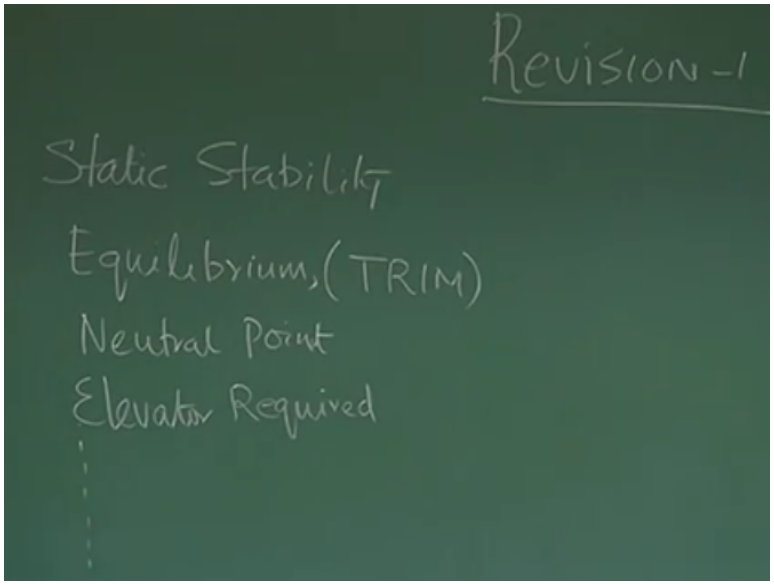
Aircraft Stability & Control
Prof. A.K. Ghosh
Dept. of Aerospace Engineering
Indian Institute of Technology-Kanpur

Lecture -56
Tutorial - 1

Good morning friends what do have to be decided by reviewing all the fore arm questions, that potions that we need to have one or two succession words. I can revisit whatever discussed in this course and try to touch the salient points this you can treat as tutorial you can treat as a mann ki baat but this week completely. I try to revisit whatever we have to discussed and underline the salient point if you see we started with let me give a name for this revision-1.

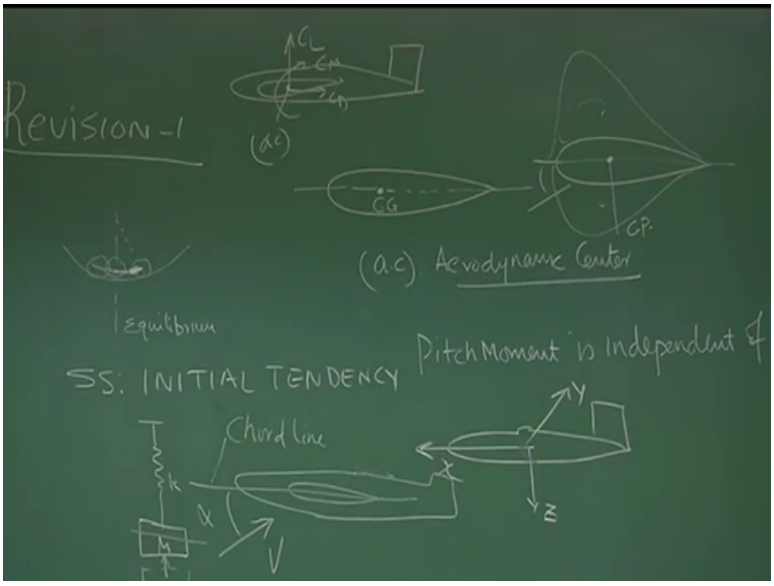
(Refer Slide Time: 00:50)



If you see that, when we started this course we use one term at statics stability we use term like equilibrium also we use specific one trim, and then we also talk neutral point. We also talked about Elevator required for trim then as we progresses we glance throw lateral directional case and finally came down to dynamic stability ok. They will start with static stability. What understood?

What our understanding is as for as static stability is concerned it said if body in the equilibrium is disturbed and if you observe it has initial tendency to come back to equilibrium it said the body is having static stability ok.

