Aircraft Stability and Control
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Lecture – 54
Stability Augmentation System

Good morning, friends.

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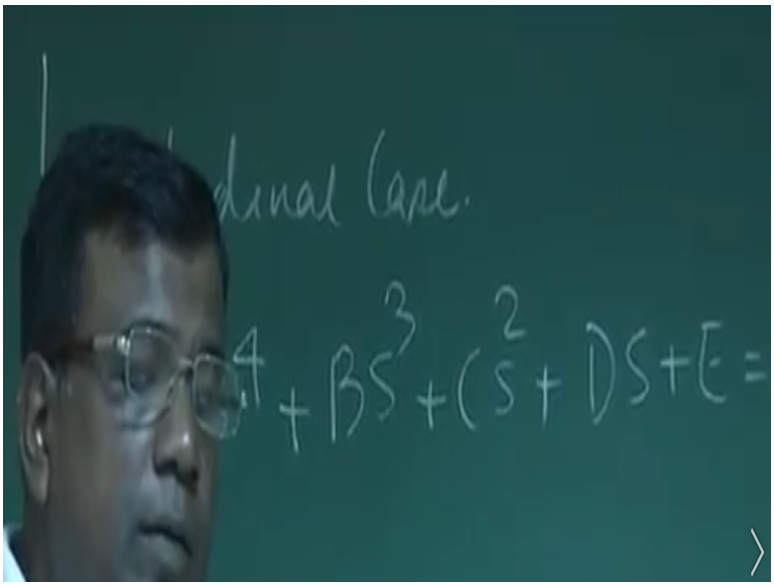

We will be revisiting phugoid mode little bit for enhancing of our understanding we will recall for a longitudinal case we got equation characteristic equation we form A s four plus B s cube plus C s square plus D s plus E equal to zero right and this coefficients of A, B, C, D, E can be expressed in terms of algebraic derivatives and probability etc and what we found from the example numerical example.

Once we find this root we get two complex value here and what we attribute to short period mode that is this disturbance compared to equilibrium very short time and during that time it's fair enough to assume the q perturbation is zero or speed remaining constant. Second root problem that we solve as coming pretty less or lesser really getting valued that is a long period mode unlike short period mode where the real root was large negative around minus 1 for this sample case.

The second case which is long period mode, we realize that this is phugoid mode that is after disturbance the airplane get excited like this ok and what is the assumption here that if you see this, the airplane.

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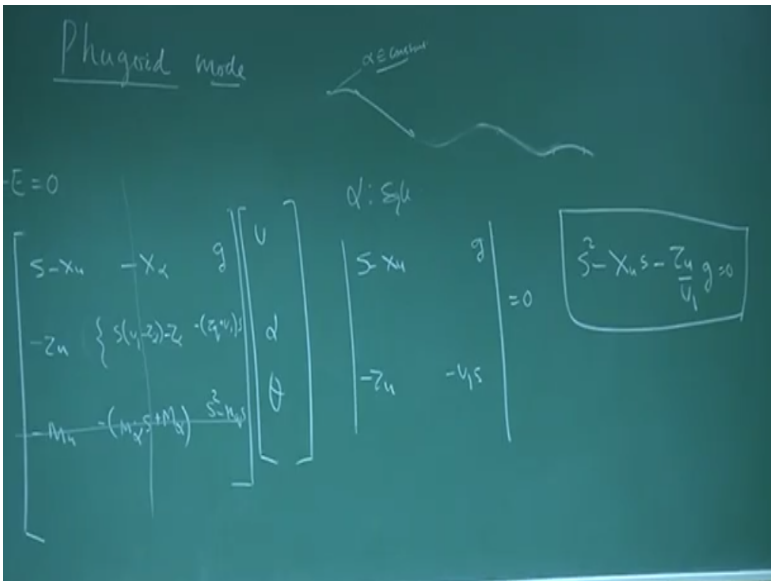

So alpha the angle of attack alpha almost remain constant which is at which is fairly put the approximation, I will not say a good, very good approximation but ok approximation. So we assume that the alpha equation is superfluous that is you need not consider that alpha equation at all right. We are not considering oscillating the moment this will about axis. If you do that then we get we can do the trick let me try s minus x u minus x alpha g minus z u u 1 minus z alpha dot minus z alpha minus z q plus u 1 into s minus m u m alpha s that is m alpha dot plus m alpha and s square minus n q s.

