Aircraft Stability and Control
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Lecture- 35
Determination of Neutral point and Maneuvering Point

Yeah dear friend, by now must be tried of writing so many expressions, let us come back do some experiment and try to prepare our self for some experiment. And what you will discuss in this lecture is.

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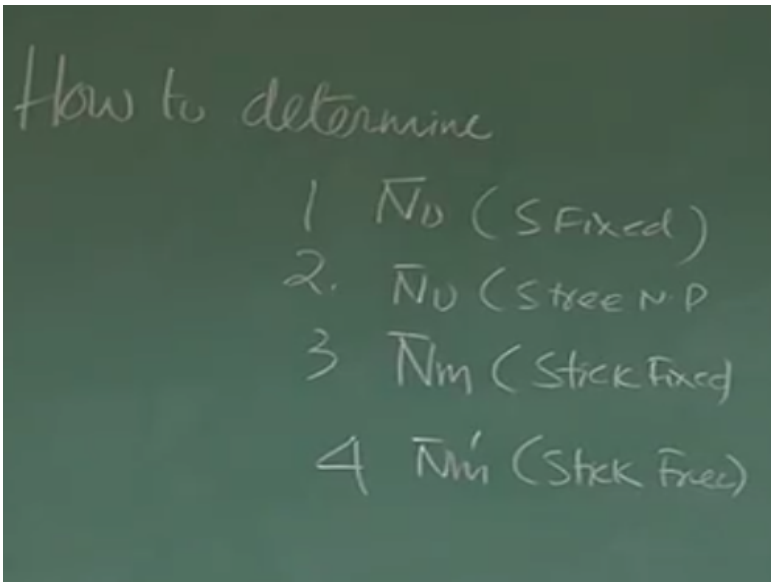

How to determine number 1 stick fixed neutral point, number 2 it is stick fixed neutral point, stick free neutral point, then stick fixed maneuvering point and 4th is stick free. It is important because so many expressions, so many assumptions were there right. Is fine, this expressions tells you so or give you some physical interpretation, sometime you have to put lot of effort in getting all those expression managed right?

CH Alpha, CH Delta E Tow so many varieties of symbols, But best way to see what is simple in life is do an experiment, and try to find out experiment.

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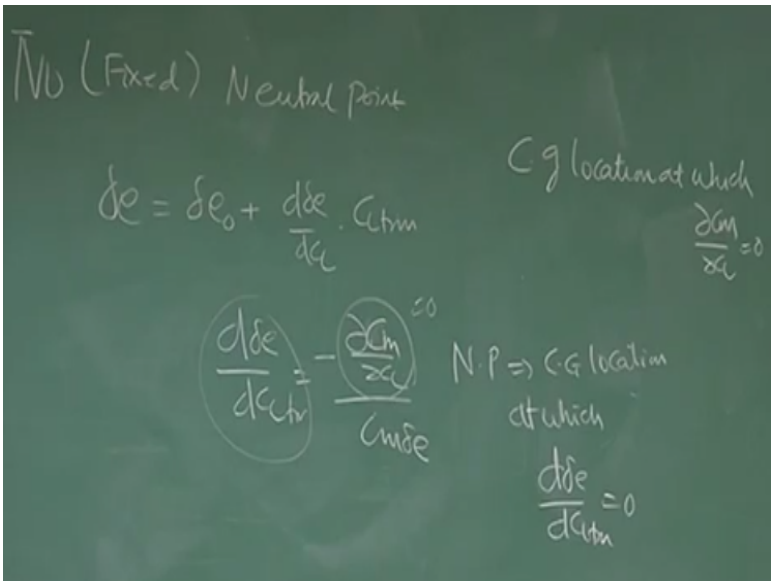

Tell I can find out, stick fixed neutral point, stick free neutral point, stick free maneuvering point and a stick free maneuvering point if you do that whole world will be assured. That whatever, you have generated or whatever physics of the situation if they collaborate every what is happening right. All those pane of writing big big expression goes, so I am working in flight laboratory, a aircraft so whatever expression you give me my patience will be to that point, till that time.

