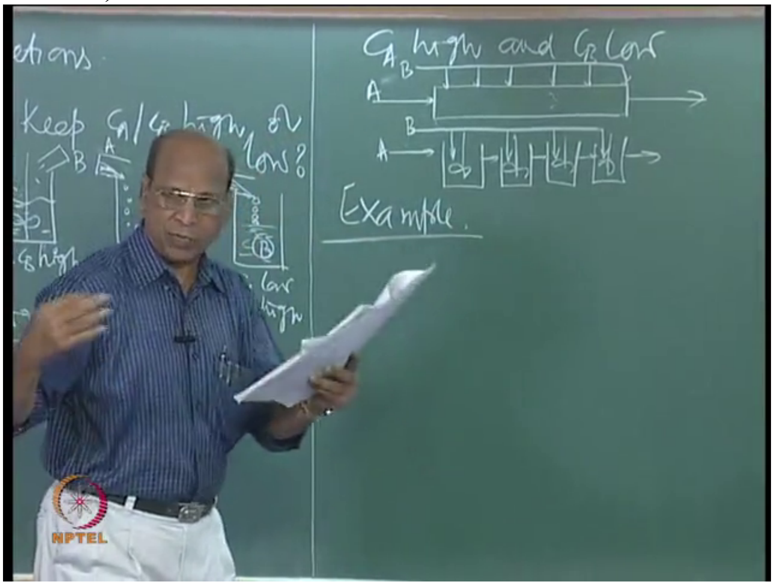


contacting patterns you can use.

I have a reaction. These are very beautiful problems in Levenspiel. You have to see those problems. I think seventh chapter or eighth chapter and, third edition also I think it is seventh chapter, Ok. Wonderful problems, particularly the examples are beautiful examples. Solve them.

I am just trying to give you so that you will have whatever we learnt, you know just extension, so that you can be involved in the class and then you can answer this, right? So wonderful problems he has designed. No other book has given that kind of beautiful problems. Ok. I am telling beautiful because they are simple problems to get the concepts.

If you go to Carberry and other complicated books you will have excellent, highly complicated problems. But you do not learn the concepts unless you learn here. And then go there and then enjoy that. In fact, if you understand all the concepts of chemical reaction engineering, Carberry is the best book for enjoyment. I am not telling for marks, for enjoyment. Enjoying is different. That is what I told you know.

Chemical Reactor Theory by Denbigh, beautiful book! Like novel you can read that. Like novel only. So beautiful, less mathematics, wonderful explanations, right. So but I think again I do not know what is, how many of you are really appreciating that, right? Ok.

Anyway the example is A plus B going to R plus T

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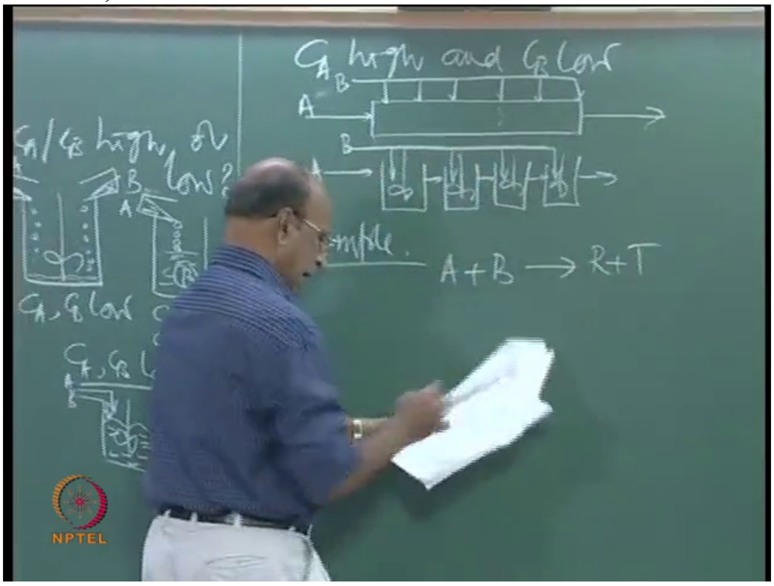


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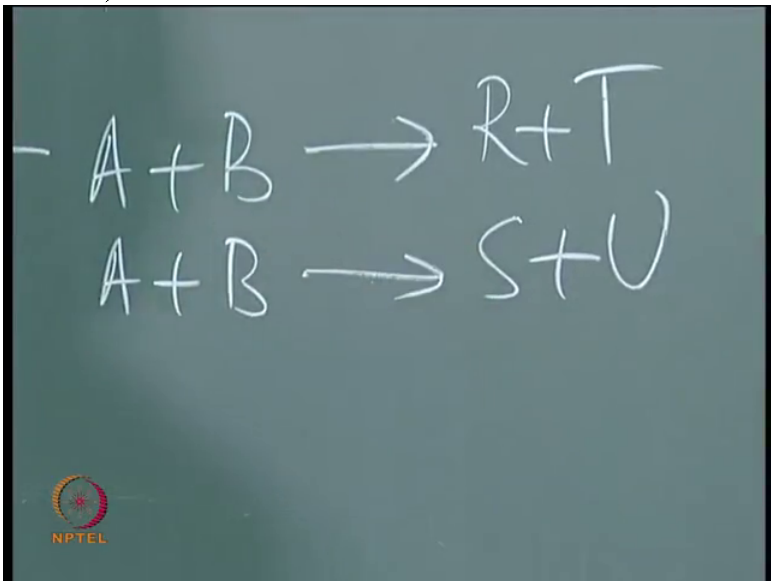


going to these two. Then I will have here k 1, k 2 as the reaction constants.

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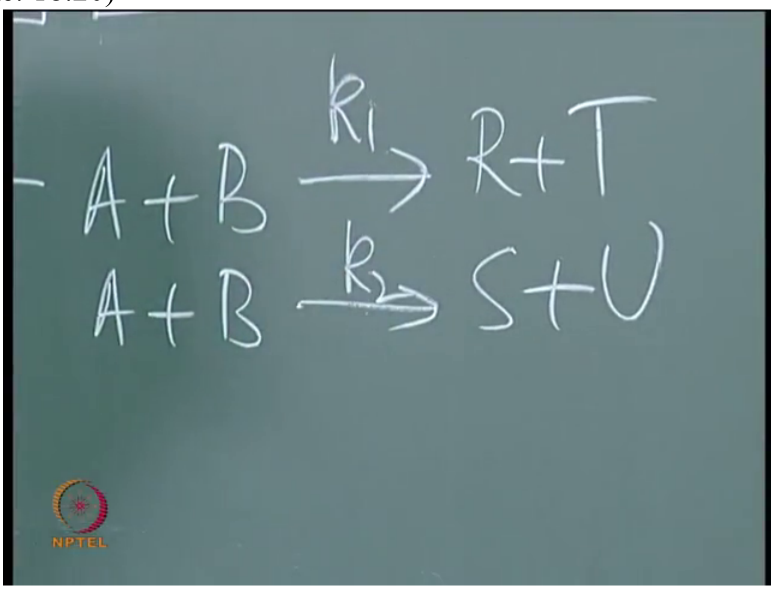

Then we also have here, d C R by d t also equal to d C S by, T, by d t, equal to k 1 C A to the power of 1 point 5, and C B to the power of point 3. That is the rate for this first one.

For the

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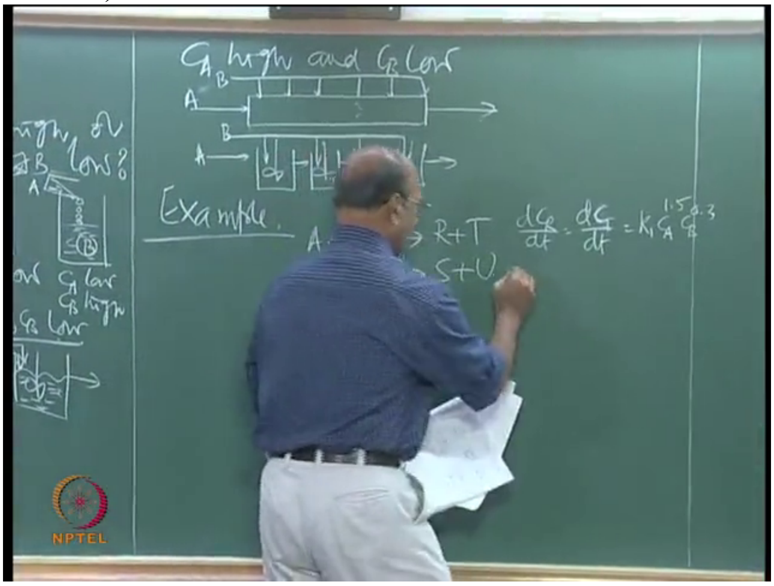


second one, we have d C S by d t also equal to d C U by d t equal to k 2, C A to the power of point 5, C B to the power of 1 point 8

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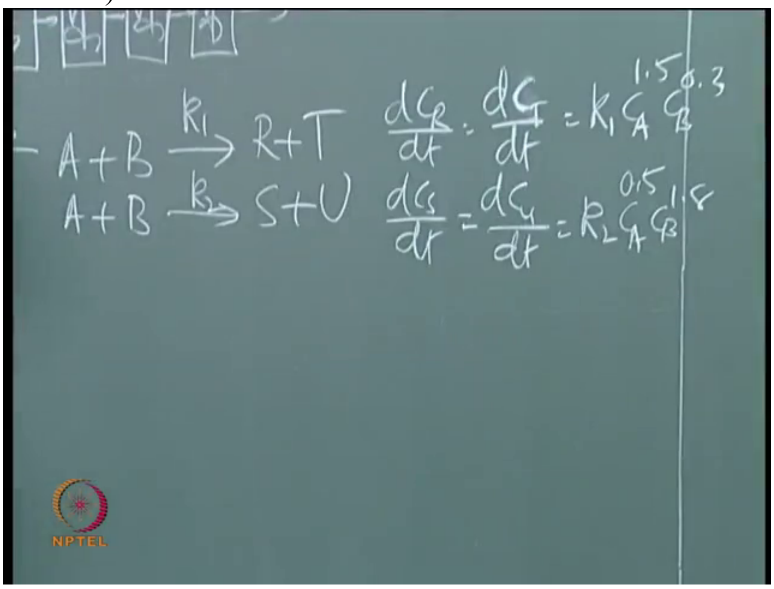


Our desired product is R,

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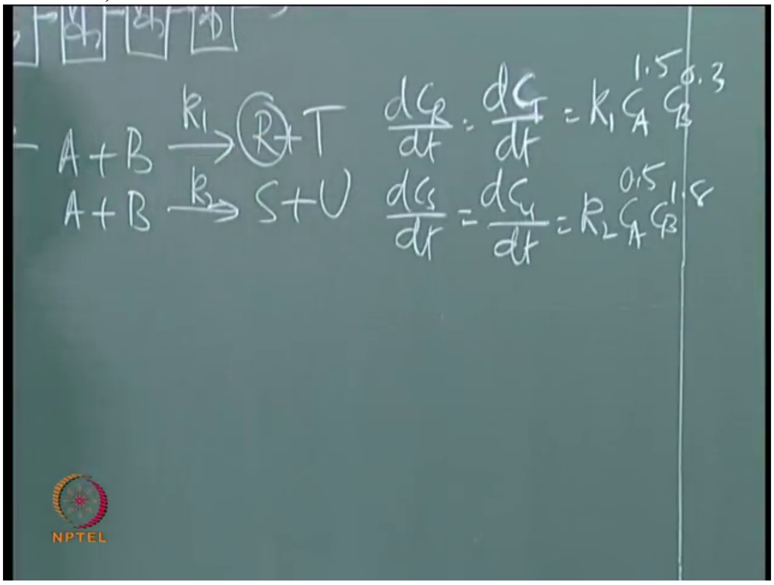

Ok, desired product is R. Now find out what are the conditions so that I can get maximum R. You can try, desired by undesired. Undesired C S we can take. C S or C U? Both are same.

(Professor – student conversation starts)

Student: C S should be taken

Professor: Yes?

Student: C S should be taken

Professor: What do you do? You just took now d C R by d C S equal to, what you get, k 1 by k 2 C A and C B to the power of, minus of point 5. So how do I maintain so that I will get this ratio high? This ratio is nothing but again r R by r S, So what are the conditions so that r R will be more?

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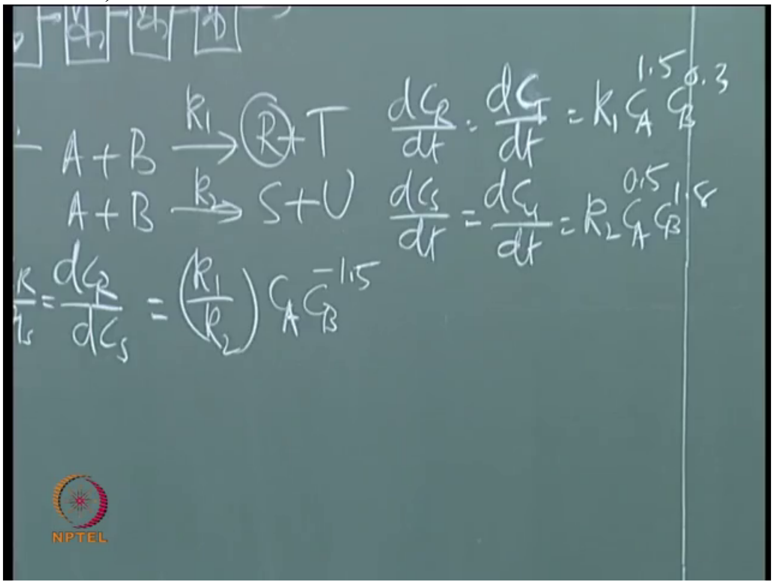


Student: C A...