(Refer Slide Time: 02:36)



And we try to explain throw with the shout of diagram where this is the equilibrium, and by equilibrium we all understand at this condition heck force and neck moment is zero ok. And how we explain we said it is disturbed from the equilibrium and one the disturbance is withdrawn it has initial tendency to come back to equilibrium. We say it is static stable and if see that such a diagram. There is force component of gravity and this ball will role here like this but we talk about static ability it have initial tendency that's more important.

We not talking about the dynamic at all, we are talking about the transient at all only the initial derivative tendency. If it is having an initial tendency we said it is static stability so what was the keyword for static stability it is the initial tendency to come back to the equilibrium ok. We try to explain this throw mass spring systems this is spring this is mass and you know if I stretch it somewhere here and release it.

It also has initial tendency to come back to equilibrium it will oscillate that is not the point of concern for the static stability concern it is only the initial tendency that matters ok you are from this two examples, this two illustrations when we are talking in terms of aircraft. What we said we see this is aircraft this is only a wing aircraft and flying wing type concept and said this is the center of gravity and define term for a c is a aerodynamic center.

What was that aerodynamic center? Aero dynamic center is that 556 point at which the pitching movement is independent of angle of the attack. What is the pitching movement pitching movement you know it is a movement about aircraft y axis. What is air craft y axis. We have following this convention if this is x this is y and this z in right hand side and what is pitching movement about the y axis ok. What is the air dynamic center that 56 point about pitching movement.

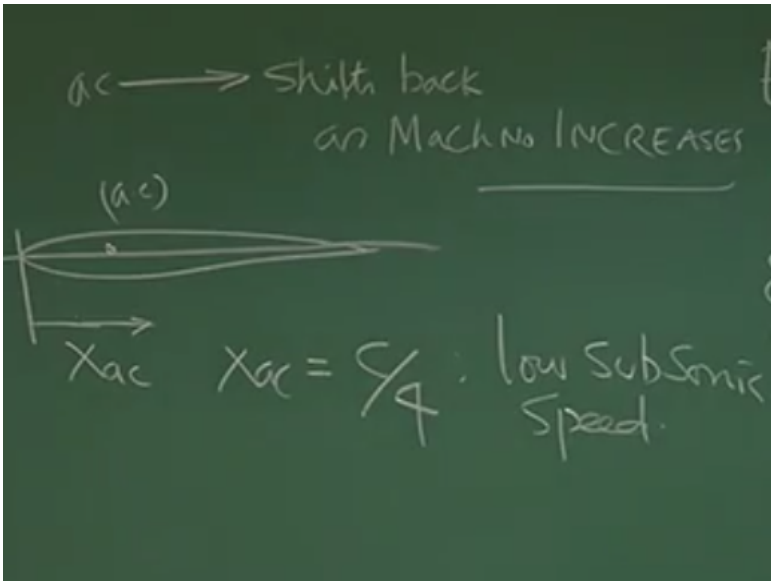
Pitching moment is independent of angle of attack and what is angle of attack as we also understand. If this is the airplane this a wing and this is the chord line and this is the velocity vector the angle between the refers line and the velocity vector in the vertical plane is defined as angle of attack ok. So we know understood are reconfirmed of understanding.

And the Dynamic center is that 56 point about the pitching movement is a independent of an angle of the attack, pitching movement is independent of angle of attack. Now we also understand and this is the body and any angle of attack that will be perturbed distribution and net force .We can be represent at the center of pressure and you know what is the center of pressure the center pressure is at that point of this resultant is force is what about acting here and there in fact the pressure disruption top and bottom surface.

When is we integrate the pressure of area top and bottom we get result in force and depending on the perturbed distribution depending up on the quality we can define find out the center pressure of like you have center of gravity ok but what about doing will here we have the represent the forces moment acting at the center of pressure. What we will do forces and moment we represented at aero dynamic center.

