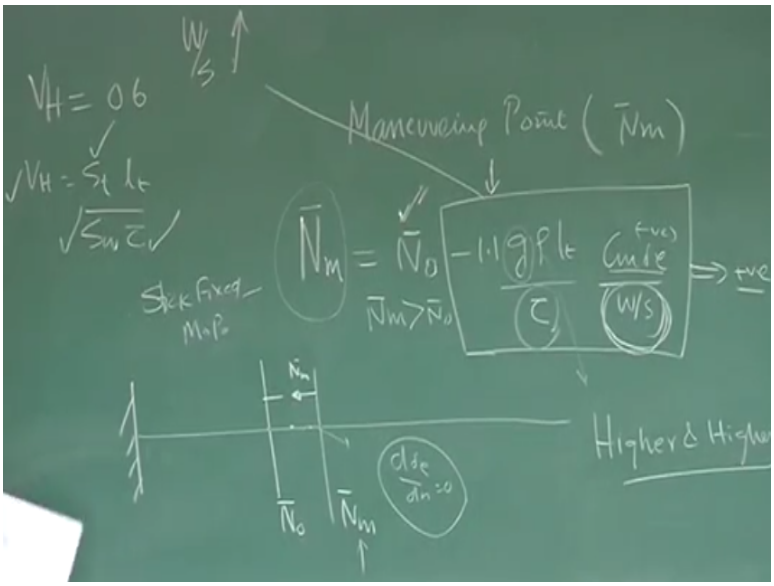
Aircraft Stability and Control
Prof. A.K. Ghosh
Department of Aerospace Engineering
Indian Institute of Technology-Kanpur

Lecture-19
Numerical: Stick Fixed Maneuvering Point and Flight Demonstration

We have just now solved a problem on Delta E required for cruise for climb we will also talk little bit of about the maneuvering point.

(Refer Slide Time: 00:31)



We know by now what is maneuvering point denote by NM bar again it is expressed in terms of chord this much percentage of chord or it is that is why bar is there to non-dimensionalized the actual distance dividing it by mean aerodynamic chord, what was maneuvering point if we see we have already explained that NM is N0 let me write this expression – 1.1 G row LT by tow CM Delta E by W by S right?

So what is N0 here? N0 is stick fixed neutral point and what is NM? NM is stick fixed maneuvering point okay. And now if you see what is the relationship little closer, if this is the reference if this is the N0 bar the maneuvering point NM will be this side or this side from this expression let us check first see here this sign is negative CM Delta E is negative so negative into negative positive. so NM bar is greater than N0 bar so if it is N0 NM will be somewhere here okay.

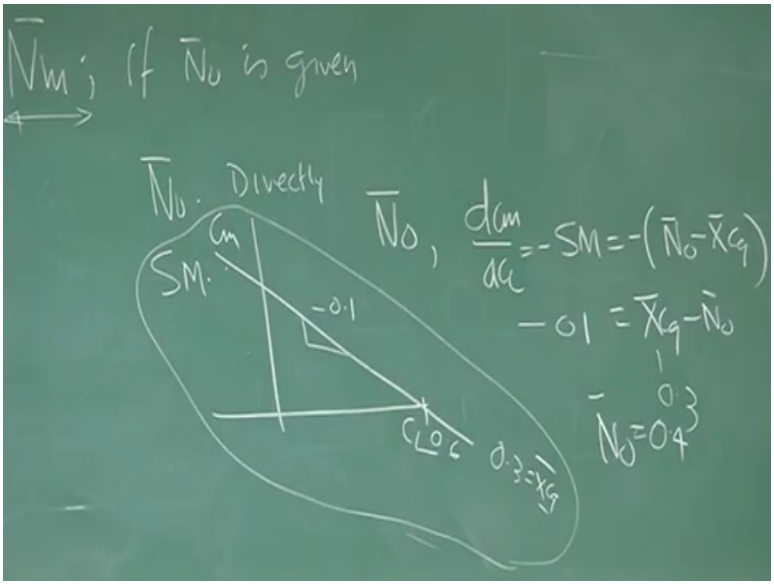
Which by conceptually we also are very clear as airplane maneuvers there is additional angle at the tail, which gives the pitch down moment so it increases apparent stability of the airplane longitudinal stability of the airplane. So, naturally is neutral point or maneuvering point should be behind the neutral point stick fixed because I already said more stable during maneuver right? meaning thereby if you draw the CG here it will be statically unstable but if I am doing a pull up put the CG here right CG here the moment you put CG here you find the Delta E you have seen that D Delta E by DN = 0.

