Aircraft Stability and Control
Prof. A. K. Ghosh
Department of Aerospace Engineering
Indian Institute of Technology-Kanpur

Lecture- 25
Revision

Yes, dear friends, this is the mann ki baat session for lateral directional case, you could see this is Cessna 206 what type of wing it has it has we call it high wing right. And if you see the Hansa 3 air planes and this sort of an airplane is having wing which is called low wing if you see the contrast of the low wing and there is a high wing okay. And if I see another air plane this is back of Cessna 206 that is also low wing but having appreciable dihedral.

That is wing low wing from dihedral is given, okay. These are important aspects for giving lateral stability of the airplane right. Also you should understand that vertical tail which is here whole is the vertical tail this is extremely important for giving lateral stability and for lateral control you have aileron virtual which is here this is aileron we are familiar with it this is aileron up aileron down and also we have rudder if you see this rudder.

If I turn it like this, this will give a force in this direction that will take the airplane towards left. You are the airplane towards left if I do it like this the airplane will act like this okay. So these are the control surfaces for lateral control primarily is the aileron which is here and rudder which is there if I come back to the Cessna 206 you will see here the aileron is somewhere here which will always near a the wing tip this portion is the aileron up and down up and down.

And this is the rudder here it is rudder see it goes towards left towards right and you could see very appreciable size of vertical tail. We could see this is rudder and please carefully see that rudder is a rudder is this portion at. Total when I take total area is the vertical stabilizer and rudder is almost 40% of a total area 35% to 40%. So rudder has to be very powerful because it does not have the enough power.

Then the airplane has gone into a stall and if it is spinning then the aileron will not get effective then the rudder will be used to counter the rolling you could hear background sound of airplane

taking off so we always love it we want the sound to be there all the time so before I go to the class.

Let us, revise again as per aileron is concerned it is supposed to give rolling moment and when right wing is going down and left wing is going up that configuration we say rolling moment is positive for the yawing moment right wing going back is yawing moment positive with this understanding we now go to the black board and try to understand few things which we have perhaps missed or not clear that is why this is a mann ki baat session.

Here we have come very long distance today we are having a mann ki baat session on directional lateral static stability, okay.

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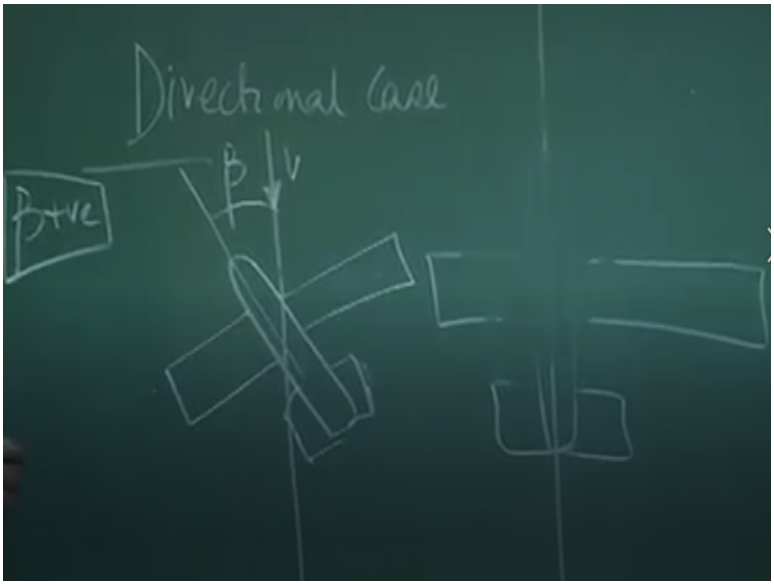

You know that we have seen but do you mean by static stability if there is a initial tendency to come back to the equilibrium once it disturbed let me say it possesses static stability for directional case for what was the understanding for directional case we said if I am flying the machine like this is the relative wind V and this is beta.

We revising the directional case and in directional case what do you say if I use watch my hand if I am flying like this right. Then, I said beta is 0 beta means side sleeping angle that is if the airplane is actually CG it is actually having motion like this and also going forward right. That is

side slip that is if you see here this airplane if I put my if I am moving like this then beta is 0 but if I am moving like this okay. Then that is the configuration air beta is positive what is beta positive.