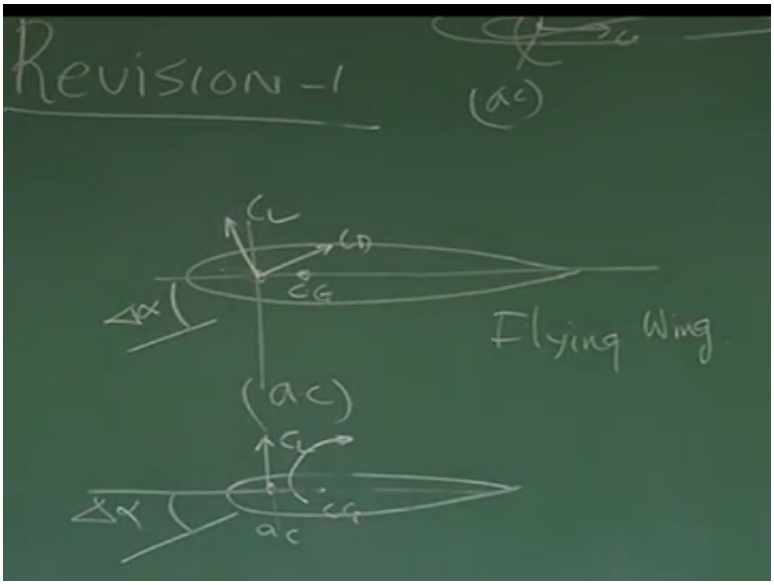
I put to the cl and cd, cm it set putting at center of pressure. We will transfer and the represent the acting at the aerodynamic center because have additional advantage at above the aero dynamic center pitching movement is independent and the angle of attack is that helps and typically we also know for a low subsonic wing.

(Refer Slide time: 08:33)



This aero dynamic center location is if I measure from here if I write it x ac. The x ac is typically c/4 low subsonic speed for conventional air ok. But as I increase the speed as it goes to higher, higher speed. Then it in convincible to subsonic to high subsonic supersonic, this aero dynamic center shifts the backward as mac number increases. This is the understanding of the aerodynamic center ok. Once we understand this aerodynamic center now we will try to see for the aircraft. What is our understanding about static stability?

(Refer Slide Time: 09:43)

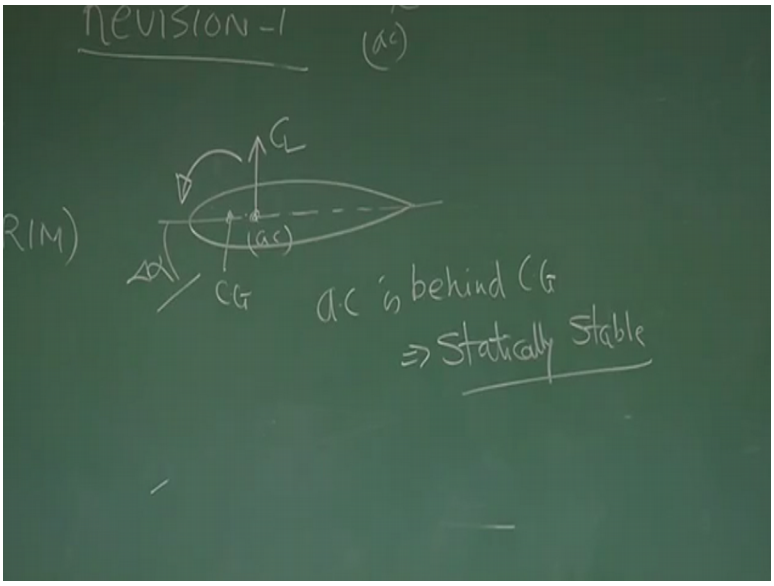


I will draw in here lets at the flying wing configuration and if this is and center of gravity is flying wing. So this flying wing let see the aerodynamic center is ahead of center of gravity ok. One this compound is possible now see. We going to see ask a question.