This is the equation characteristic equation I may know we are trying to approximate to get it characteristic equation for phugoid mode and want to check alpha to be superfluous that you do not consider alpha at all. And then you could see here that u alpha and theta so what we do. You drop this and drop this, that's takes care of this approximation we are assuming that alpha becoming constant and that how we get determinant. S minus X u g and then here minus z u and this is minus u 1 s right, this equal to zero ok.

This is equal to zero so then you get the characteristic equation s square minus x u s minus z u by u 1 into g equal to zero. So what I want to stretch is please understand that from this equation we get the approximation we assume that alpha is superfluous so we have dropped this and this and says there is no pitching moment be considered about y axis because it is going like this. This is the approximation ok right so.

Then convenient results last term will have obtained no other point want to find but I am going to tell you is answer. Let us see what we have done we have done the short period phugoid mode of approximation.

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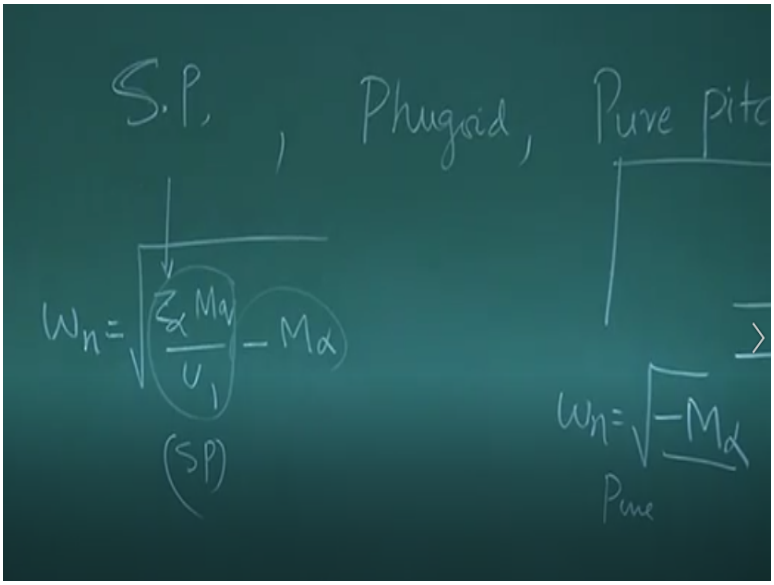

Short period then phugoid and we have also done pure pitch ok. What was pure pitch, pure pitch was as simple as let I am going like this the airplane is at equilibrium and give a disturbance all the motion is happening pitch but you can understand airplane in free space if this lot of thing is happening so that's why the angle of attack will change.

So it will have this short of motion also right. When in pure pitch we are neglecting that. That is essentially what we are telling if we are picking similar to model wing -- here and oscillation is like this and the velocity vector will be constant here. So there is no question of very vertical motion of the airplane. So all in this theta dot which is equal to q right. I will make an airplane

where you take the theta either alpha force in this direction there will be motion in this direction also right. This answer comes to the combined motion.

There was pure pitch and there we found omega n angle root minus m alpha. For short period what we got omega n is I write under root minus, z alpha m q by u 1 minus m alpha. If you see this short period approximation and if I go by pure pitch here root of minus m alpha this term here additionally comes down which has z alpha that you understand the z alpha will come either restriction on the airplane to go up and down ok.

At the designer for the designer air craft I start with this I got with the so many numbers I know what we have got. M alpha means what. M alpha is related to cm alpha right. So I design an airplane what is the stability margin? Static stability margin that is we know that cm alpha can be related to d cm by d c1 ok.

So I can start for consuming the airplane d cm by d c1 by 10 percent and then I found natural frequency and then I go for designing the airplane so this way I did. Then I go for modify when come to short period and if my airplane will shows configuration by and then I come to dynamic stability is A s four plus b s cube plus c s square plus d s plus e equal to zero. I solve that whole equation so this is the simpler root go from here to here then go to that big equation ok.