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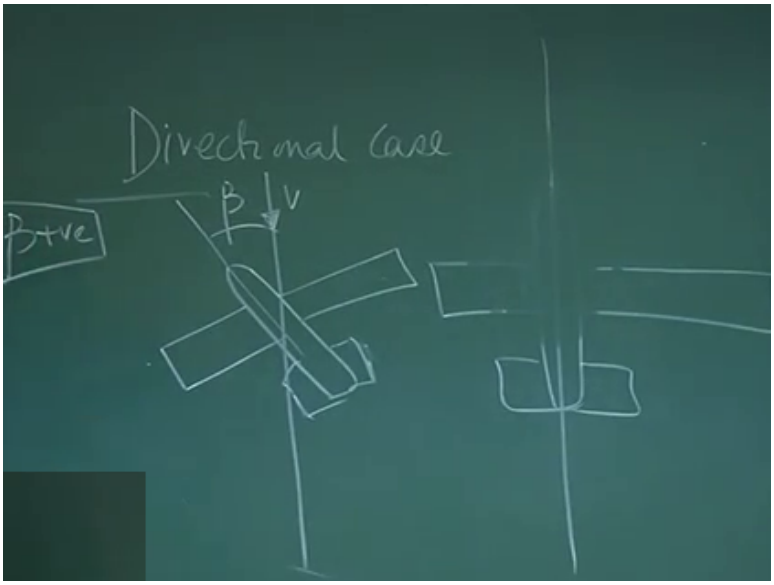

Very common mistake we make beta positive the base way to understand is when I moving if the relative wind is coming from a right side right then it is beta positive. Remember this okay. This is beta positive. Now the point is some of the body was of the airplane was moving like this because of some disturbance there is a beta introduced what should be in natural tendency if it is statically stable it should immediately

Generate a moment like this right. That is right wing going back and then we should generate if positive Yawing moment correct.

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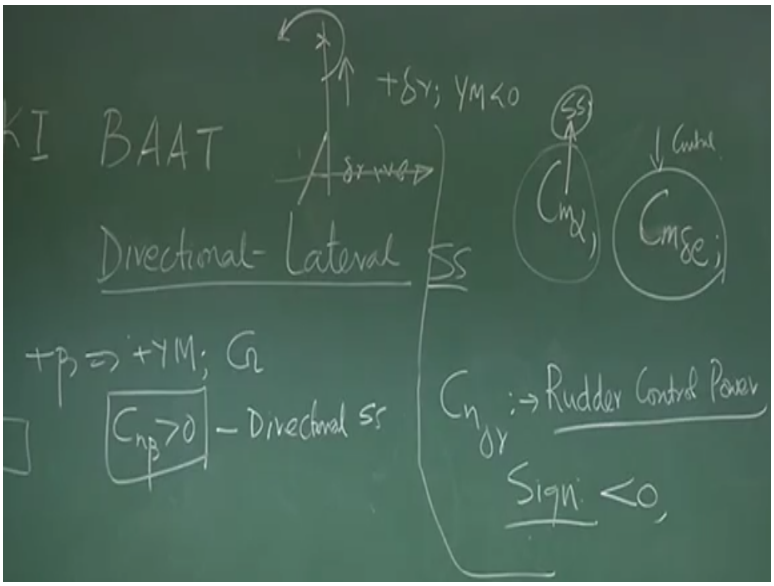

Positive Yawing moment and you know by now you have coefficient is CN right. In a totality what we say this means CN beta should be greater than zero. This will ensure directional static stability this is clear right. Please understand that this is very important derivative it has to be very well controlled because if it is too high in if the airplane will become too sensitive to crosswind.

You don't want that because our wind is coming like this and the beta is positive it will turn like this when it is coming from this side it turn like this that will become miserable. So you have to have very clear understanding what is the magnitude of CN beta I am going to design the airplane for.

Then we discuss about CN Delta R right. What was the CN Delta R? Very easy to understand, remember for longitudinal case we have CM Alpha which is static stability then will have CM Delta E so elevator control power what was the understanding understanding was this man is static stability parameters and this is a control parameter unnecessary what if this man is very high then if keeping everything same.