I can write on the black board but my satisfaction would be, when I fly the machine conduct an experiment, find out those parameter and check what sure is telling. How closed they are, right, If you plan their experiment correctly we find this theoretical experiment they go hand in and together. If you not able to plan it properly lot of confusion come, and then somebody will say what is in theory doesn't work in practice, and all those logic support, this is all rubbish.

Theory gives you the basis and you should smartly design that experiment, knowing the limitation and then always most of the time will get good result right. So we will now plan for how to find out stick fixed neutral point, how do I develop the physics behind it? Remember we know that Delta E = Delta E0, + D Delta E by DCL into CL trim and we know D Delta E by DCL trim is given by - static margin DCM by DCL by CM Delta E approximately.

So what is neutral point stick fixed? It is that CG location at which DCM by DCL is 0, that is neutral point stick fixed. So if I now translate this understanding here, since at neutral point DCM by DCL will be 0, DCM by DCL will be 0, So I can say neutral point is that CG location at which approximately D Delta E by DCL trim = 0. Why we say approximately because this expression is approximate, remember we neglect a few terms, so now from experimental point of view it is extremely important.

So what of the approximations you are doing right. So what is the message now? if I want to estimate neutral point, I know neutral point is the CG location at which DCM by DCL is 0, so I also know D Delta E by DCL trim is given by this, so I translate that definition approximately here, when I say neutral point is the CG location at which because this man is 0 DCM by DCL is 0. So I say CG location at D Delta E by DCL trim is 0, this concept I use for measuring neutral point stick fixed.

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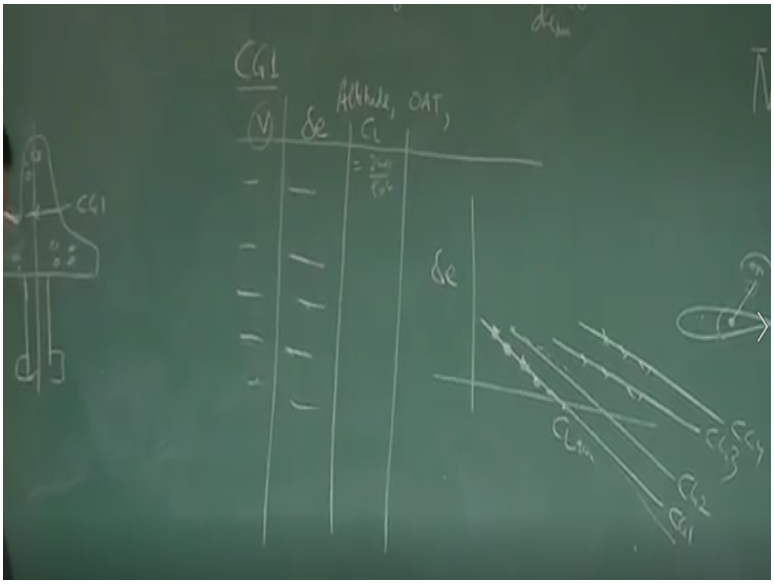

So let me write that now I have to conduct an experiment what I do, I take an airplane I take 3 passengers, and I take the weight, in weighing balance in the hanger, and I estimate calculate does CG of the airplane with passenger on, Let say that is CG 1, So what is CG 1? If this is the airplane passenger are sitting here, and Pilot is here so this is the CG 1. Then I go for a cruise, cruise means a good in altitude and I maintain on accelerated flight.

So I note down what is the altitude, and note down what is the outside air temperature, and note down what is the V and cruise wings, I am cruising at V right, Immediately I should able to measure what is the elevator deflection given. How do I measure elevator deflection? In a aircraft are instrumented like that experiment like aircraft. So this is the elevator path and as it rotates it rotates a potential meter okay, so this is the potential meter shaft, as this elevator rotates.