What that this is statically stable are not? How to I do that I introduce the disturbance the angle of attack. The movement I do this I know by now there will be cl there will be cd know this force is the ahead of cg the small angle is make not a simpler. I can write this is ac and this is cg for small angle and this is cl and what is happen. As I introduce the angle of attack because the cl will be there because the angle of attack and it will give a movement about the cg nose up.

If we see that force is here is it nose up moment it doesn't have a restoring the tendency of and it doesn't have initiate tendency to make a alpha 0 because this is alpha actually. It statically stable you should do like this let alpha become a zero alpha become whatever original it was right. So this ac is the ahead of cg of the flying of the explain wing. Then we say the aircraft is statically unstable and what will also same configurations.

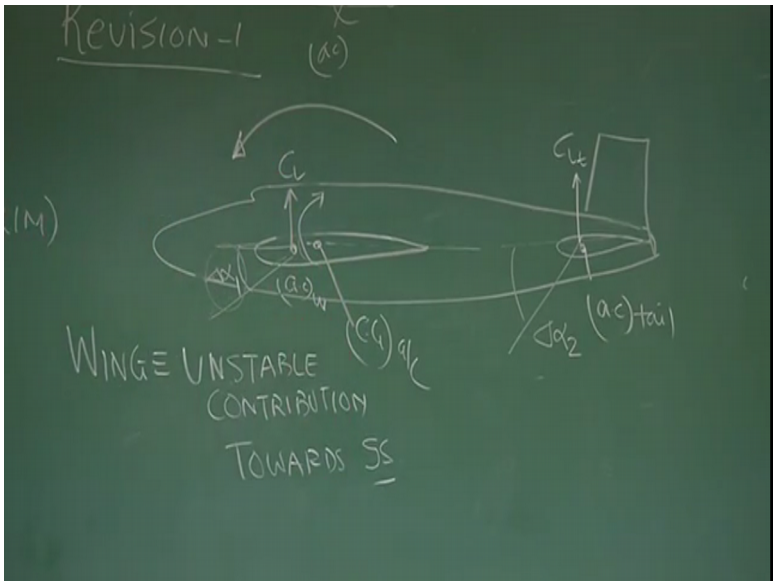
(Refer Slide Time: 11:38)



If cg is here the ac is here you could see that if there is the alpha disturbance that is. When I say the alpha disturbance is what the suppose the airplane is closing at alpha 2degree because the angle of attack becomes 2.5 degree so this is 2.5 minus 2 degree is 0.5 degree is the disruption. So you know that the disrupt is there ac is begin cg and i can draw the cl and this give a nose down movements nose down pitching movement.

So it will try to do come back to that whatever all given alpha was there it will discourage any increasing angle are if have initial tendency to come back to the equilibrium. So this configuration. Ac is behind cg is aircraft is statically stable this find for the flying wing but we talk about aircraft. When it is the aircraft when drawing the aircraft.

(Refer Slide Time: 12:58)



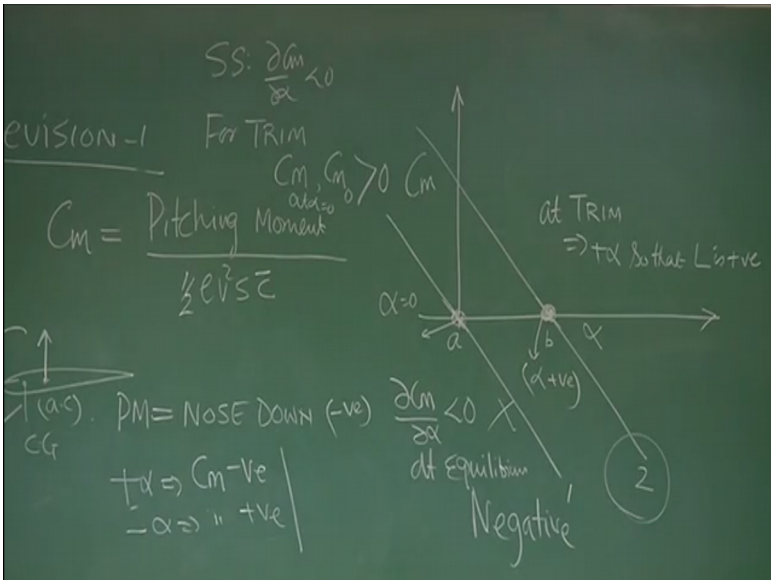
So suppose this the aircraft right as wings now let's see the ac of the wing is of cg of the aircraft if this is combination. Then if I you ask a question as the wing is concerned the wing is static stability to aero plane in constant of here is see is ac of the wing is ahead of cg of the aircraft this will give unstable contribution towards static stability right you can understand very well there is the alpha disturbance the cl is here the cl will give nose movement it will further increase the angle of attack.