When the XCG is at NM bar the D Delta E by DN that is elevator per G is gradient become zero, so that is definition we knew I just revise that, and if you want to solve such a problem before solving a problem see, what are the relations and what are the parameters that creates this difference numerically. You could see here this is the term and this term is a positive term this term is positive, and what are the parameters we have CG force explanation to gravity row is decided by what altitude I am going to fly.

So now you see if I go on flying higher and higher and higher, if I go on flying higher and higher if everything remains same theoretically, what is the effect of row? This row will go on decreasing so the effect the numerical value of this will go on reducing so, theoretically there would be a point where NM and N0 will remain will be very very close, they cannot be distinguished theoretically speaking because row is reducing the way higher and higher.

And that is true also if conceptually, all these terms whatever you are seeing here when I say it is going for a Q there is a change in angle of attack here, there are almost like a dumping effect okay. And dumping definitely row is going down so dumping effect also will reduce so as I grow higher and higher these two try to come closer this NM try to come closer to N0 bar right. This is one understanding second understanding, you do not required any other additional information, to find NM bar.

(Refer Slide Time: 04:58)



If N0 bar is given if N0 bar is given we are discussing that how to find NM the maneuvering point, if N0 is given and you will see in such numericals or in practical field also you will find N0 could be given two ways, one is directly another is you know, if you know static margin say it is static margin let's say it is something like this this is CM vs CL graph is there, let's say this value point 6 this value is let's say this is slope is - point 1 and XCG is point 3 correct. What is given even.

If CM versus CL variation, let say this point CL point 6 this slope is - point 1, and this corresponds to a particular CG location, which is point 3 XCG bar is point 3. Now if you see this diagram you also can estimate what is N0, we are trying to find out stick fixed neutral point, by analyzing the data given in this CM versus CL graph.

Very simple and know DCM by DCL = - static margin and that is = - of N 0 - XCG or this is XCG bar – N0 bar, now DCM by DCL is how much from this graph, it is - point 1 what is XCG? XCG is point 3, so if I solve this I get N0 bar = 0.4, so two ways we find mostly the problems are displayed like this okay? You should very carefully know this, this information you can easily find out what is the N0 or neutral point stick fixed.

So once I know N0 this is known N0 bar what information I required to find NM CM Delta E, which will be available because the elevator control power tow depends upon AC by ST you also

know it maybe around point 4 point 5. LT the distance between AC of the wing and CG of the tail that also will be given. How it will be given you see many airplane there will be given VH point 6 and VH is nothing but you know ST LT by S wing C bar, S tail will be known SW will be known C bar will be known and VH is given you can find LT.

It's a physical number right? Nothing so you have nothing to do actually all the things are available once you know N, put the number CR you will get NM bar I am explaining this problem just to familiarize you that problems are given a different fashion that data is present a different way you need to extract relevant information as long as you understand what do you need. So that is the skills of solving the problem but before I end, please see here this gentleman W by S is also here so before I end this part of this lecture, let us have a closer look on W by S.

And you could see W by S increases then this term goes on decreasing, because this is in the denominator, so as W by S goes on increasing the difference between NM and N0 bar or NM bar N0 bar also shrinks. What is the meaning of W by S increasing means it is AC is going down for a given W right. Then only W by S increases size smaller area larger weight typically high speed airplane so, you will find high speed airplane will have larger W by S come back to a glider.