Potential meter also rotates this gives you voltage, and that depend calibrate and get the deflections right, so we assume that Delta E is also measured, and I do this experiment for different different trim, what is this V, at is V I am maintaining lift = weight. So 1 trim, at this speed I am maintaining lift = weight, another trim so 1, 2, 3, 4, 5 trim, I get. And for that I get different, different Delta E.

Then what I do, I convert V to CL V which should be = 2 W by S by row V square, I can measure the weight of the airplane I take the weight of the airplane and the ground, passenger and then I know what is the full consumption. I take a stopwatch how much time is consumed, I separate that much of fuel, I get the weight, I have reached weight, so I can easily calculate the CL so what I do, I plug Delta E VS CL trim.

So I will be getting some graph like this, so 5 points I have taken why should be negative slope? you know that D Delta E by DCL sign will be this is negative this is negative, so positive and this is - sign is negative so you will get 5 points say 1, 2, 3, 4, 5 point join them and mark it, this is for CG 1 now, what you do you come back and take different passengers now what you do, you put some passenger to here 1 here, or may be 1 here.

Like different weight so that you have a different CG, and again you go to altitude measure the altitude take outside temperature, and when your cruising at different different V, You measure the Delta E and elevate deflection, calculate CL again you plot this like this CG 2, you will get CG 3, you will get CG 4, you can go on doing this experiment with different different people, different different CG location, so this data i have generated now what we have to do. You have to find the CG location for which D Delta E by DCL trim is 0,

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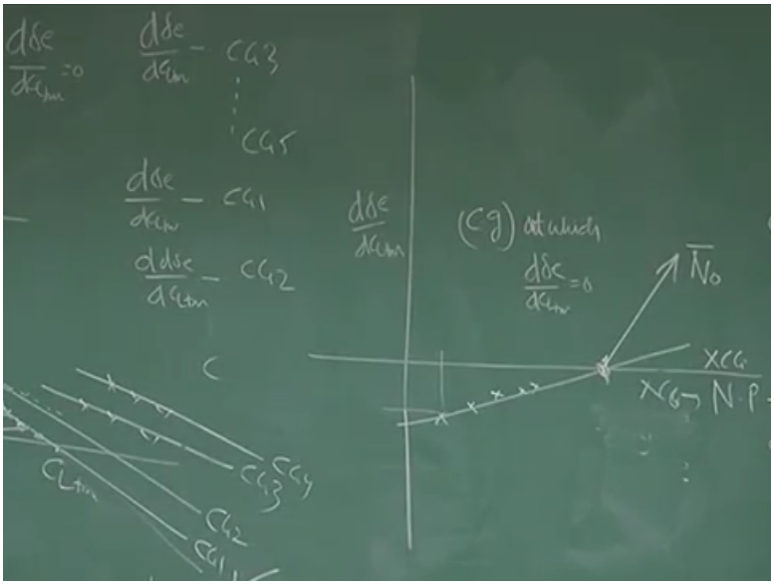

So what is the way? you take each graph, take their slope, what is the slope will give you, this is nothing but D Delta E by DCL trim for CG 1, similarly will have D Delta E by DCL trim for CG 2, like this you will have D Delta E by DCL trim for CG 3, So you can have for many points say CG 5, Clear? We are taking slope of this line that is D Delta E by DCL trim corresponding to this CG 1.

Second graph you come D Delta E by DCL, the slope of this line and first CG 2 line this will generate, and obviously this only all negative now you cross plot, here you put XCG, here you put D Delta E by DCL trim, which we have extracted from this graph, and now start plotting for this CG location, CG 1 what is the value somewhere here, somewhere here, somewhere here and draw them in a straight line.

And this is the point is what? this is the CG location I am plotting XCG So this is the CG location at which this is the CG location at which, D Delta T by DCL trim is becoming 0, CG location at which, D Delta E by DCL trim becoming 0, So this is, this CG location is neutral point stick fixed clear so by definition, so you know how to find neutral point stick fixed to fly data.