Professor: C A should be as high as possible, C B should be

Student: Low

Professor: as low as possible. Very good. I think all of you have got that. I think, no. Then what kind of reactor I have to choose? Which one Pooja?

Student: Batch reactor

Professor: There is a name for that, no?

Student: P F R

Professor: P F R with

Student: side stream

Professor: Yeah, P F R with side streams is the best one or this M F Rs also with yeah, side streams again you know, wherever you know each reactor you have to put that. But definitely that P F R will only give you, when compared to this number of tanks, correct no. Definitely, unless you put infinity number of tanks. Infinity number of tanks you cannot put. Because various things you know to keep infinite number of tanks, Ok good.

(Professor – student conversation ends)

So now I think you know the rules now. That what are the rules we have? If the desired reaction is having higher order then maintain the concentrations as high as possible. Ok,

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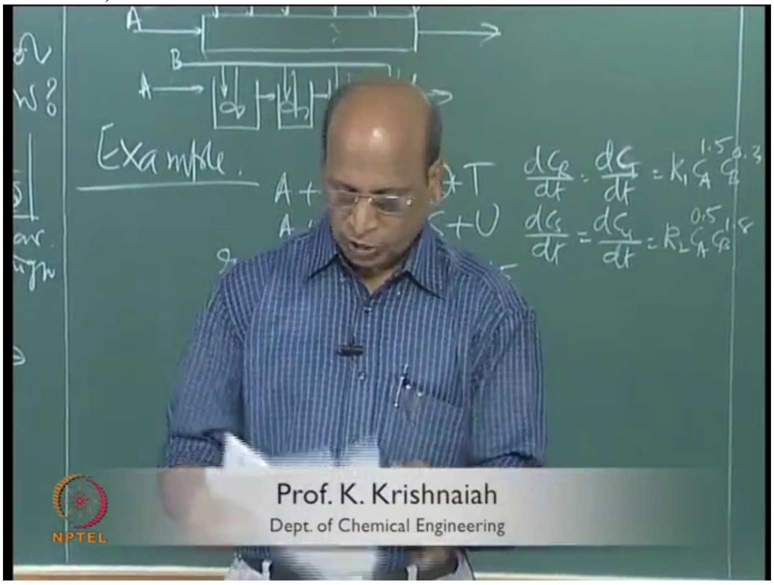


so this rule I think I will tell you, Ok. Please make a note of this, and also mug up, remember, right, yeah.

For

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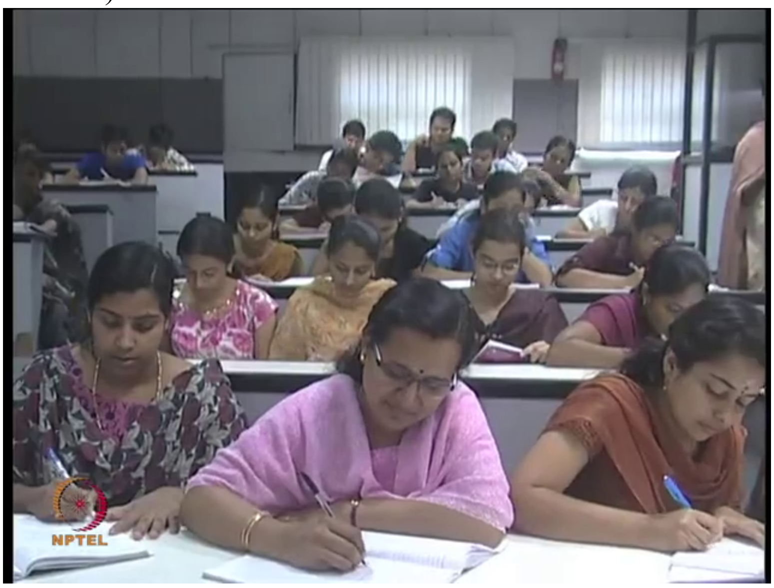


reactions in parallel the concentration level of reactants is the key to

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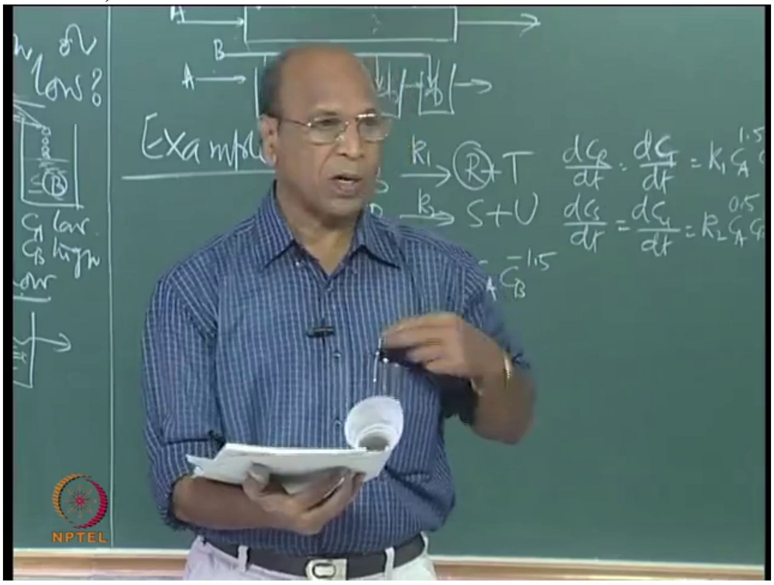

proper control of product distribution, full stop. A high reaction concentration favors the reaction of higher order; the reaction of higher order comma a low concentration favors the reaction of lower order comma

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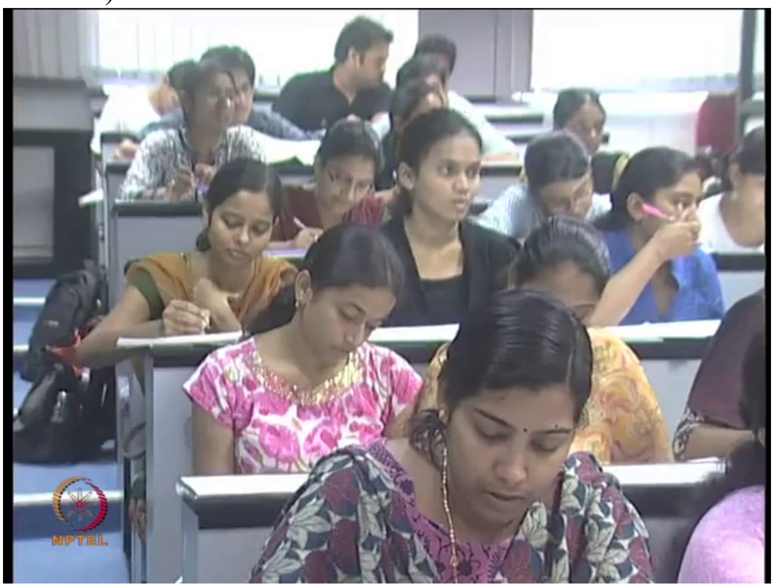

while the

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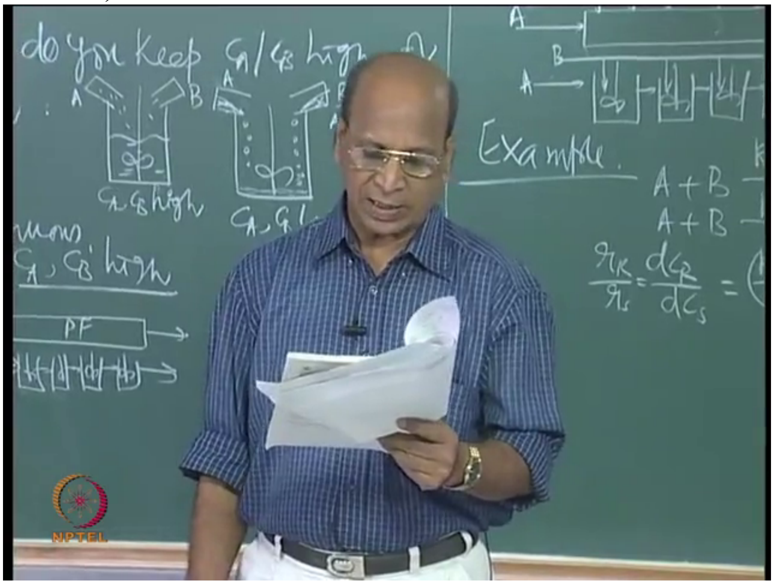


concentration level has no effect on the product distribution for reactions of same order,

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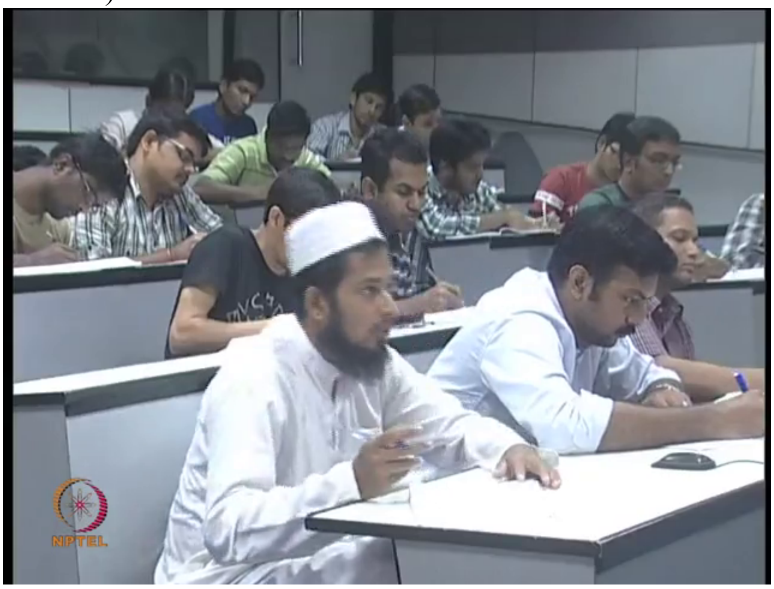

not zero order, same order. Because concentration, concentration will get cancelled. Ok. So that is the one, that is beautiful. This one you have to remember. We would like

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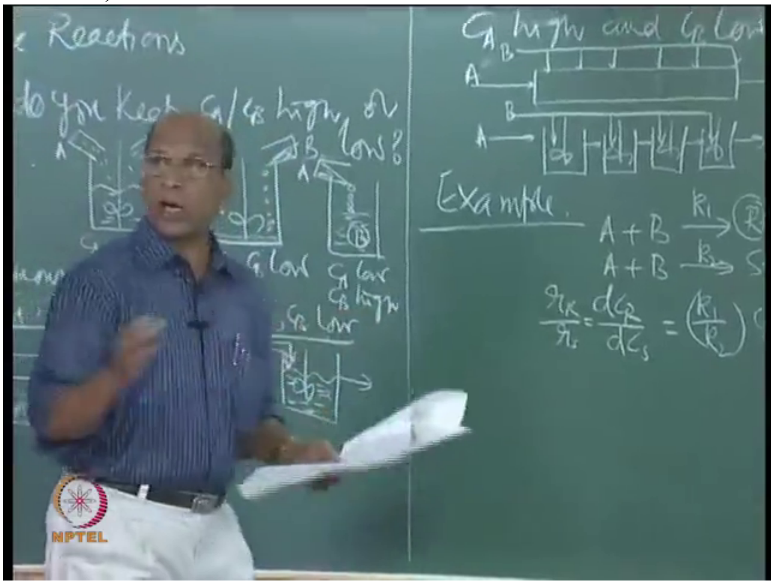


to quantify, now you see these were only analytical things only what we have discussed, right? So what do you do, when to maintain high or low, but if someone wants to say, now tell me what is the maximum yield you will get, exactly a number, quantification, so then we have to go to mathematical equation, right?