So wing will proved unstable contribution for the satiability but now want to make it statically stable. What can i do? The question is this and that is where the concept comes. We put horizontal tail. Now what is happening actually you see if there is alpha contribution and disturbance. The delta alpha activate wings and let's assume that same delta alpha and little delta alpha 2 and I call it delta alpha1 and the I am in little bit concise that is I know that angle of attack and wings difference which you know because downwards buying that please understand.

If there is a delta alpha at the wing to give CV and the nose up movement so it is the tendency to increase angle of attack but what is happening at the tail the tail aerodynamic center of tail which is behind center of the gravity of the aircraft. So it will give contribution physically what will happen because of this cl tail and this moment of the large info a nose downs movement.

It will try to decrease tail to comeback original angle at the depending of on which contribution is more is dividing on is contribution stability, contribution of because a wing and, the stability contribution of the tail, and the stability tail then more. Then to vision then the airplane will provide the stability got it that is the basic understanding ok now from here we talking in terms of cm vs cl graph remember cm pitching movement coefficient.

(Refer Slide Time: 16:54)



We defined as pitching movement /1/2 eV square s c bar .The c bar was what do have notice the static ability this is the aircraft center. And this is the center of gravity. So if there the disruptions in terms of this combination no downs movement pitching movement is nose down. The nose down is as per of conversion is negative. What we you like for static ability is there is positive angle then the pitching movement cm should be negative right for negative alpha should be positive.

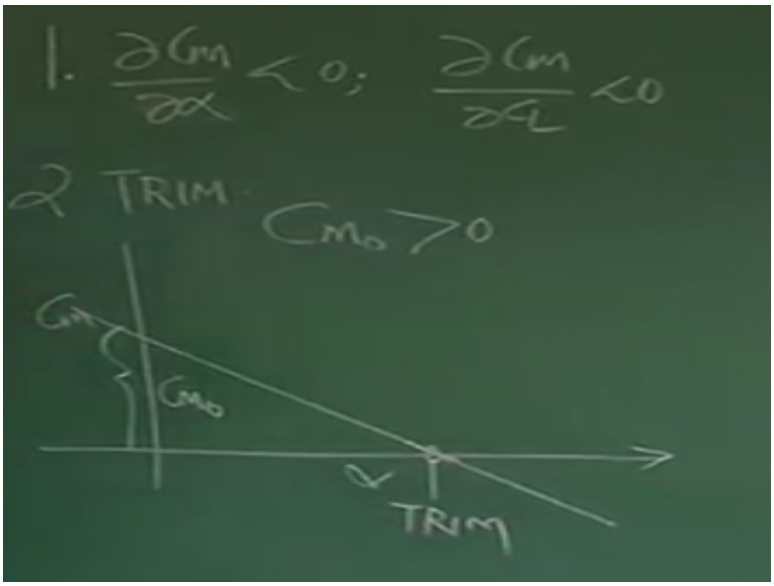
So this understanding is develop cm and the alpha graph this is these are possibility if c between 1 and 2 first identify what are quality of points the equality point. Where cm =0 a and b equilibrium point you know that if we want to insure that statically stable then this dcm/d alpha in less than zero. The positive alpha cm negative the negative alpha cm should be positive. We translate the understanding in the mathematical form is let the slope at equilibrium should be negative.