You have to go to in altitude, measure the altitude and outside air temperature. This are important to get the density of air, then you cruise a different trim speed V all V 2, V 3, V 4, V 5 measure the elevator deflection required for trimming it, convert V it to CL because for CL V be row this outside air temperature altitude will help, also V indicated air speed. So all this shift have done plot Delta E VS CL trim it come like this for different different CG location.

Take their slope cross plot D Delta E by DCL trim VS XCG okay, XCG and extra plotted it will get a point on the XCG axis at which D Delta E by DCL trim will be 0, and that is by definition is the stick fixed neutral point. So by do this experiment you can easily find out the stick fixed neutral point, clear.

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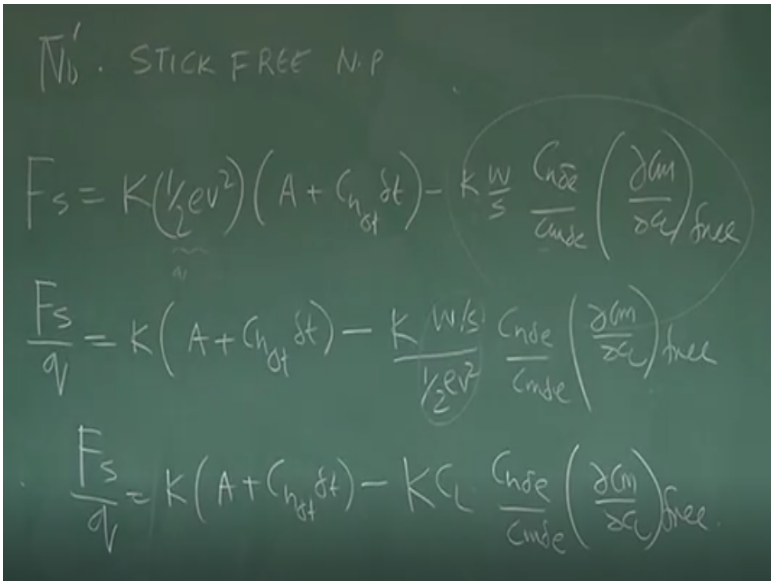

Now we want to find out N0 prime that is stick free neutral point. How do I find it out and what is the physics value. What is my strategy behind it, I need to understand the physics then will conduct an experiment okay, Let us see that physics part, if we recall the stick force expression as half row V square, A + CH Delta T into Delta T, - K W by S CH Delta E by CM Delta E into DCM by DCL free. You are familiar with the FS expression.

Now we divide both side by Q so ahead FS by Q, here it will become A K A + CS Delta T into Delta T, and ahead with K W by S by half row V square CH Delta E by CM Delta E into DCM by DCL free right. And you could see here W A, W S by half of V square is nothing but, CL I am

sure you have in touch with me, I have divided this term also by half row V square so, K W by S divided by half of V square CH Delta CM Delta or bla bla are there.

This I can write as FS by Q = K A + CH Delta T into Delta T, - K CL into CH Delta E by CM Delta E into DCM by DCL free no issue because, for W by S divide by half row V square nothing but CL, now see the trick. Trick is here, what is our aim? We try to find out the stick free neutral point that is what is that CG location, at which DCM by DCL free is 0.

What is N0 prime? N0 prime is that CG location at which DCM by DCL free is 0, with this at why were try to do like this, if I can somehow manipulate this expression, and find an equivalent meaning of that then I should be able to conduct an experiment which parameter measurable right.