I have to put larger control power to change from one trim to another trim because if CM Alpha is highly negative statically stable it will not allow it to go for one trim to other trim or it will

resist change from one trim to another trim so that was the relationship come similarly CN Delta R you have seen this is the rudder control similarly CN Delta R is the rudder control power okay.

And it sign what is the sign check your lecture notes its very simple all discussed first we decide what is the sign of Delta R Delta R is positive if I am flying like this and rudder is deflected towards left if it is deflected towards left and it is moving like this and the force will act in this direction above the rudder and above the CG it will give moment like this you look from the top Isn't it.

So that means the airplane will turn like this and you know yawing moment positive is this right wing going back but in this case this is left wing going back so this yawing moment is negative so for a positive Delta R yawing moment is less than zero and hence CN Delta R sign is less than 0 correct. Please keep that back of your mind for longitudinal case.

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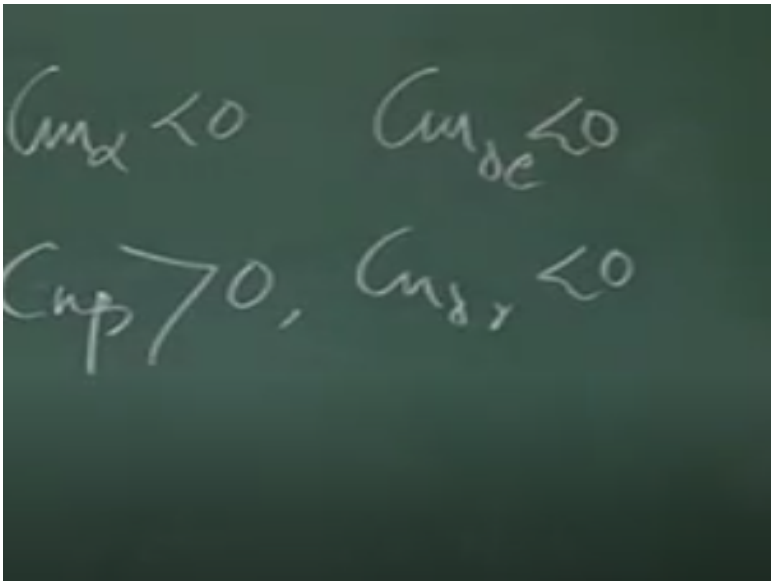

CM Alpha less than 0 CM Delta E less than 0 for directional case CN beta is greater than 0 and CN Delta R is again less than 0 right.

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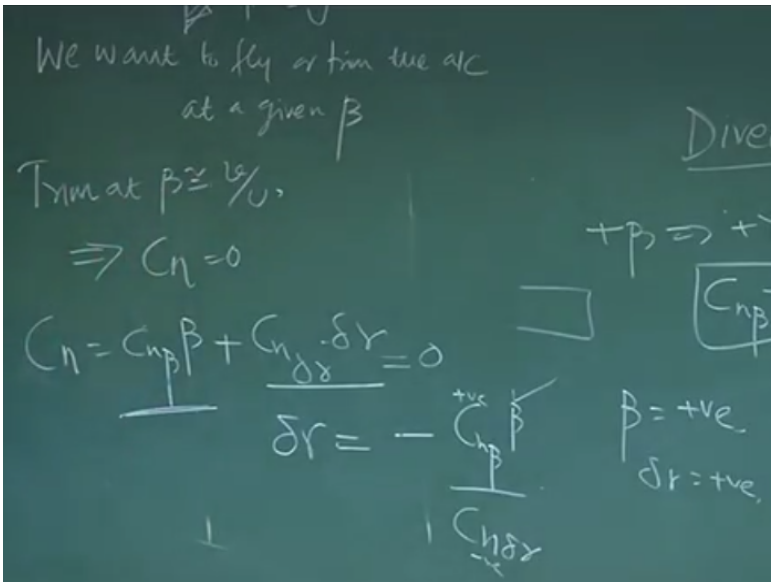

Now I ask you a question suppose we want to fly or trim the airplane at the given beta it is possible I am going like this and there crosswind is coming like this say this is small V and this U in the beta into induce will be how much will be V by U roughly right. Suppose I want to fly at a given beta so what will be my configuration such that my whole rational control is activated that is I will fly such a way that CN will be 0 trim at beta = let us say V by U right.