So now we are trying to do that mathematical equations. Then we will say that this is yield quantification and we have instantaneous yield defined earlier as phi equal to d C R by minus d C A. So this is the instantaneous

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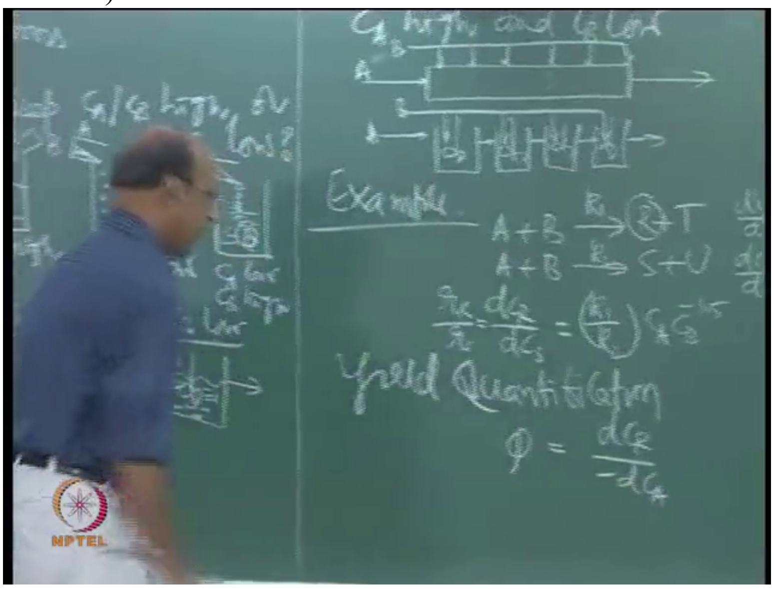


yield phi instantaneous, instantaneous yield is phi there.

So how do I quantify means, yeah this equation we will take and then discuss, if I have a plug flow how do

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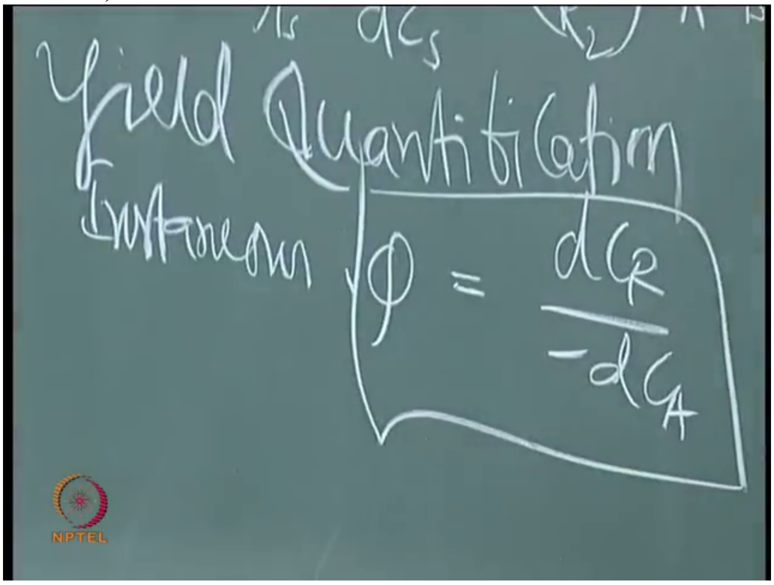


I get the yield, Ok. Yeah. Now you have to think a little bit, Ok. So how do I get a plug flow yield from this equation? I call this equation as 1.

How do I get yield, overall yield that means capital phi P, how do I get that? For plug flow. That is instantaneous yield. Where is this instantaneous yield? Yes, inside the reactor only but at what point? At any cross-section. So now overall yield how do I get; integration right?

So when I integrate what do I integrate? Yeah. d C R phi d C A minus, this minus is there, no. Now this one, right so what are the limits?

(Professor – student conversation starts)

Student: Zero to C R

Student: Zero to C R naught.

Professor: Where is C R naught? Normally C R naught is zero. Normally. We never take a product in the beginning unless you have catalytic reaction, autocatalytic reaction, Ok. Yeah, this is, and the other one corresponds to

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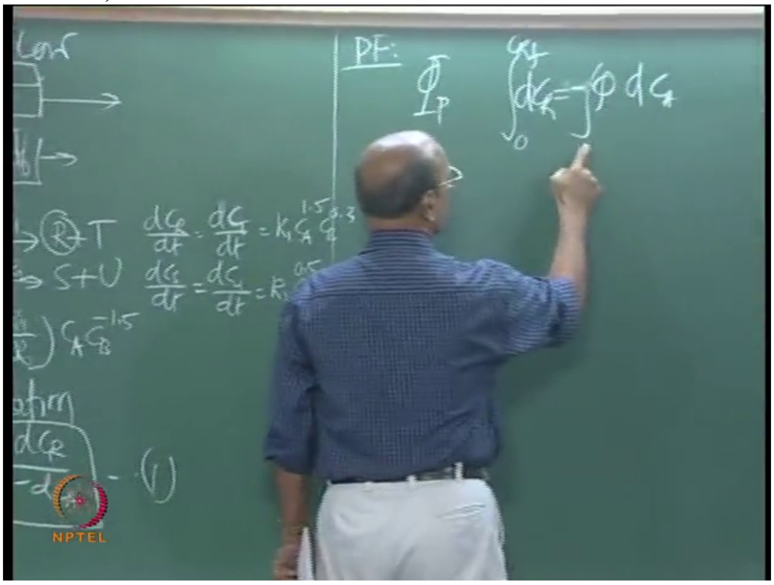


Student: C A naught to C A

Professor: That is C A f, Ok.

(Professor – student conversation ends)

Now this one I can write as C R f equal to minus phi d C A, C A naught to C A f. This is equation, but this is not still yield. This is not still yield. What is yield definition?

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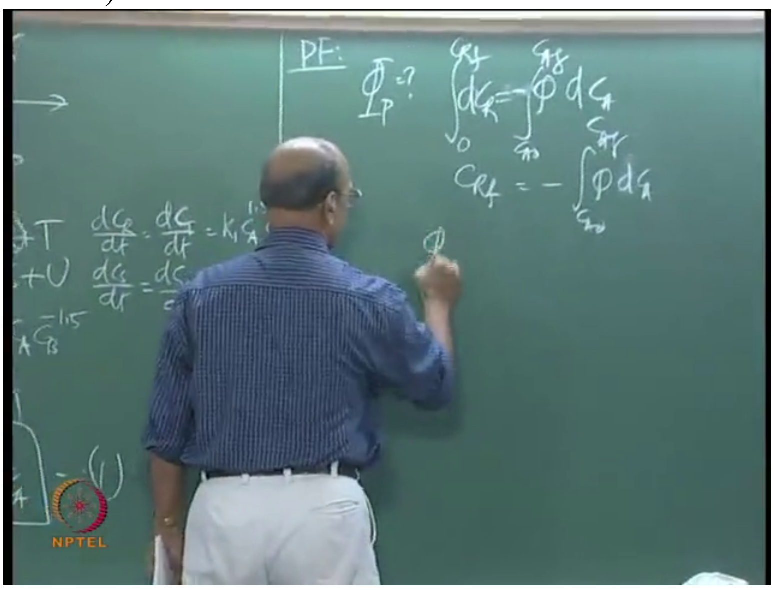


Yeah, there are two definitions, if I take the second one, if I take the first one this will be simply C R f by C A naught, this is 1. If I take the second one? Yeah phi 2 if I take, then this will be C R f by C A naught minus C A f, right.

So

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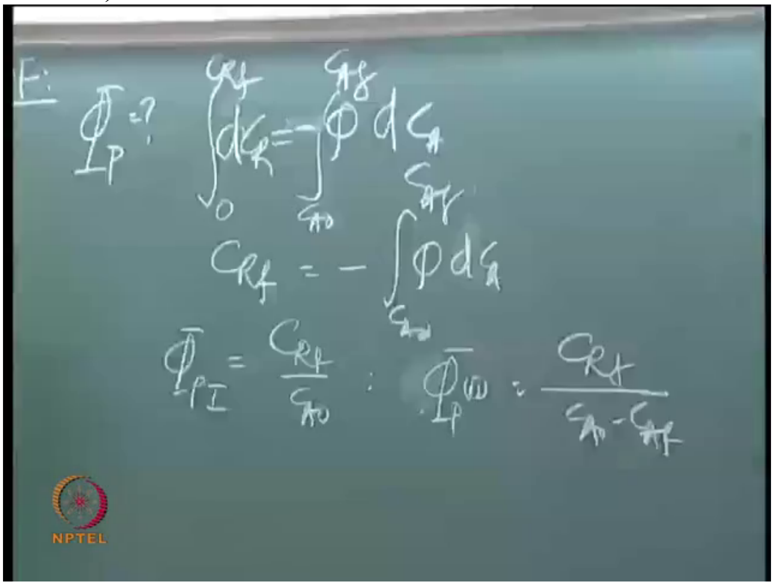

that means if I take the second one for example, first one is easy, so phi P 2 if I take, then this equation for yield will be, this entire thing is C R f, right? This entire thing is C R f. So this will be 1 by, integral C A naught to phi d C A. So this is the expression where I have to integrate and then get it, yes you are

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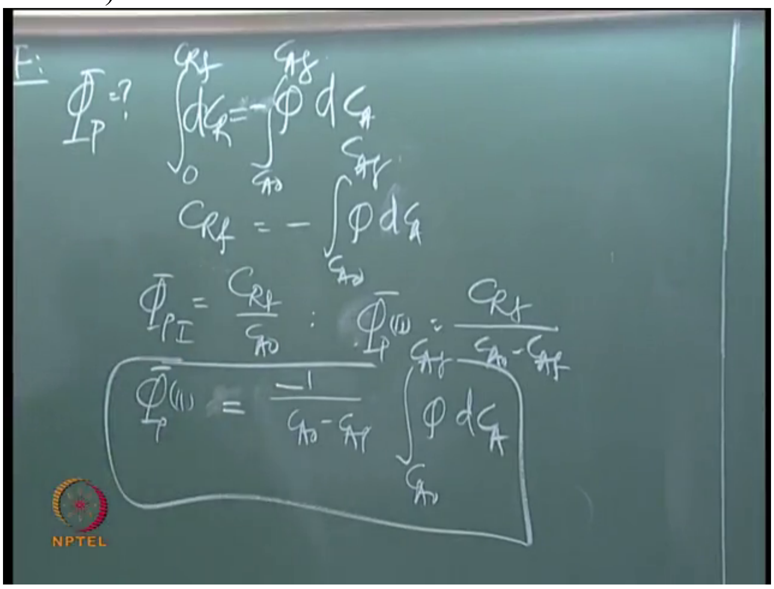

right. Minus is there. Because, to care of this one, correct no? This is more and that is less.

So this is the one. So that means now I should have this phi in terms of C A, in terms of, otherwise I cannot integrate, right? So how do I get that information? Ok we will come to that later. So now if I have M F how do I find out phi, capital phi? Phi M that is phi P. So instantaneous yield also is there. This is the definition of

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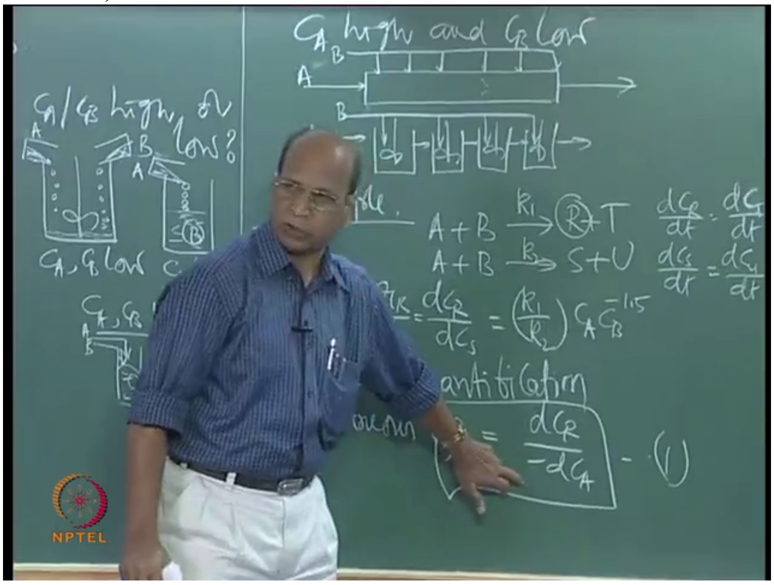


both.

But where is that instantaneous yield for mixed flow? So I think inside the reactor, outside the reactor, outside both are same. So what is outlet concentrations? So this differential equation will be equal to difference equation where this is nothing but, yeah C R f minus C R naught and this is also C A f minus C A naught.

(Professor – student conversation starts)

Student: Sir, negative is there, d C A naught?

Professor: Yeah, Ok. Minus is there but I told you

(Refer Slide Time: 26:47)

only d C A expanded, so now that is the equation what you get.

(Professor – student conversation ends)

So phi M is, actually capital phi M is, small phi M at outlet, correct? Outlet means at C A f. Because the same definition. So then this will become delta C R by delta C A, minus delta C A, right. So that becomes now, C R f by C A naught minus C A. So this is very easy.