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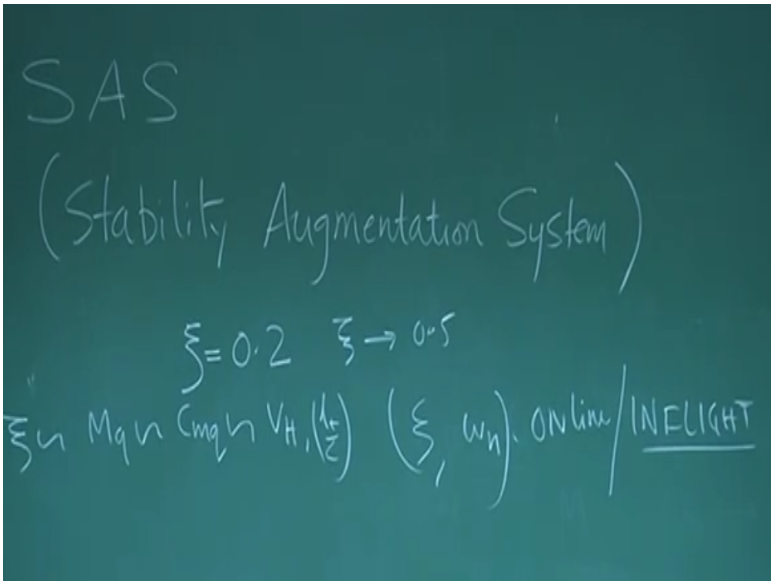

Today I thought I will share with you something called stability of augmentation system. This is SAS what is the meaning of this SAS that how can I augment stability of airplane that is suppose the airplane has some zeta is 0.2 since this is longitudinal mode. Now we want to increase zeta to.5. what are the ways we know that zeta is proportional to m q is proportional to cmq as cmq are in the ratio l t by c. so I can change the terminal ratio I can change lt by c I change m q and in turn theta change.

But if you want this zeta to be changed without changing further the geometric of an airplane is configured. How online we can change zeta or how online we can change omega n online in a sense it can be in flight ok. So what we can do we can reserve that I will be discussing, our discussion will be there. Let us understand how to do that.

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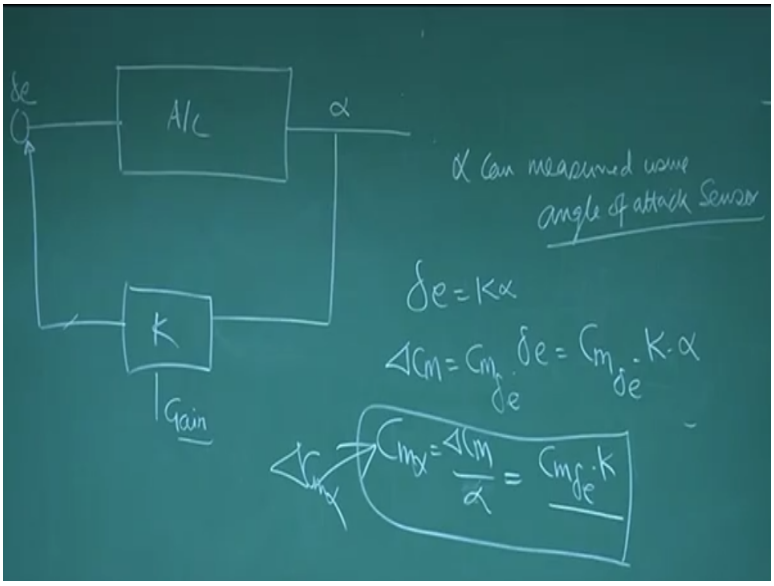

Let's us everyone see cm alpha if we have cm alpha basic and that give cm alpha new so designed well. What is the mechanism we have seen we have seen this is the airplane equal to SAS this is the aircraft and you know this is the delta e and this will be the alpha and that in alpha. What does these diagrams tells you it is telling that in flight you tab alpha. How can I tab alpha. Alpha can be tabbed using alpha can be measured or paired using angle of attack sensor.

So I tab alpha and then I deflect this elevator delta e proportional to alpha k alpha k is gain ok. Now giving delta e equal to k alpha.