Means at this beta CN should = 0 like when I said trim at Alpha what we say CM must be zero trim, no CM should be available there. Now, we know CN I can write as CN beta into beta and CN Delta R into Delta R please understand what is CN beta into beta. It is coming from the fact that this airplane is statically stable so if I am flying like this if there is a wind coming like this which gives me beta and because of static stability which I will tend to turn it will tend to turn I do not want it to turn.

I have to hold it so what I will do I will give a moment CN Delta R into Delta R such that this is nullified that means the moment given by Delta R and moment because of stability that sum should equal be = 0 here I can find out Delta R = - CN beta into beta by CN Delta R okay. Now interesting thing please understand if I want to trim the airplane at a positive beta what is the sign of the CN beta

It is positive sign of CN Delta negative so what is the sign of whole of this term. For a beta positive positive negative negative, negative positive so Delta R is positive meaning thereby if I want to fly I flying like this I want to put the rudder towards left solved and then I will get a configuration where I am flying like is this part clear okay.

Now this was simply I was talking about your rudder control and rudder if you remember the one of the important thing which rudder should do is engine failure case okay.

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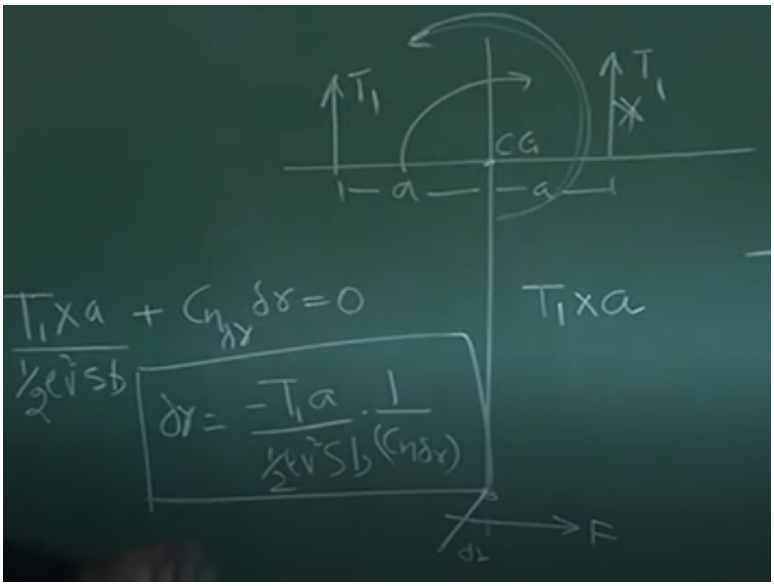

let us also revisit that it is very important this is the wing and let us say this is fuselage and all. Now, the important aspect in the directional case is basically for tool engine airplane right. You know in tool engine airplane there are two engines let us say both are having same thrust but there is a possibility that one of the engine can fail right.

If I must have enough rudder power I must have enough single engine power so I can maintain the altitude and I do not turn like this right. So what there what is the way to handle it what will do is you keep this distance A keep this is A for some of this has failed so then what is the moment given by one of the engine above CG is T1 into a this direction correct. Then, how and in what direction I have to generate a moment to counter it.

It will be in this direction right. So I have to put the rudder in this direction if I put rudder in this direction it's Delta R then the force will be in this direction that will give the moment in this direction above CG. As long as the moment given by the rudder and balance is the imbalance moment because the engine failed my aircraft is still remain like this I have to increase the throttle definitely to see the lift = weight okay.

But as well, the yawing moment is concerned, I see that T 1 into A + CN Delta R into R they should be = 0 but please note down the this statement philosophically is correct but dimensionally they are wrong this is CN Delta non-dimensional is it denominational so what I have to do that will be divided by half row V square X into B. So now this becomes non dimensional CM Delta E into Delta E0 so I know what is the Delta R required that is - T 1 into by half row V square SB 1 by CN Delta R.