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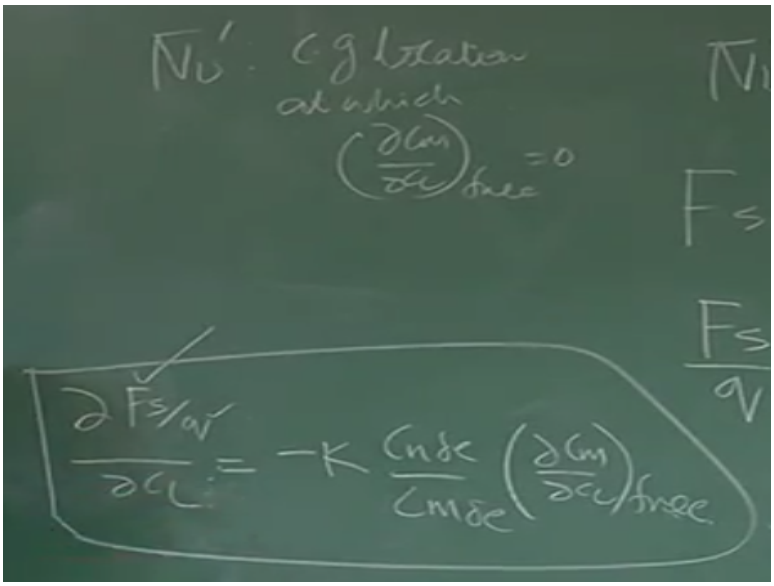

Let see what do I mean, if I now write it FS by Q by DCL what this will become, this is simply become - K CH Delta E by CM Delta E into DCM by DCL free. So what is the meaning now will see, carefully this expression, what is our aim? We have to find out CG location at which DCM by DCL free is 0, that means if this is 0, that means at that CG, where DCM by DCL free is 0 DFS by Q by DCL is also this is clear. I repeat the CG which is stick free neutral point at which DCM by DCL is 0; this relationship tells you that mean DFS by Q by DCL is also 0.

Why we were operating with this term is please understand this FS stick force I can make sure using a strain gage on the stick, Q I can calculate by half row V square, CL always I can find 2 W by S row V square right. These are all it's the measure, I cannot measure DCM by DCL, I cannot measure CM at trim CM will be 0 right, So we do not use this directly but, we use the interpretation and convert into an visible way.

Which is equivalent and which are having terms or parameters which can be measured like here for N0 prime, it is a CG location at DCM by DCL free 0, Which means N0 is the CG location at which DFS by Q by DCL is 0 as per the experiment is concern.

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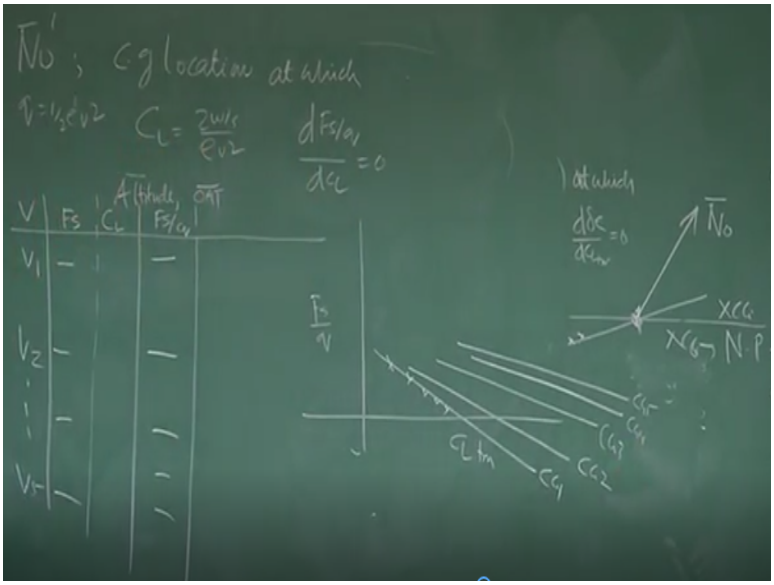

So I can write to find N0 prime, I can write it is the CG location, this is for experimental purpose at which DFS by Q by DCL is, how do I do the experiment? When I am going for when Pin point experiment, I go to in altitude again note down altitude, I note down also at the temperature because this are required measuring the density. I trim my airplane for V 1, V 2 up to V 5 I get I measure FS, for every trim I measure the what is the stick force.