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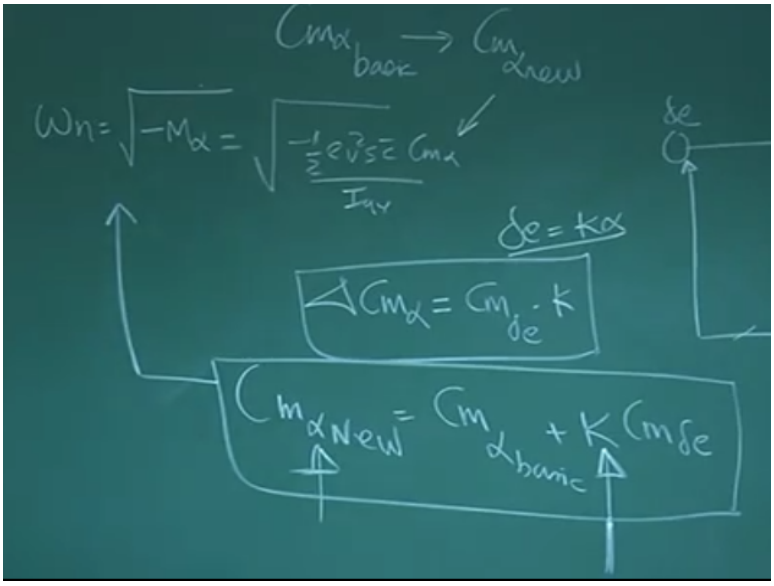

I have delta cm equal to cm delta e into delta e that is cm delta e into k into alpha that is delta cm. Now what is delta cm alpha now that is delta cm by delta alpha or alpha it is the cm delta e into k. You could see that this cm was additional cm alpha ok. So by giving an equation proportional to k where predict additional cm alpha into am delta e k what is the value of k. k has the value of 1.001 and I can go on filling alpha ND deflect the elevator proportional to k alpha and then I give delta cm alpha which is equal to cm delta e into k.

So cm alpha new whatever you want which is equal to cm alpha basic available plus k into cm delta e we have to choose the value of k so that we will get cm alpha new whatever we have.

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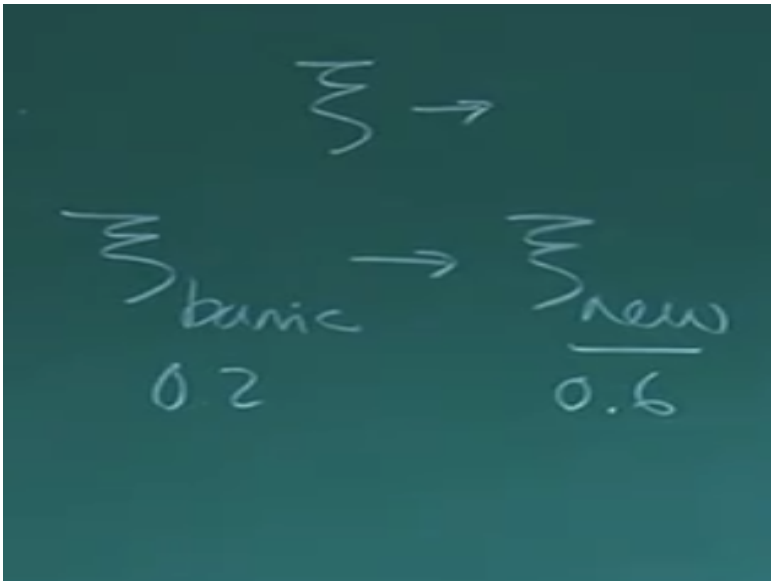

This is one way we are augmenting cm alpha one of us above the cm alpha what zeta sets. zeta sets primarily matter of frequency between under root of minus m alpha equal to under root of minus half rho v square s c bar cm alpha by I y y if you are changing this cm alpha and omega n will be changing right. So you have problem is you need to change the natural frequency from this value to that value I can tune sheath to get that cm alpha new value or omega n value right.

Suppose if second question want to change zeta. Suppose we want to change zeta that id the requirement that is the zeta basic in the airplane and we want zeta new. This side was 0.2 and this side was 0.6 to flight. How do I do that? Again I will come back here.