And next, another beautiful thing is our graphs. So now how so I represent this information

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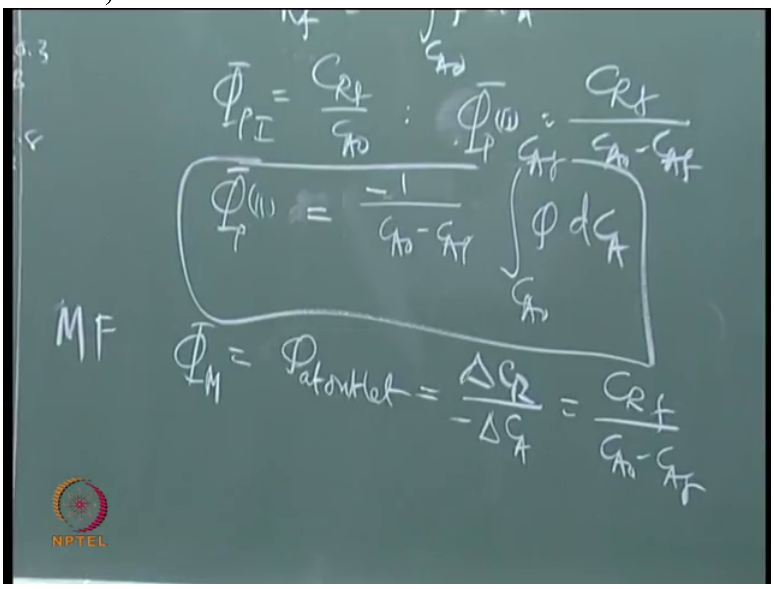


for plug flow on a graph sheet? Ok. Simply this one. I am talking about this, this one.

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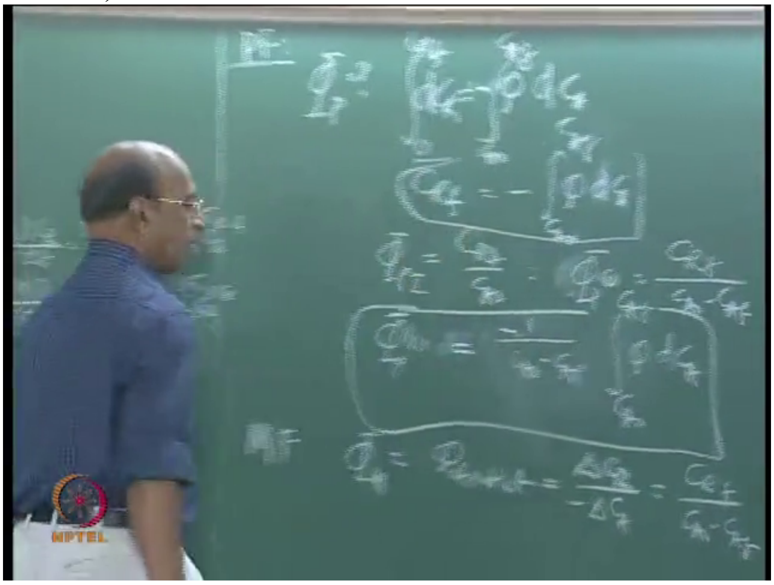

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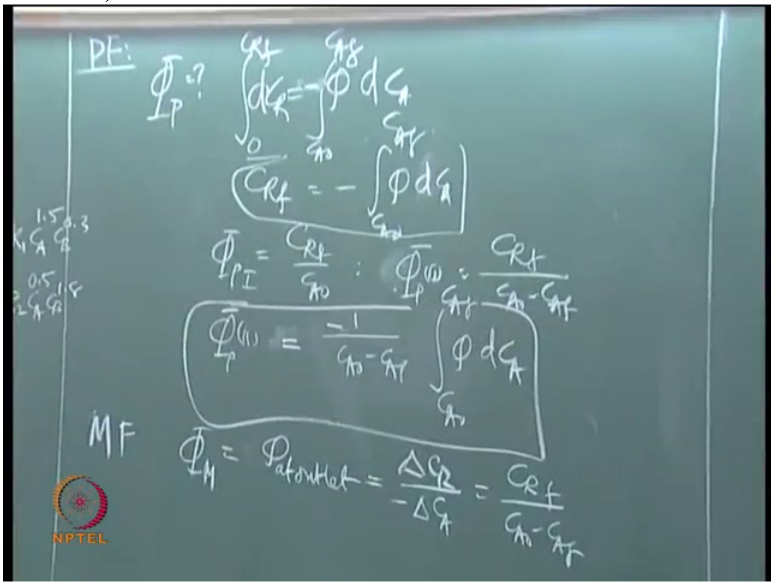

Yeah so I have to now plot, this is again simple graphical representation. This is phi versus C A, right?

So you may get something like this. Concentration versus phi. Right. That is not the only way. Just I am showing. You may get in one case like that. Then how do I find out from this graph my C R f.

(Professor – student conversation starts)

Student: Area under the curve

Professor: I should know, yes area under the curve. I should know first what is C A naught, C A naught is this side because C A decreasing

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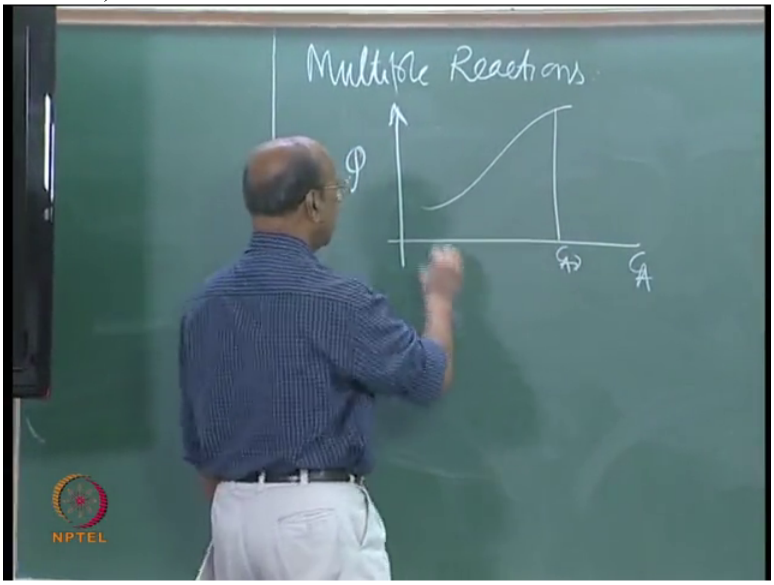


then this will be C A f and this area will be, very good. That

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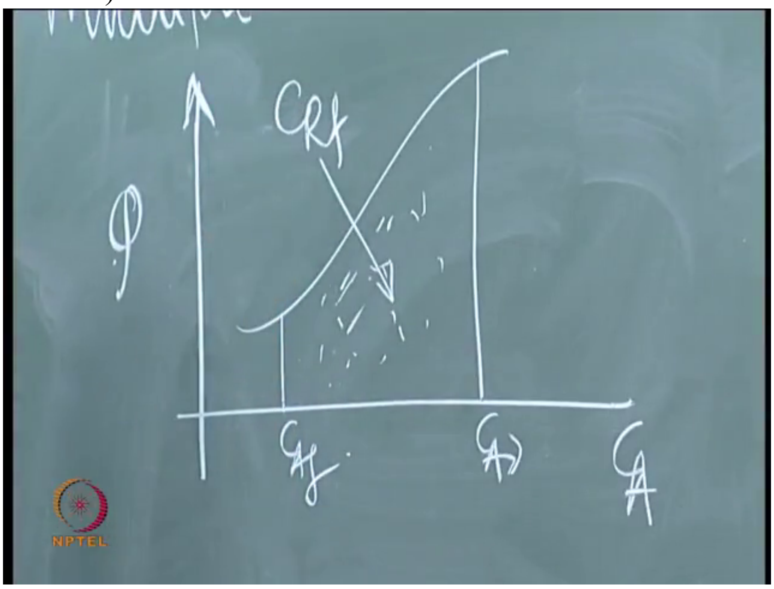


is C R f, right, excellent.

(Professor – student conversation ends)

Now the same thing, how do I get for, this is for P F. For M F how do I get that? Phi versus C A I get again the same thing, right? My C A naught is somewhere here. How do I get my C R f from? Which rectangle? I can draw any number of rectangles. What is upper rectangle?

(Professor – student conversation starts)

Student: C A f

Professor: First of all I have to equate with C A f. Ok I will equate with C A f. Now tell me which rectangle?

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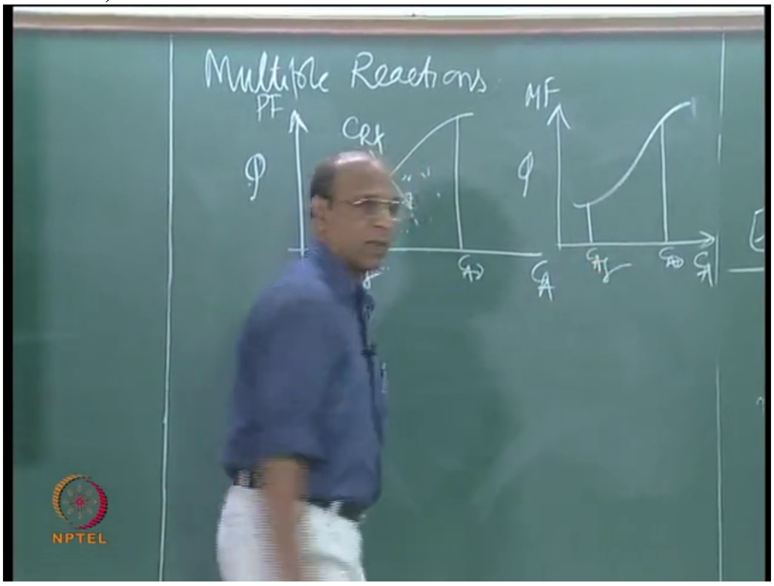


This one, no?

Student: Lower rectangle

Student: C A f.

Professor: I expect Debian, Ok Abhishek?

Student: Lower rectangle

Student: The middle part

Professor: See, compromise

Student: (laugh)

Professor: Middle part, somewhere here?

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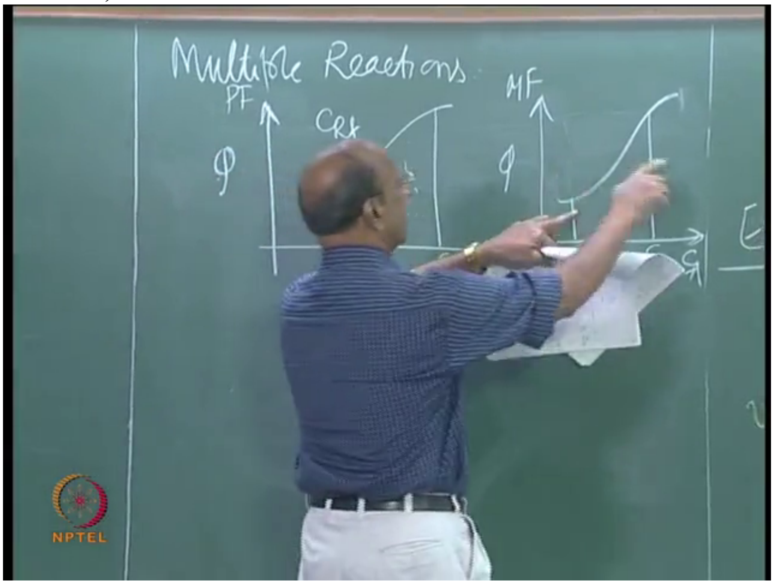


Student: Average area

Professor: Why average area here?

Student: C A f, C R f

Student: Lower rectangle

Professor: This is C R f.

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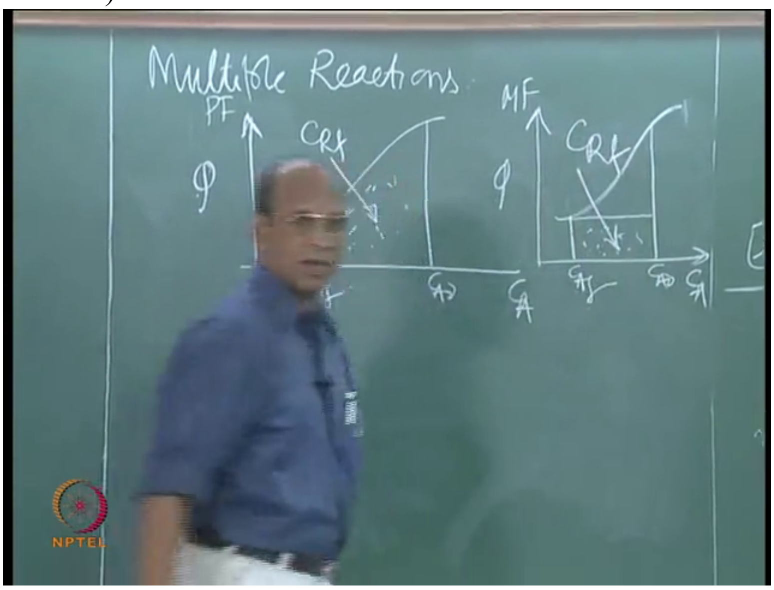


(Professor – student conversation ends)

Now tanks in series. Phi versus C A, same shape. Then I have here C A f.