I have applying because my stick will be having strain gages, which can measure the forces through deflection, and now I convert V to CL I calculate FS by Q , What Q is what you know that Q is half row V square, that is why we taking outside the temperature altitude so they can density we are getting from air sprint indicator, you need to correct it because there is a indicator

air speed, all those things are finite detail but conceptually this is relevant to you CL also you can calculate.

Because CL you know = 2 W by S by row V square okay ,So this information I given to you now you plot, what you do you are smart now you plot, FS by Q VS CL trim, for CG you want, that is with 1 configuration, we are 2 students we are taking and flying away, next, you take 3 student and another CG that is for different different points you are getting FS by Q from here, for V 1 this is FS by Q, V 2 this will be like this.

Those I am plotting for the given CG location, like that 3 4 5 I generate okay, So I have CG 2, CG 3, CG 4, CG 5 now simple what is our aim? What is that CG location at which DFS by Q by DCL is 0. So what will I do? I will take slope of this line what is slope will tell me? this is DFS by Q by DCL by the slope of which line.

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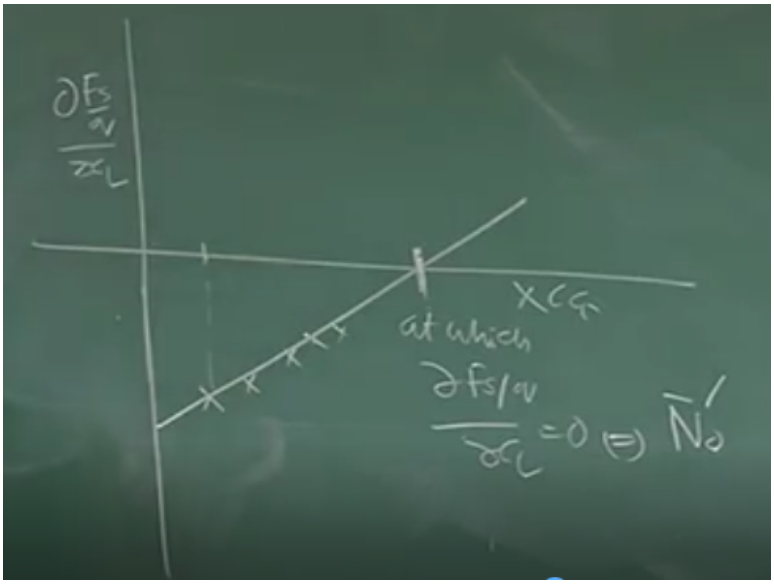

So now I will plot DFS by Q by DCL and XCG location here, So for 1 CG location I am getting value here second here, third here, 4th here, fifth here join them what is this point, This point is the XCG location at which DFS by Q by DCL is 0. So this is the CG location which we are talking about stick free neutral point, clear. DFS by DQ by DCL which is the slope of each of this line, I am cross plotting them with CG.

And then I am extra pulling it on weight comes to the CG axis, this is the point where it is the CG location at which DFS by Q by DCL is 0, which is nothing but stick free neutral point that is how I will measure Stick free neutral point clear, now the 2 more neutral point you need to find out so let us finish that also.