The equilibrium we identify point of the a and b and see the slope at a and the slope at b was a negative. So both are statically stabile place right and what are difference. We find out send after all the trim at trim. I want positive alpha for that lift is possible after all lift equal to weight is one of all equilibrium point. Of course it also debit in comorbid you can have lift positive lift given at negative angle.

We have not positive in that ok so these are the trim points realize and slope about the trim point should be negative now between two radians resaleone and realize that this a is equal to alpha = 0 this b is = to alpha positive how requirement is two design a aircraft cm is = alpha should be close and difficultly should be like this not this because it is following the trim of the figure 2 can derived positive alpha.

The positive alpha for weighting lift that is how for the put another condition the static stability find dcm/d alpha < 0 but for trim of the positive angle at that cm at alpha = 0 are cm not> 0 and this is the condition. We put mathematically throw our understanding of aircraft of the static and trim right. What is that nut shell of our understanding as for as designer is concerned that we need to

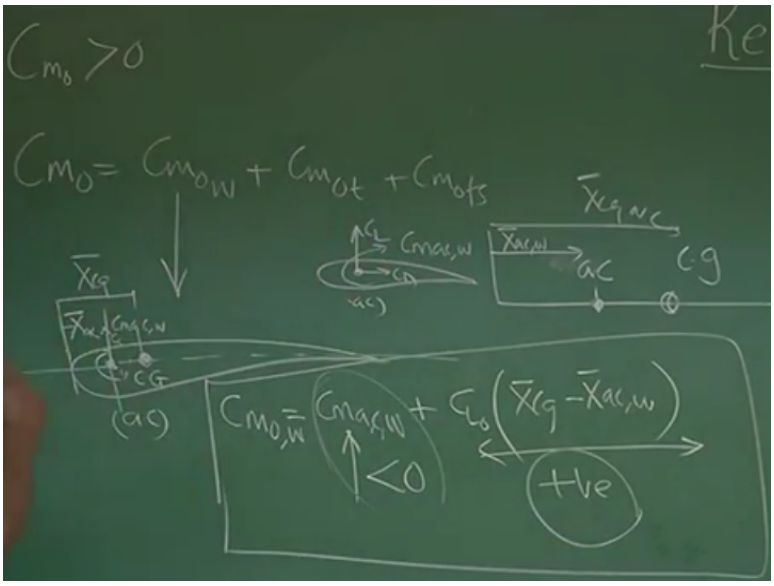
(Refer Slide Time: 21:32)



Insure the dcm/d alpha <0, we know is equal in dcm /dcl<0 because cl not + cl alpha into alpha second thing for trim we want to ensure that cm not>0 finally. We are focused to version of cm

and versus alpha like this. This is cm not and this is cm alpha the catch point is cm alpha the slope of this line at trim at this point that is important trim point right clear .

(Refer Slide Time: 22:25)



We are talking about cm not>0 and also because that cm not =cm not wing +cm not tail +_cm not fs. I will just try to cm not wing understand if we using the camped aero foil wing suppose then this is the cg let this is the ac and this is x ac this is xcg I put the bar. You know what is bar, is the non- dimensional as in the aero dynamic chord. This is the aero foil you know that I represent at ac for a cl this is cd and there will be cm as was know these.

So there is am ac wing for cl and cd then you know that then we calculate cm not that will be of the wing =cm ac wing then +cl not(x bar cg –x bar cl w). Please understand here the cm al w became a < 0 as aim cm not positive or negative next negative finally. We want c mo w is = positive ok. This is negative so. I try margin throw this expression and that is possible and the when x ac of the wing is ached of cg otherwise this became negative the x ac of the wing this is x cof the ac in the center and this is the center of gravity of the airplane is x ac of the wing this is x cg aircraft.

If would see that cg it give it statically and stable contribution at cm not is constant. It could x ac the one and only becomes positive right .We are not the burgherat about become contribution at

static stability because we have a tail it just stable at and this is very important should not forget this lessons.