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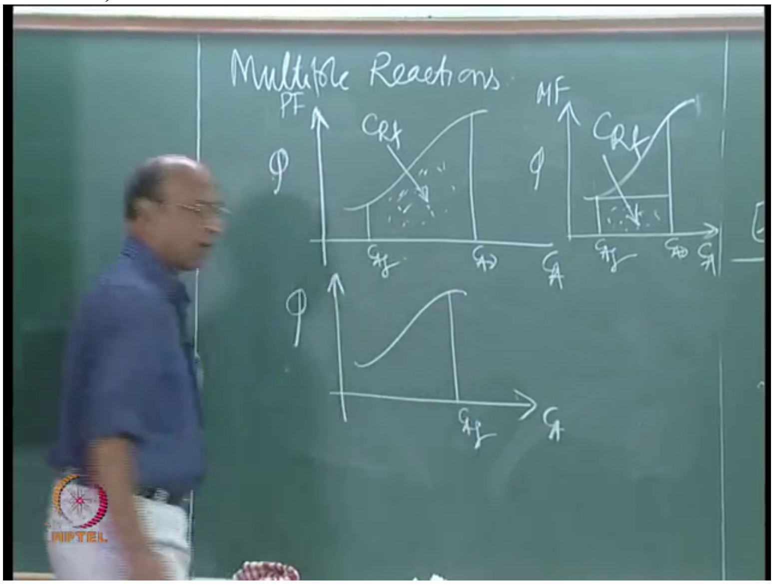


I have 3 tanks. So my C A 1 will be somewhere here, C A 2 will be somewhere here. This is C A f. C A f, C A 2, C A 1; of course this also is nothing but C A 3.

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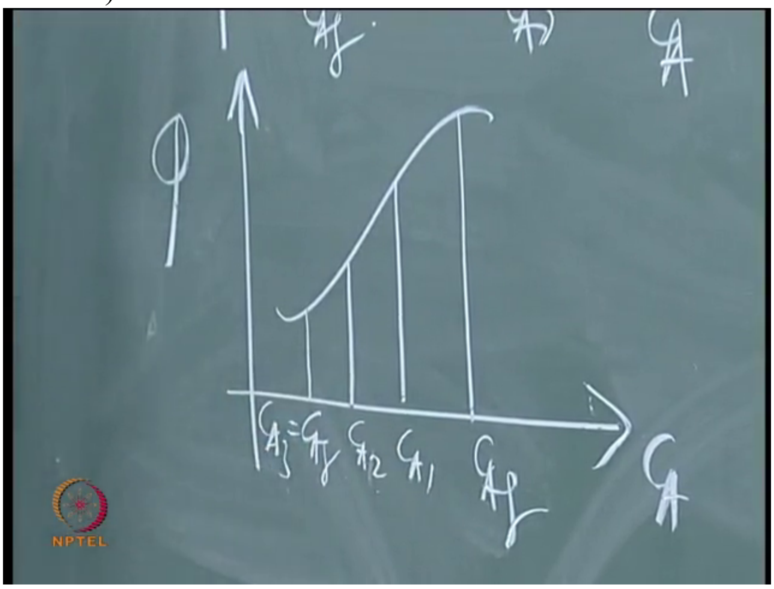

Very good, catch me like that. (laugh) . I am very happy if you catch, Ok. Good.

So how do I get now? This is the one. That is C R 1. This one is C R 2. This one is C R 3.

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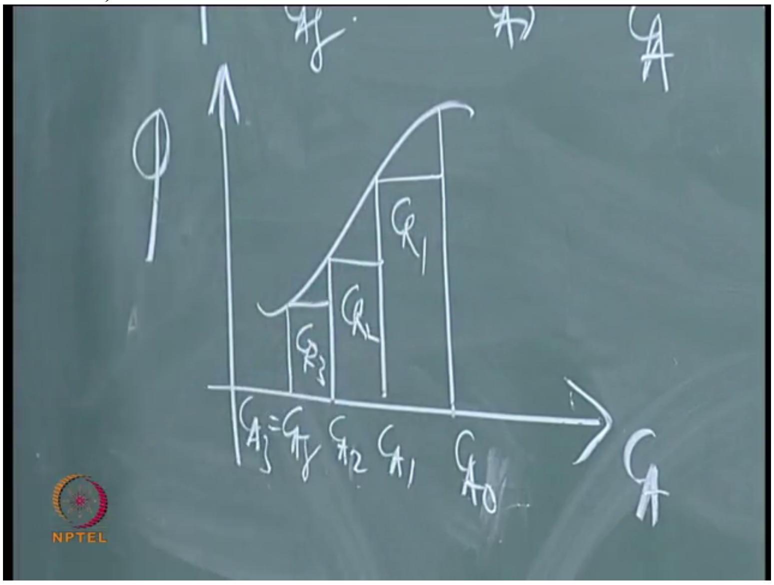

You see now, if you put infinite number of tanks what will happen?

(Professor – student conversation starts)

Student: We will get C R f.

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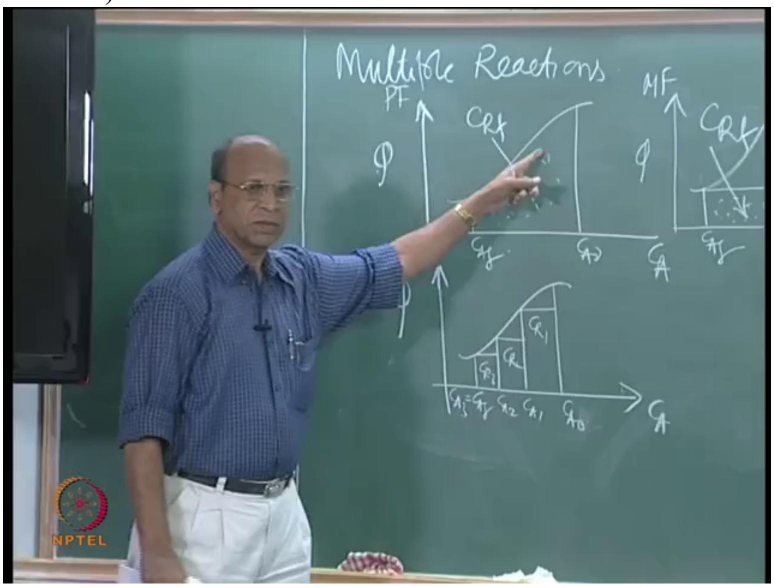


Professor: See how easy to remember graphs, you now. How easy, how beautiful to remember graphs! I think, start drawing graphs I say. It is really very, very good.

(Professor – student conversation ends)

But the only thing is now you should have information of this phi as a function

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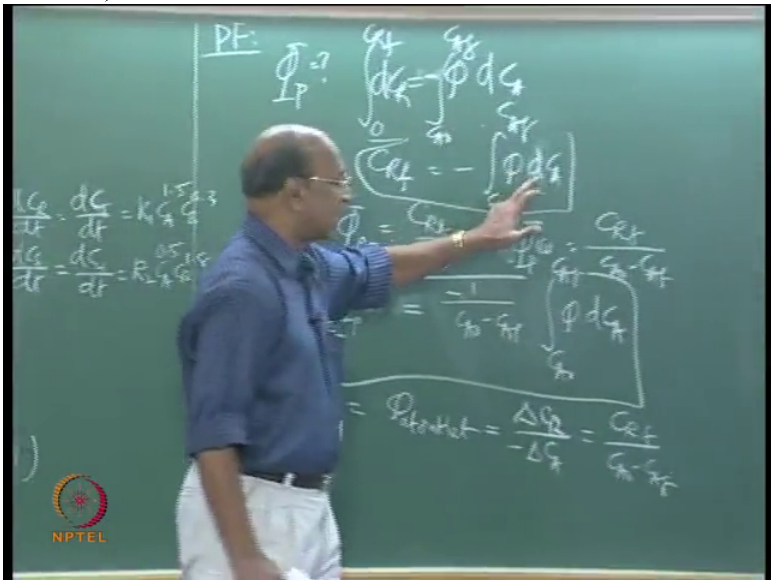

of C A. How do you get that? You have to go to laboratory and then take the whatever reaction that is you are studying and then mix the reactants, take out the products and then analyze for all the components.

If there are 3, at least 2 you have to measure and then third one you can get by difference. Ok, so like that, then you can list out now with various, you know timings will come if it is a batch reactor. So for this C A what is C R? So if it is C R it is desired product. Or if C S is the desired product, for this C A, what is C S?

Now you plot C R versus C A. That is this function. Right? So this may be, for example 1 plus 2 C A square as an example. C R equal to 1 plus 2 C R square, or maybe 1 plus C A

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plus C A square. That you have to plot. That line you have to plot. Ok. Then take areas under the curve

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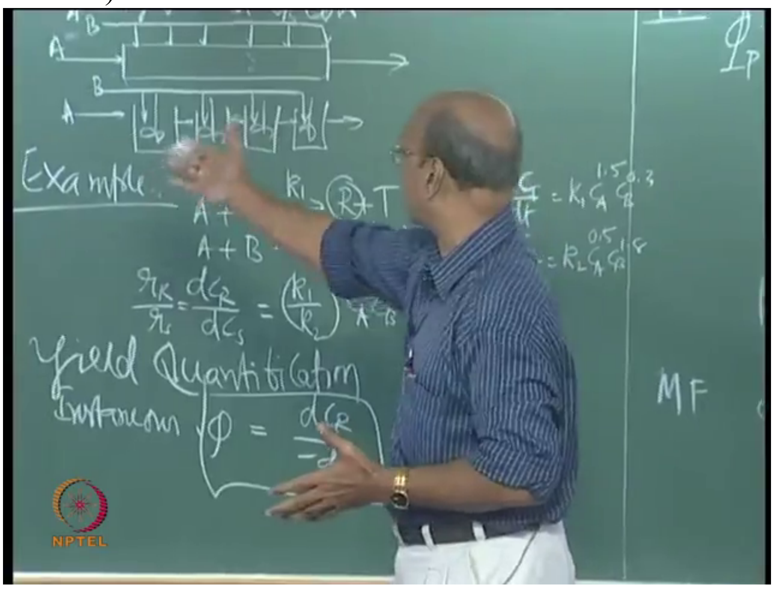


and all that. That is beautiful. As long as only C R you want to find out, you are able to find out now.

But what actually you do to find out what is the volume of the reactor? See here, till now, we have not talked about the volume of the reactor, no? Yeah, Ok. So one more thing I will just draw. In some cases I may get phi versus C A may be like Ok, like this, decreasing.

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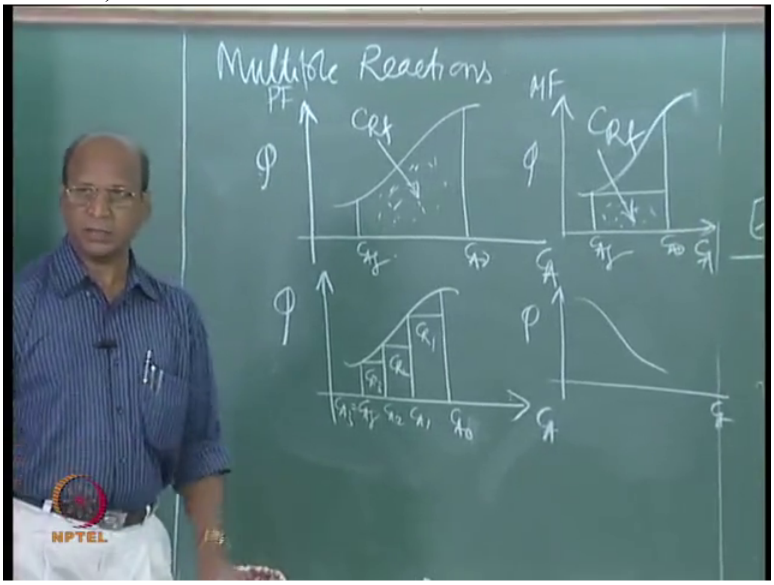


Because it is not in our hands. Anything may happen in the reactions. So, but this is still C A naught. This is C A f. What is

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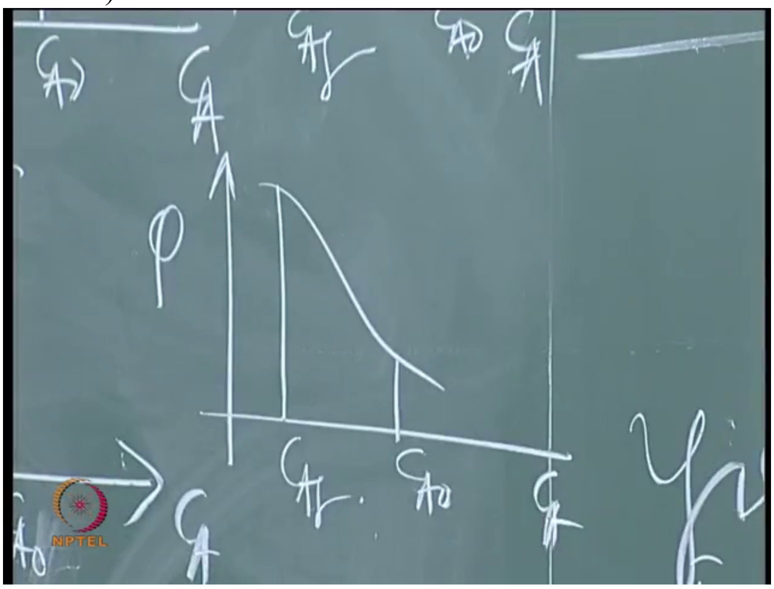

P F R yield and what is M F R yield?

(Professor – student conversation starts)

Student: Area under

Professor: Area under...

Professor: P F R will be simply

Student: Area under the curve.