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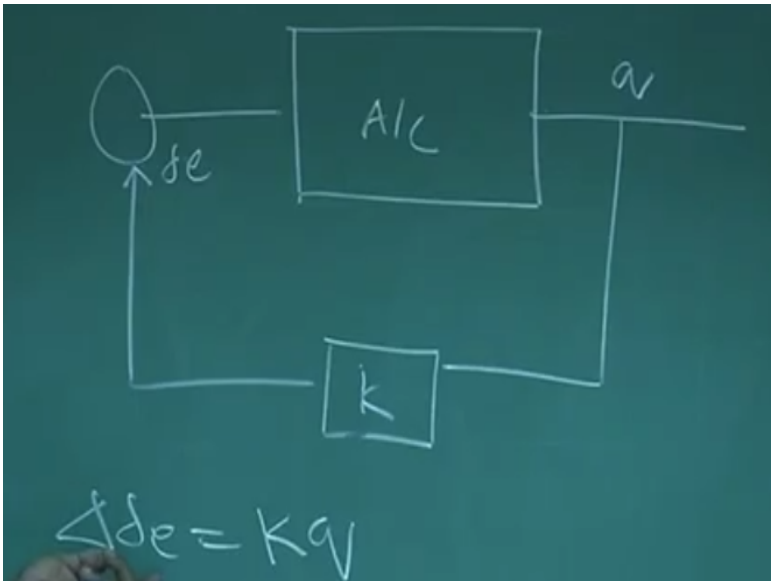

This is aircraft and this is again delta e and this is q this is k and what I am doing now and giving that additional deflection proportional to q right. I sense q through q and through master dimension plane and ensure that the delta e is proportional to k q. Once I do that what is happening what is delta cm.

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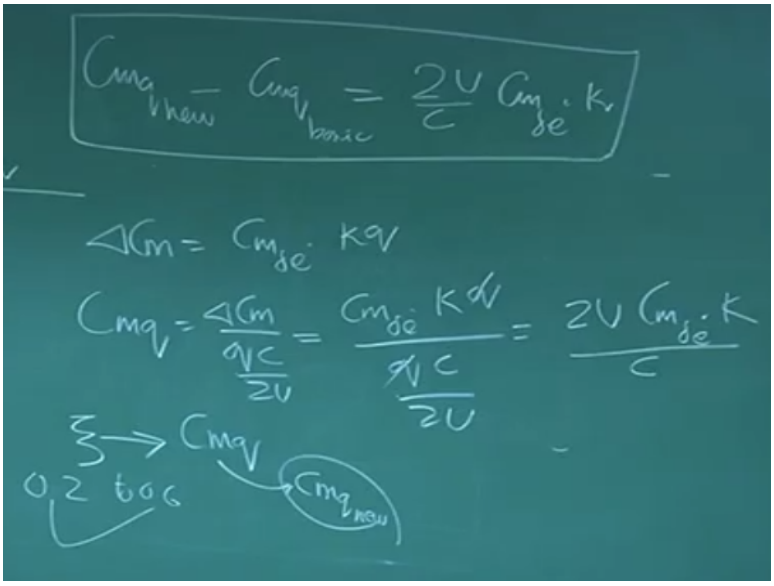

Delta cm is cm delta e into k q is the additional velocity. So what I can do cmq equal to delta cm by q c by 2 v or 2 u cm delta e into k q by q c bar 2 u. q q get canceled which is equal to 2 u cm delta e into k by c. Now that's you could see that suppose zeta has but I know zeta is proportional to cmq another addition for zeta we have already done that. So now I need to increase the zeta

from 0.2 to 0.6 so that is corresponds to some cmq new that is the value we required to enhance zeta from 0.2 to 0.6.

So what I will do I will write that cmq new minus cmq basic and that is additional cmq required that will be 2 u by c cm delta e into k so I can go on plugging in number in k and then c that I get appropriate cmq new at the speed that all be given that able to control power. All your guided system when you are using this mechanism in the inner loop ok. So I thought I will also end this course and I will give initial brief description on the SAS which is the stability augmentation system also measure.

Please understand that also I change cmq or cm alpha it will affect the other derivatives c1alpha will change c1 delta will change that you could see by plugging them into the equations right. Thank you very much this is the end of SAS part.