And hence you will find as I go on increasing the W by S the difference between NM and N0 will shrink as we were seeing as I go higher and higher altitude the difference also shrinks so these are the two very. Important parameter you should be very much aware at design stage that difference NM and N0 reduces as I go higher and higher and as I make W by S wing loading higher and higher okay. This is a designer need to understand this so I thought I will mention here at this point thank you very much.

(Video Starts: 10:20) Dear friends we are going for a sortinom, I have former Captain Amit Dhayya with me. He is the pilot in command, and we will try to show you few aspects of stability and control, while flying I will request student to focus here, and I will ask Captain Dhayya what is this? This is my knowledge it is PFD Captain Dhayya can you tell me what represent this?

(Professor-captain conversation starts) This is the primary function display this give you some basic instrument there in flying sir, that is called manufault pressure, rpm, airspeed, artificial horizon with attitude indicator DGI that altimeter then gives you VSI that restricts basic. VSI basically vertical speed indicator what do I see the airspeed?

So let us focus here on this screen what we will do we will go for a cruise mode and during the cruise you know that it will have a fixed altitude it is airspeed will be also constant and the bank will be zero first we will check that will be our equilibrium point about which we will introduce disturbances to check whether this airplane is statically stable or not.

But the question is how do I introduce disturbance, you could see this a control column so if I pull this column towards me then the elevator will go up and if I release it elevator again go to neutral. So this is elevator going up and then it is coming to neutral or if I push it it will go on the opposite direction so we will give a elevator disturbance by pulling the stick and see what is happening whether it is going to come back to its neutral position or not or equilibrium position or not.

You can understand once I pull this elevator and by doing this the elevator is going up that means to maintain the that sort of the CL, it needs to give a higher angle of attack because speed has decreased, so elevator goes up and that gives a nose up moment and with this background we will be seeing how elevator disturbance will create problem for the airplane whether that is statically stable or not in class I have talked about disturbance in terms of angle of attack.

But now we will be giving the disturbance to the elevator the elevator will give a angle of attack and we will withdraw that we will see how the airplane is behaving whether it is coming back to his equilibrium or not. Once you want to increase the speed, so we have a throttle setting here, through this throttle we can increase the speed, we can give a speed disturbance also increase the speed and release it then again will see whether it is come back to all those speed or not.

So that will talk about speed stability, so like that will be the discussing a while will be doing the flight right. Let's go for a flight now captain Dhayya will initiate the flying process. We can start

over aircraft then first of all you can battery on arm check, down test for ten seconds then arm on, then hold grid make sure in half inch throttle and fiction it tight and give you fuel pump for time three seconds 1, 2, 3, then you check fuel flow then

You could see here flowing is there. Yes make sure fuel pump out and then you can check the ignition buttons first of all right magneto left magneto both then start top area clear. You could see here the rpm is increasing and coming down to around 1,400 to 1,500. If we reduce the throttle rpm will further go down. Aircraft Noise Could not hear clearly.

You could see here Captain is taxing rpm is around 1,110 and you could see there is air flow green indicator is there we are operating somewhere here oil pressure, oil temperature, cylinder temperature everything is being displayed here which are very important for captain to have those information for flying. We are now entering into our runway this is IIT Kanpur runway this length is around eight five meters and you could see we are turning from this indicator pilot knows how much he has turned.

So I was asking Captain why speed is not being shown here and you understand any speed lower than stall is none our concern for flying so unless we cross stall speed or come around that this display will activated and I will show you at what point you are start getting the speed and this is air relative speed. You could see here there is analog altimeter reading so almost showing zero these are all standby instruments you could see here the air speed this is the attitude indicator right.

Now the speed has gone down. We could see the air stream aligning along the center line of the air stream our speed will further go down and as you could see the rpm is also go down and the speed has come down around 75 that is near the stall speed and we are touching down. You see the pilot is pulling because as he pulls it the speed goes down and drag will increase as a going elevators are also going up. **(Professor-captain conversation ends) (Video Ends: 28:53)**