Professor: Area under the curve. Right this is P F,

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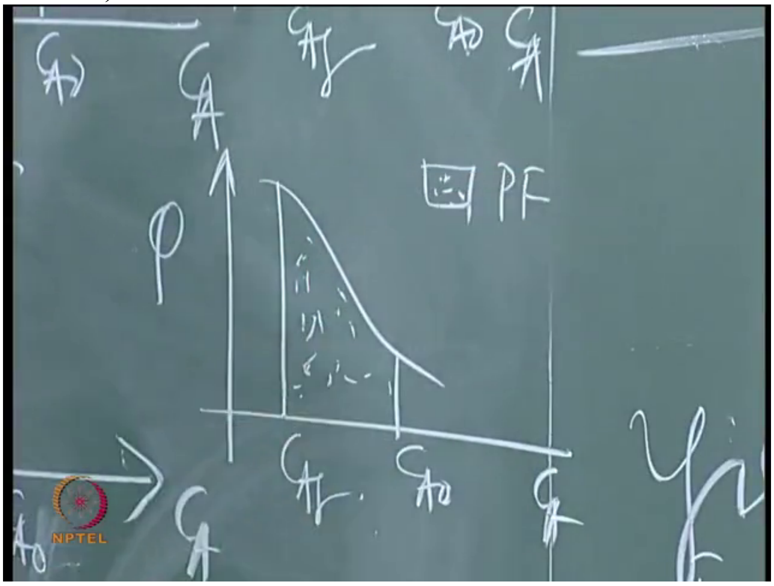


what is M F?

Student: Larger

Student: The other one.

Professor: So now, all this is M F,

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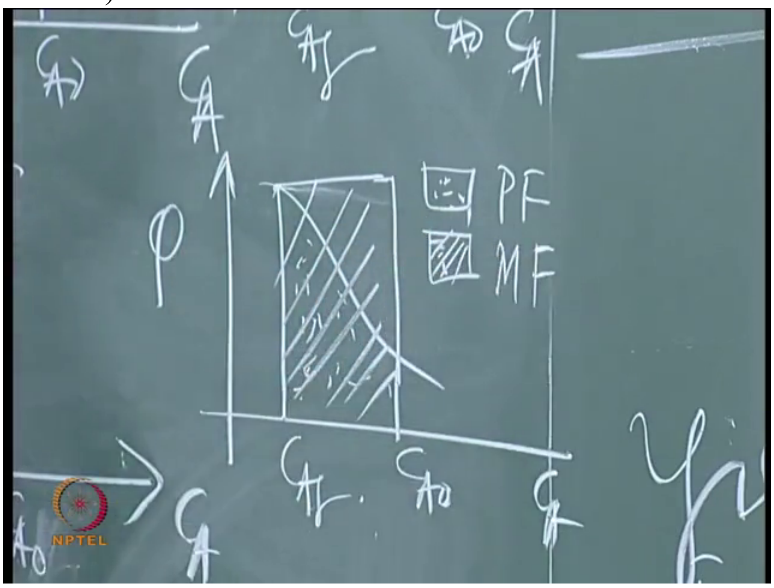


Ok.

(Professor – student conversation ends)

Similarly I may draw any number of graphs like that you know. You may draw phi versus C A, Ok, may be going like this and then after some time, coming back like this. But C A f is only here. Not C A f, C A naught is here. C A f,

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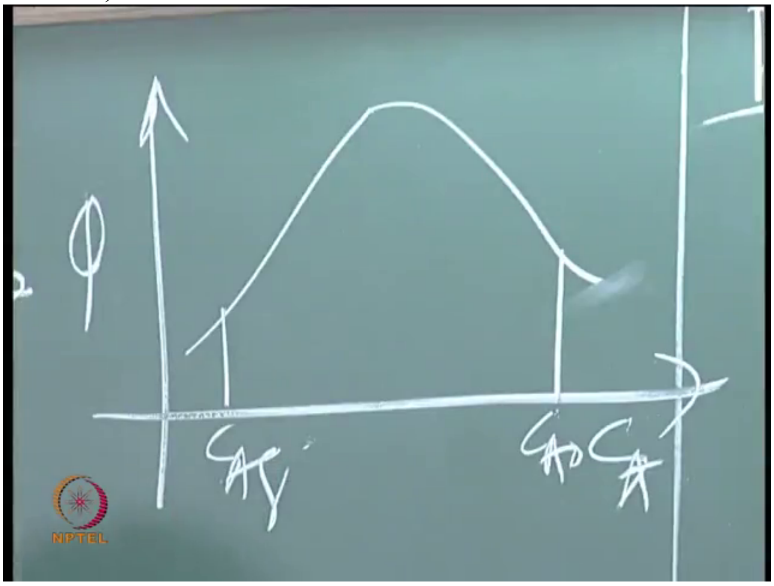

so what do you do?

So we will go till this maximum, which reactor is the best this side and which reactor is

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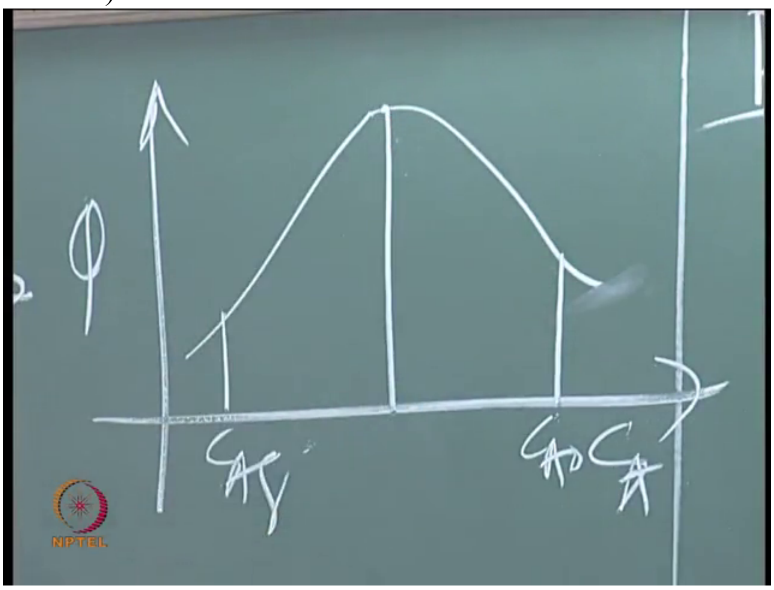

the best this side? Here it is plug flow. This is C A f.

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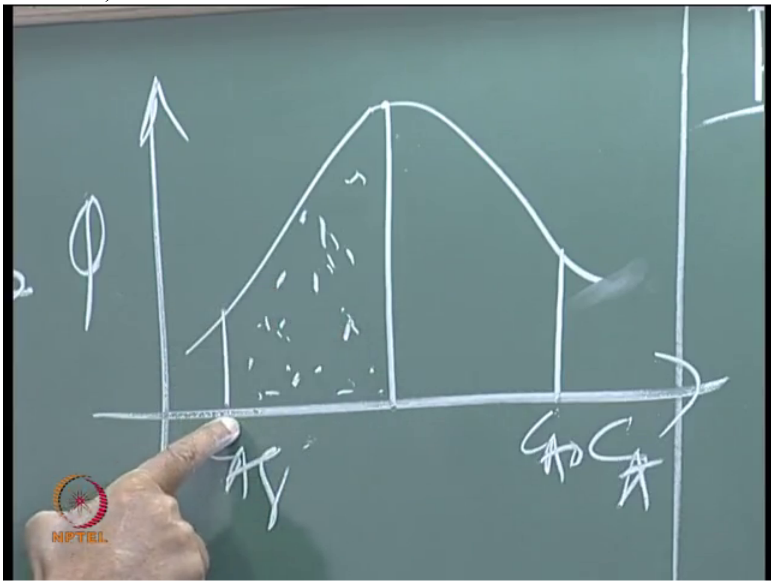

If it is M F R, I will have to draw here only, no? Highest yield. Yeah I know all of you, one voice. All of you are telling no, do not get confused there.

You are not minimizing the volumes. You are maximizing the

(Professor – student conversation starts)

Student: Yield

Professor: Yield. So this maximization minimization problem you have to remember I say.You have only one maximization problem that is without reading how do you get S Ok.

(Professor – student conversation ends)

Forget about that and then see this. So this is P F and here this is M F. Like that, any shape you can just again find out

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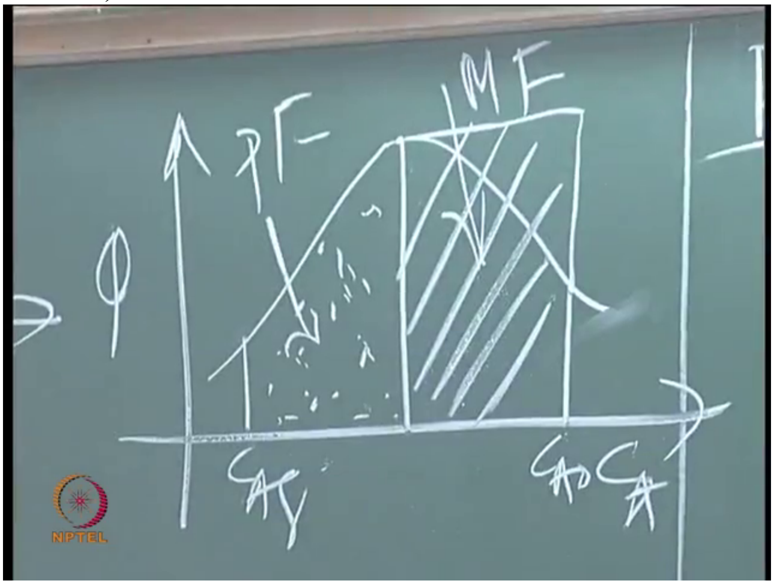


but here maximization, not minimization, please remember. If it is reactor volume then you have to go for minimum. But here it is the product. This is C R, this is C R f.

Because first we have mixed flow. From C A naught to this concentration, intermediate concentration. Concentration corresponding to maximum

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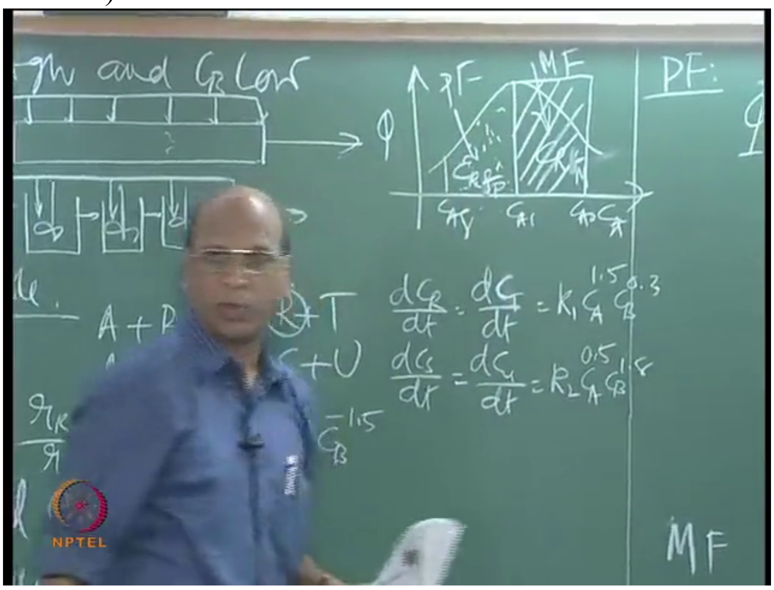


phi, right and then from there this is here. So it will be like that. That is the setup.

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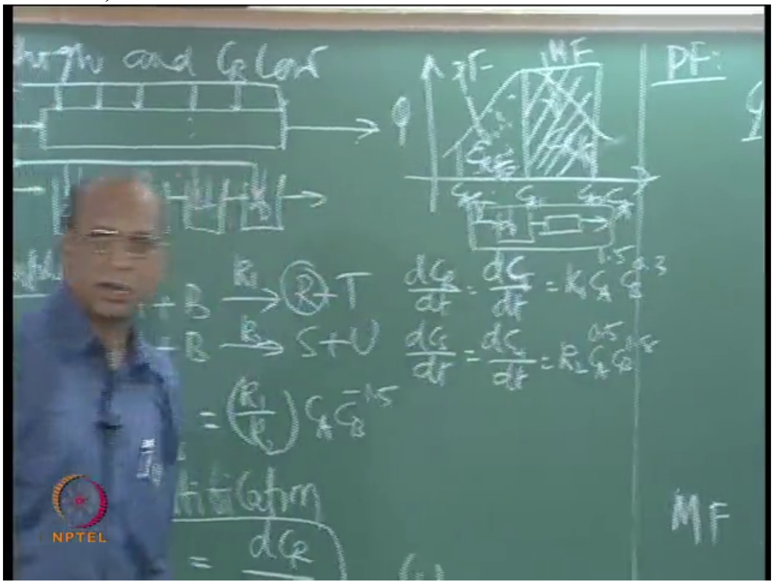


(Professor – student conversation starts)

Student: Sir this graph, last graph...

Professor: Which graph?

Student: This

Professor: This graph? Did you understand this graph?