So, this tells we that when I design an aircraft I know the crust this much of Delta R should be available this Delta R should be less than the Delta R max because Delta R also has a limit, I cannot go on deflecting the rudder like this at some time it will become break so intermediate point the flow may separate so there are some Delta R max.

Delta R max which is less than or = 25 degrees + - okay or more than an aircraft is increased to 40 degrees also but point is we should be very careful about designer that I need to have sufficient Delta R or the rudder deflection we can at all for thrust symmetry this also one of important role of the rudder and you can understand easily what is the importance of CN Delta R if my CN Delta R is high then Delta requirement will be less okay.

So that's why you find that many airplane have huge rudder right. Was direction is over let us revisit.

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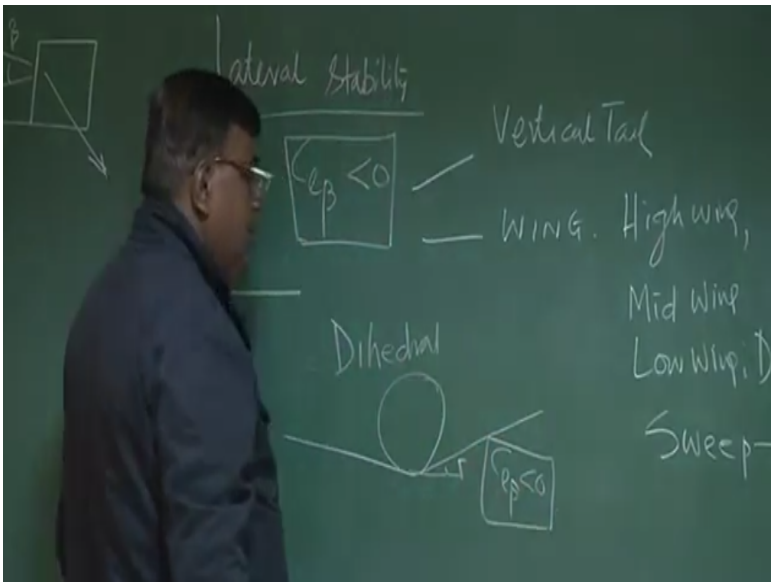

Lateral stability please understand when you are talking about longitudinal stability then is the horizontal tail which give the restoring moment. We're talking about directional we have seen that vertical tail primarily. But for lateral there are no such surface so we have been telling this what happens if the airplane is going like this.

And there is a disturbance in the role that is about X axis as it rolls like this the lift vector get tilted so it starts slide slipping as it side slips since the vertical tail is here that will generate a moment negative like this is this clear. This we have explained which lot of you see this will lot of an effort because see.

Suppose this is beta where from this beta has come this beta has actually got induced because there is a roll on disturbance like this and it starts side slipping the moment that beta comes here this will give the force that coming out this plane and that will try to give a rolling moment negative that exactly I want I moving like this you get disturbance I want it should generate a moment it should do like this initial tendency should be like this so disturbance side slip vertical tail it.

Comes like this so will say for lateral stability CL beta should be less than 0. This is very, very important and how do you achieve this? We have same we have achieved this through vertical tail number one number two wing and what is that wing we talk about high wing the mid wing

the low wing which dihedral you can have some sweep effect also and typically you have seen for vertical tailless airplane which have design to have minimum RCS to avoid a rudder inceptions.

Sweep is given you see sweep will generate some CL beta negative because no vertical tail sweep give CL beta less than 0 and its special very important contribution when there are no vertical tail. Now, let us see how high wing was giving CL beta negative we have seen this is the high wing and if a demonstrative.

You will understand suppose this is the fuselage and this is the high wing it has bang like this starts slide slipping the air will gust in here it will push the wing and it will generate negative rolling moment. So for a positive beta negative rolling moment so CL beta is negative right. If CL beta is negative then the aircraft is statically laterally stable please understand.

We give PI disturbance to check lateral stability and because of PI there is a beta introduce and high wing we will give CL beta negative will have vertical tail okay. We have also seen that something called dihedral that is in this is low wing they are not giving much of lateral stability but if you give a dihedral here right. Then you can get CL beta less than 0. This is also extremely important. Thank you very much.