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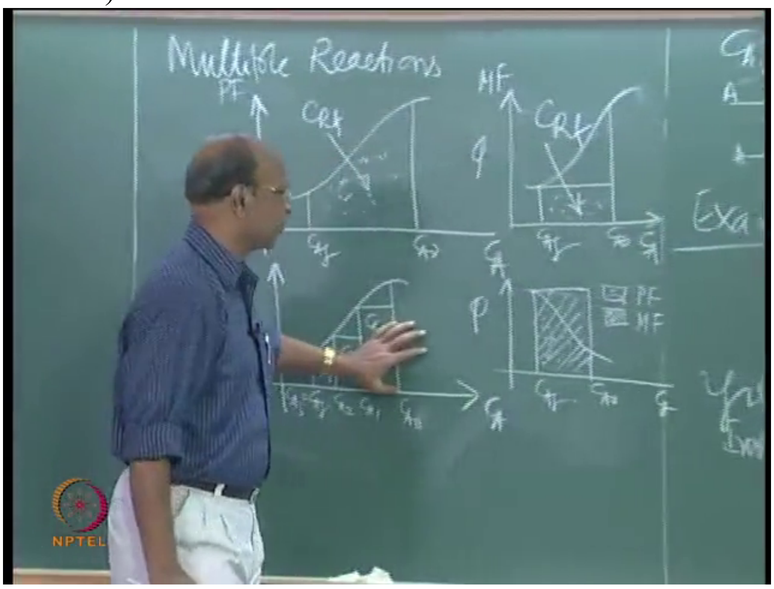


Student: Yeah.

Professor: Did you understand this graph?

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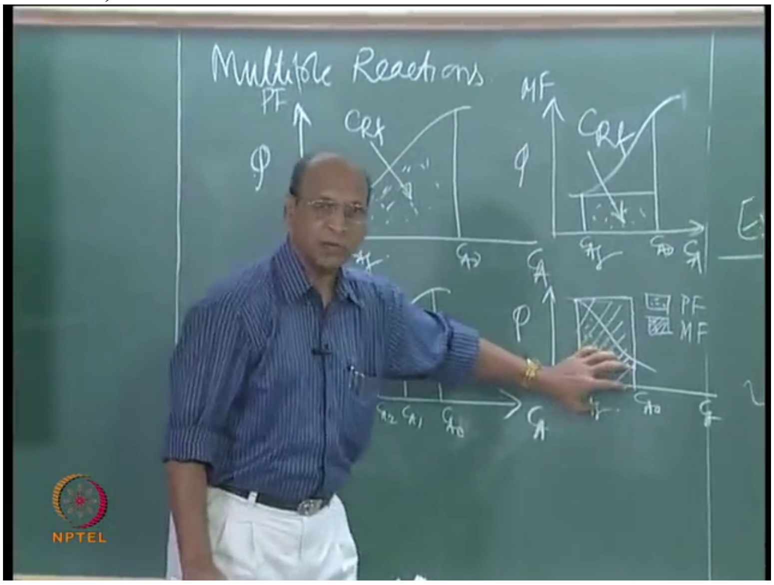


That is the combination of both graphs.

Student: (laugh)

Student: Sir, I know that is the combination

(Refer Slide Time: 35:21)

Professor: Yes, then?

Student: There you put first M F R then P F R.

Professor: Yes, you tell me. Because C A naught is starting here.

Student: You put the

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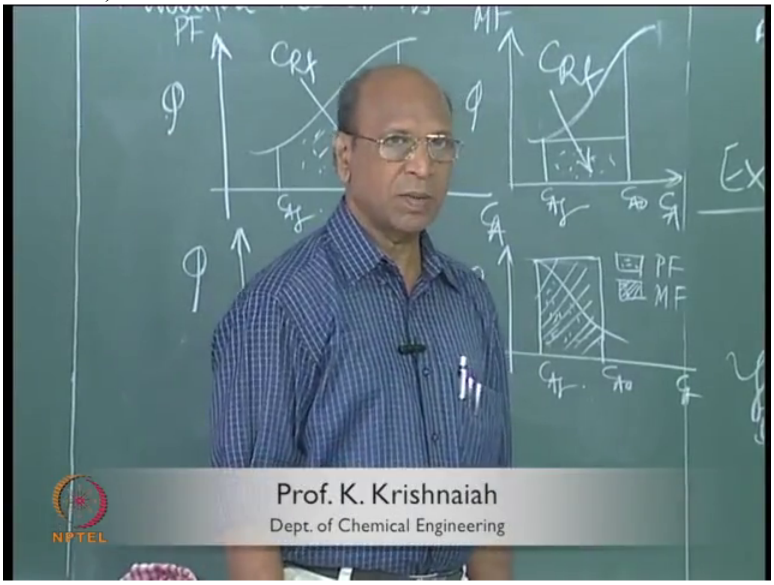


reactors in this way only, first M F R then P F R? Or by looking at the graph you are telling

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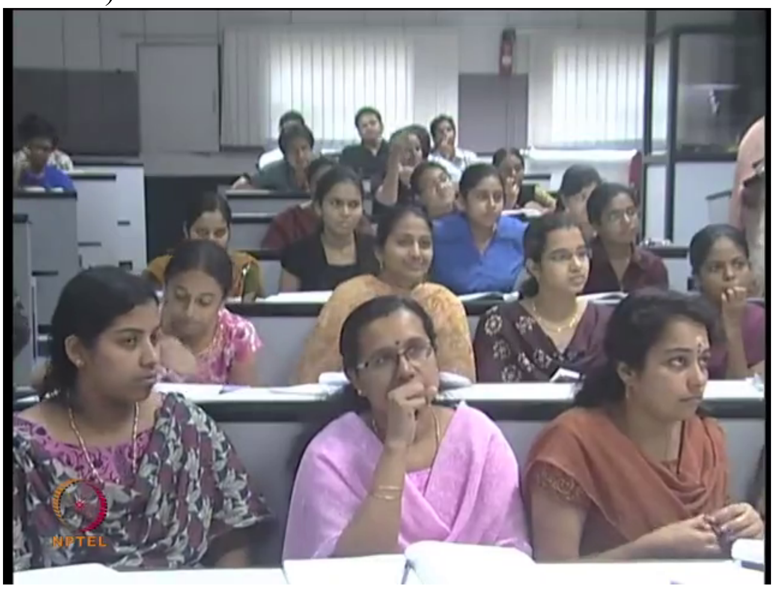

that this should be the...

Student: (laugh)

Professor: Ok, you tell me. I want to get the answer from you.

(Professor – student conversation ends)

Ok, you see I have the, again I will draw, see I have phi versus C A. It is increasing and then decreasing, Ok. And where is C A naught here, which side?

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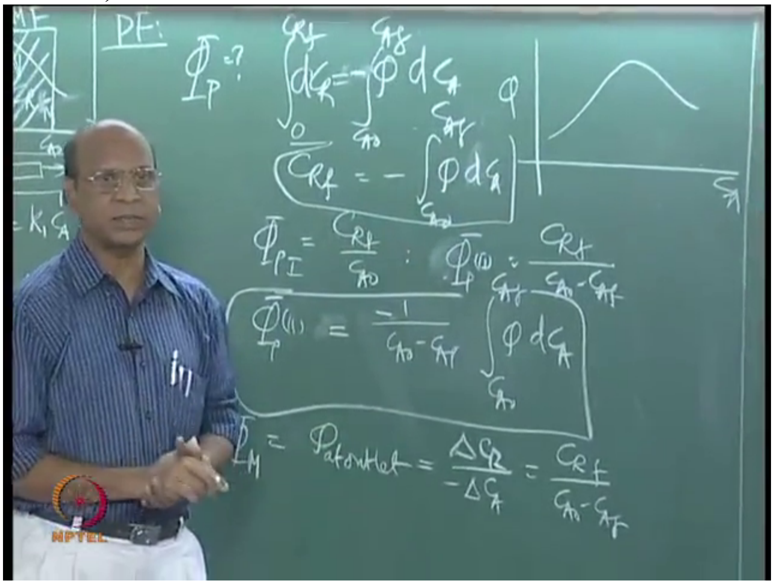

Ok. This side is C A naught. And somewhere here I need C A f. Ok, may be 90 percent conversion. Corresponding to 90 percent conversion what is my maximum C R f, Ok good.

So now this we divided into 2 parts. Because 1 reactor may not give any idea there. So now when it is decreasing,

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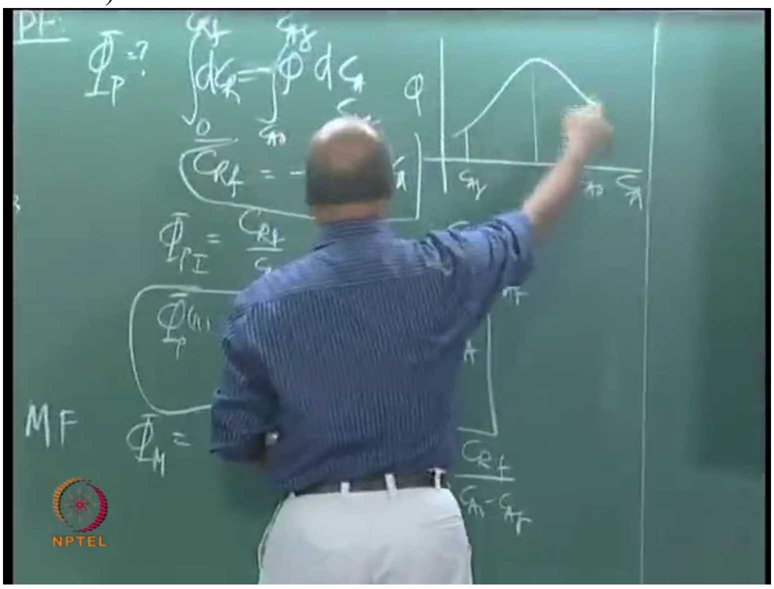

that is decreasing is this.

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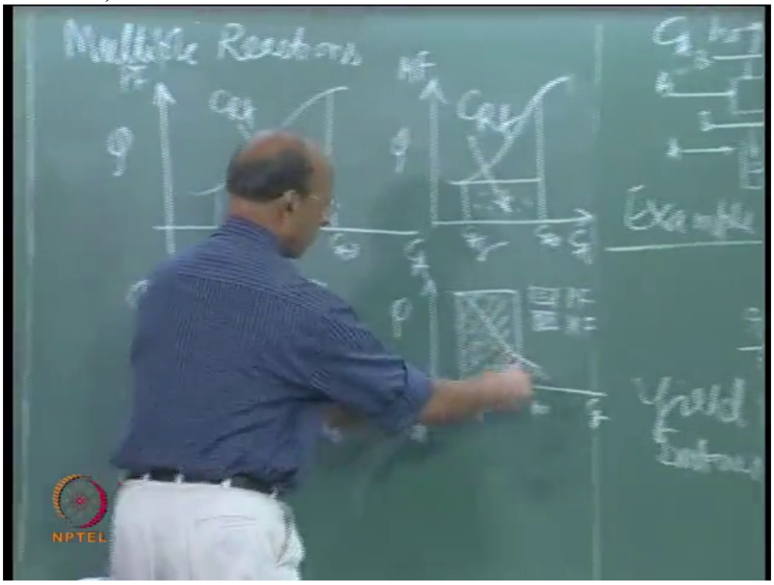

Ok. P F R, M F R is best here because this is C A naught, this is C A f, this is the extra volume also, yeah extra

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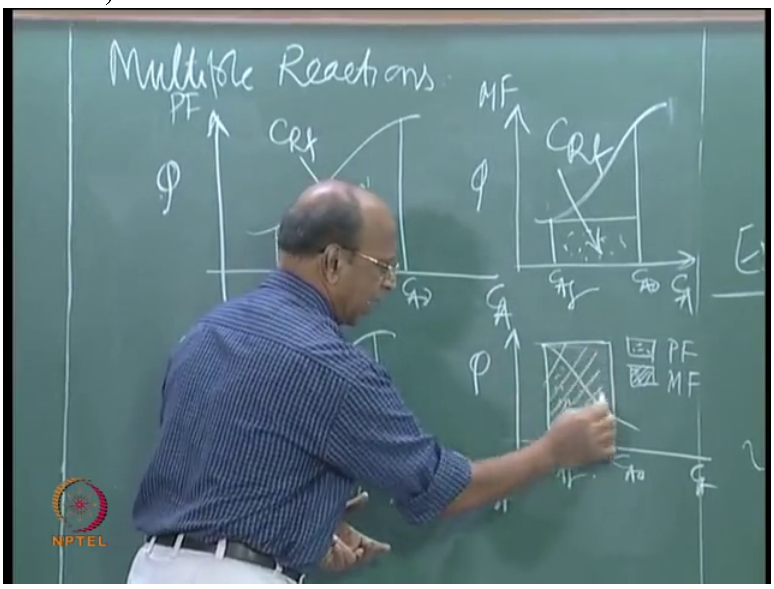


area also I have to take so that my C R F is maximum, Ok. So now till here how do I draw the line? Ok. If I take P F R here, what area I have to take? P F R

(Professor – student conversation starts)

Student: 0:36:54.6

Professor: Yeah, P F R is

Student: Area under the curve.

Professor: Yeah, P F R is area under the curve because that is the equation,

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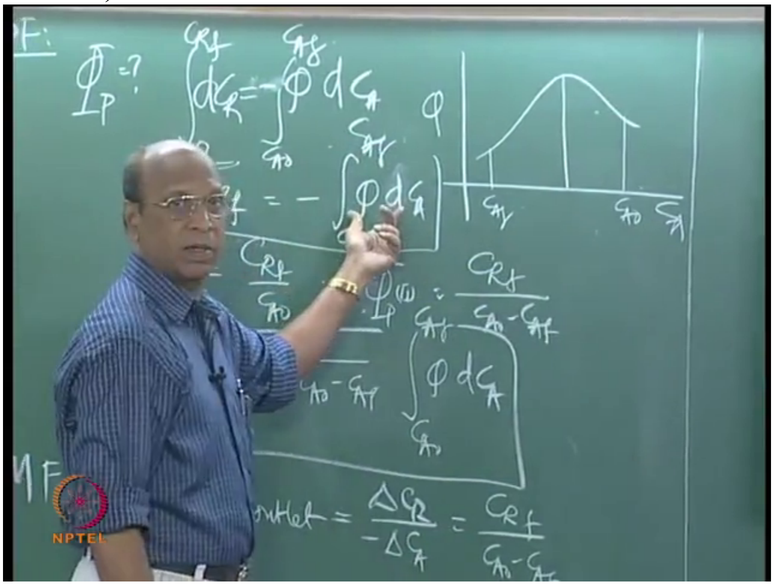

right. But if I take M F R? This is the one.

Student: Rectangle

Professor: Yeah, this rectangle I have

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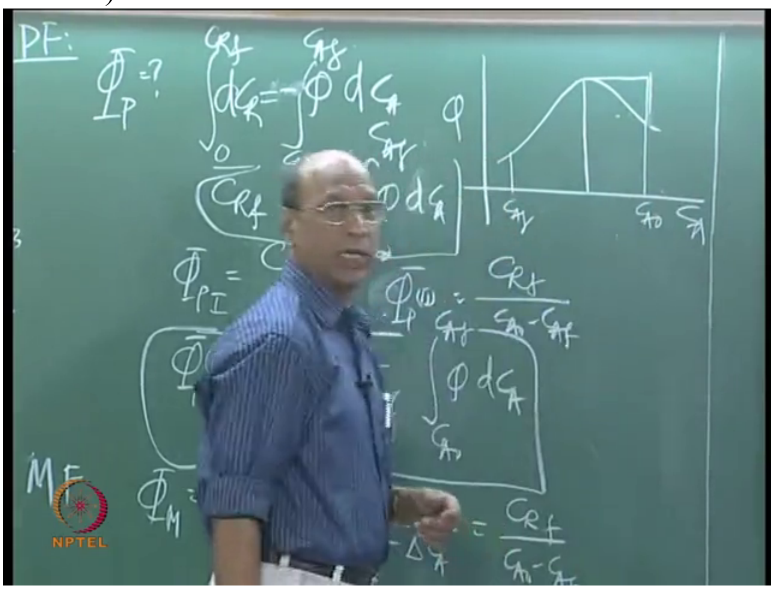

to take. So this entire thing, Ok. So now did you put first M F R or P F R? You are starting with C A naught. Ok, is it Ok or still not able to find out?

Student: Sir, we have to maximize C R f. Ultimate aim is to maximize C R f

Professor: Yeah, to get maximum C R f.

(Refer Slide Time: 37:26)

Student: So we have to take more volume for that, to maximize C R f?

Professor: More area

Student: More area. It must be M F R.

Professor: M F R first and then here,

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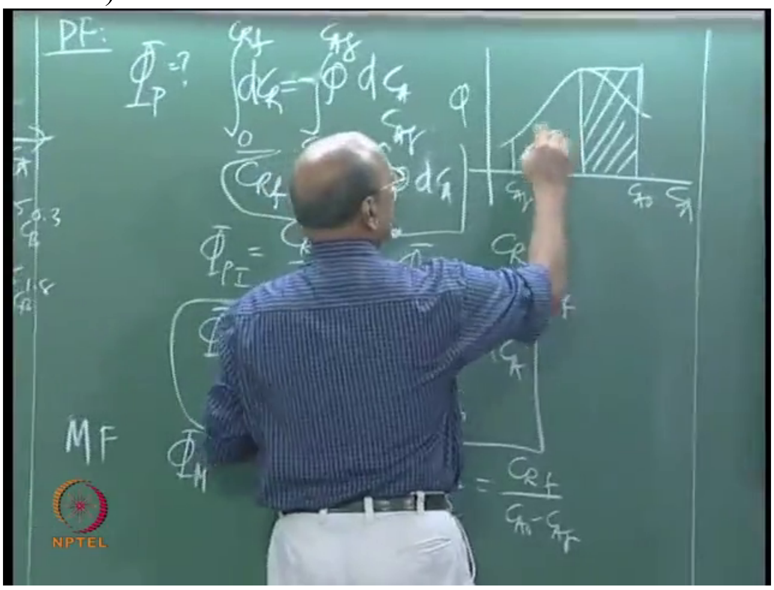


here if I take P F R what area will you get and if you take M F R what area you get?

Student: Yeah but for P F R we have to take the lower

(Refer Slide Time: 37:46)

rectangle.

Professor: For P F R?

Student: M F R, M F R

Professor: For M F R, you get only this

Student: Yes

Professor: Right. So that is why if I put 2 M F Rs,

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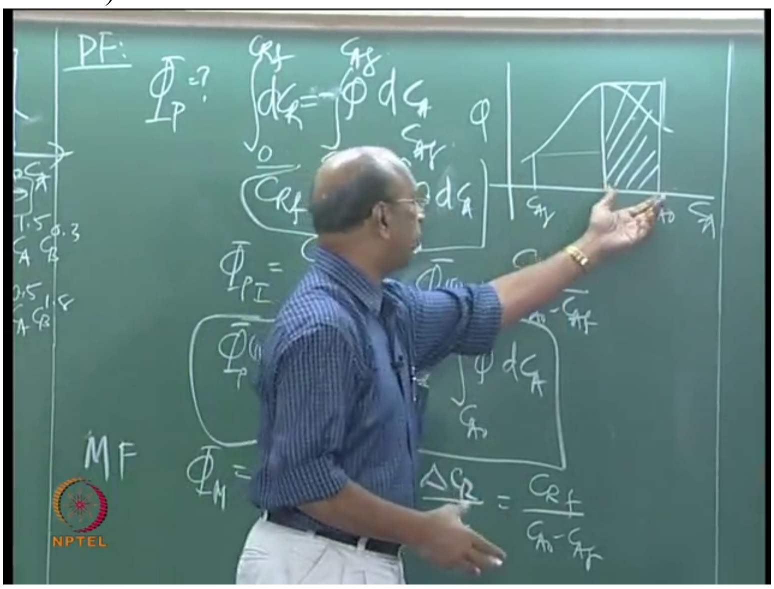


then I will get,

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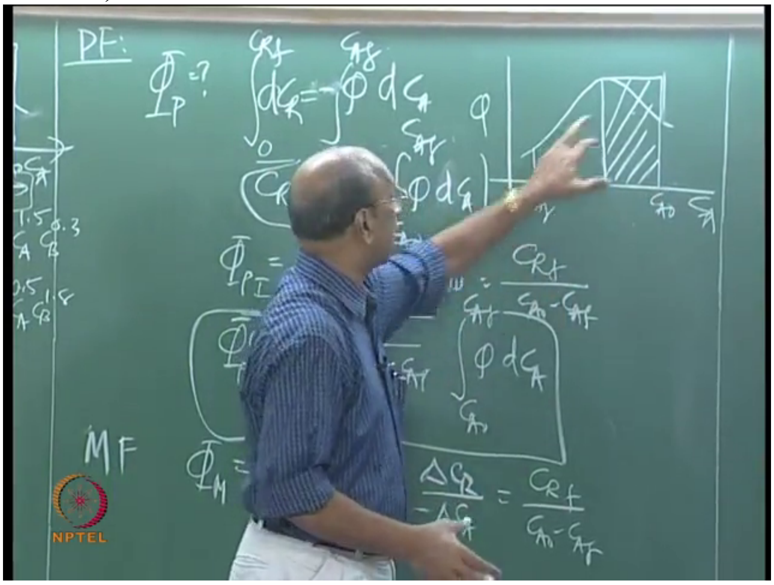


I am losing all this area, right? If I get 2 P F Rs, if I use 2 P F Rs, then again I am losing

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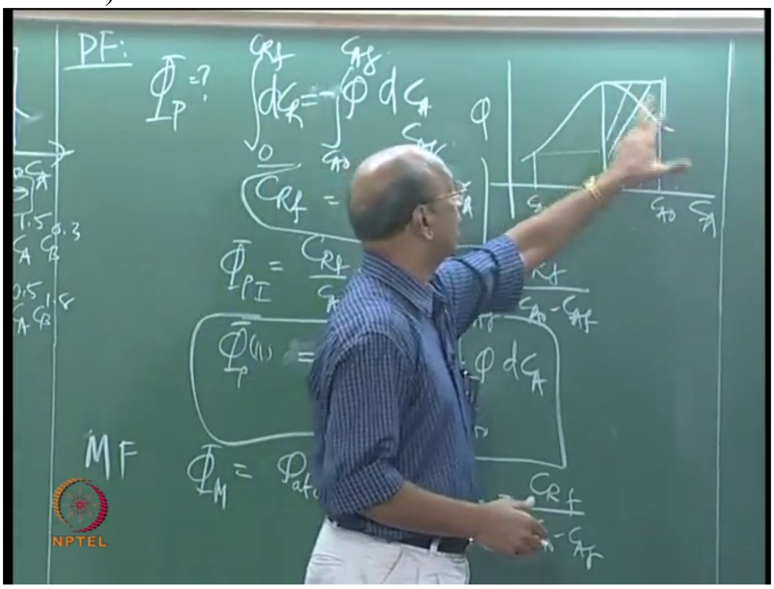


this area. So that is the reason why here P F R, that is

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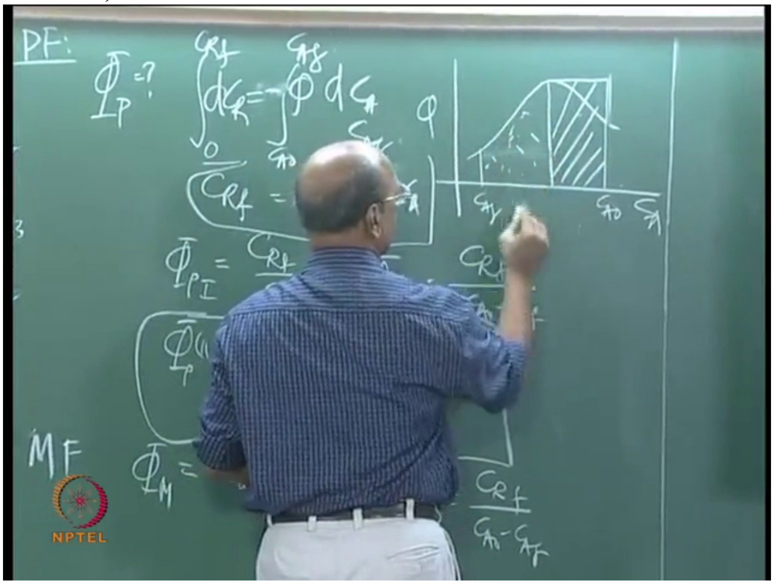

this portion is P F R and this portion is, but you have to put C A naught here, C A here, C A F here,

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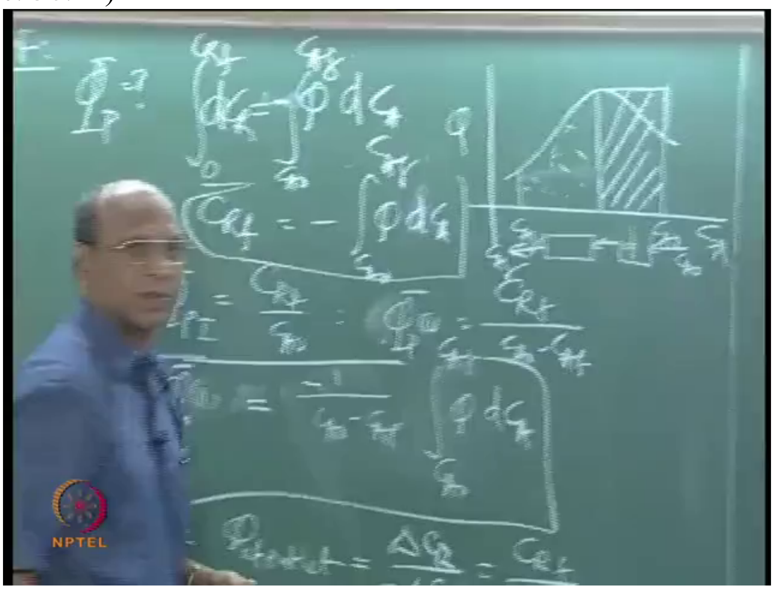

Ok? Good.

(Professor – student conversation ends)