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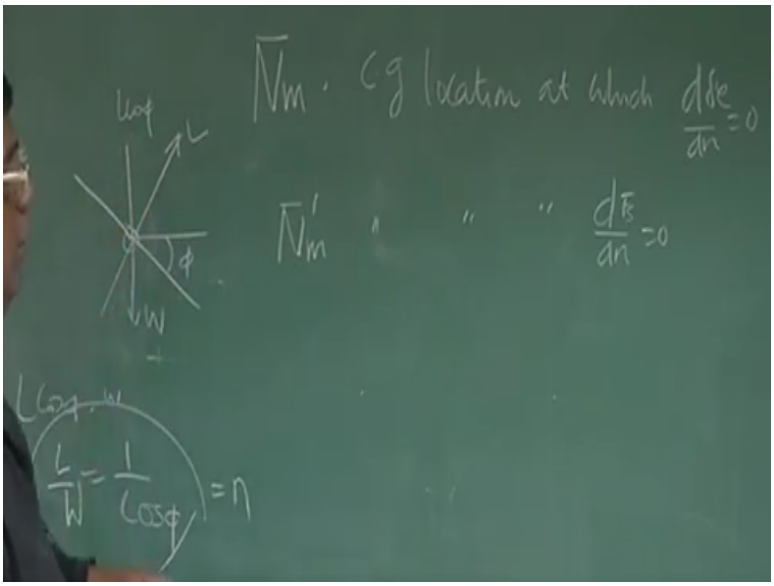

Now let us find out how can I estimate maneuvering point both stick fixed and stick free. We want to now try to find out experimentally the maneuvering point, both stick fixed and stick free, let us first find out by definition that stick fixed maneuvering point is that CG location at which D Delta E by DL is 0. And stick free maneuvering point is that CG location at which DFS by DN = 0, this have to definition we have aware of, we have to conduct an experiment to find out the CG location at which D Delta by DN is 0 and at which DFS by DN is 0.

We know very well now, I can measure elevator deflection, I can measure the stick force to stay engage ,What about load factor, in the theory class we have given a maneuvering flight in terms of pull up, and also in term of bank in turn right, we will not go for a pull up we will go for bank and turn, when I do bank and turn or turning flight then you know N is 1 by COS PI you have seen, This L COS PI = W.

So if this is your airplane which is the lift. Which is the PI, if it is the W , this will be L COS PI, so If L COS PI = W, so L by W is = 1 by COS PI, which you know L by W is nothing but, N load

factor so if I am banking the airplane and making a turn like this, and without losing the altitude because, I am balancing that weight, it will try to take the altitude by L COS PI okay.

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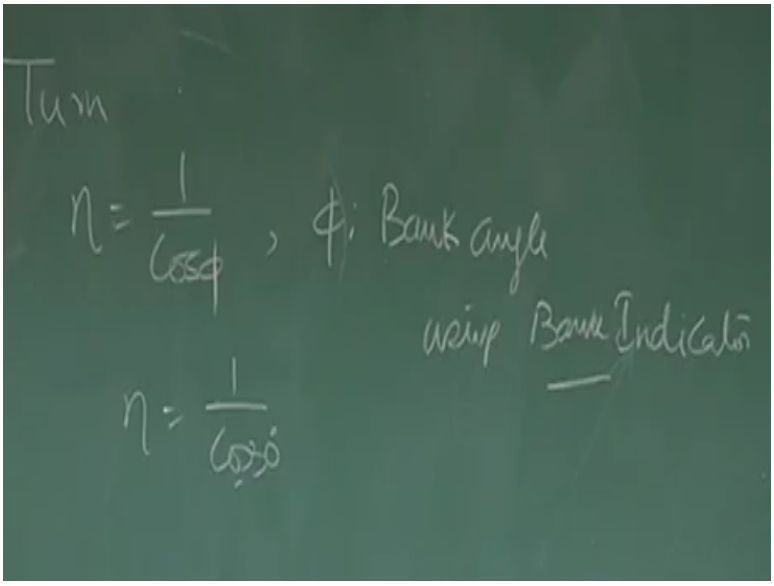

So Accordingly I can find out what is the load factor which is I am flying If I take a reading PI bank angle using bank indicator. Which is in the cock Pit okay, For example I have bank for 30 degrees, then N = 1 by COS 30, angle value of COS 30 so you know the value of N, so very simple Delta E you know how to measure, N 1 by COS of PI and if it's through stick force stay engages, so all measurements are possible. So what do I do, I go for what I do?

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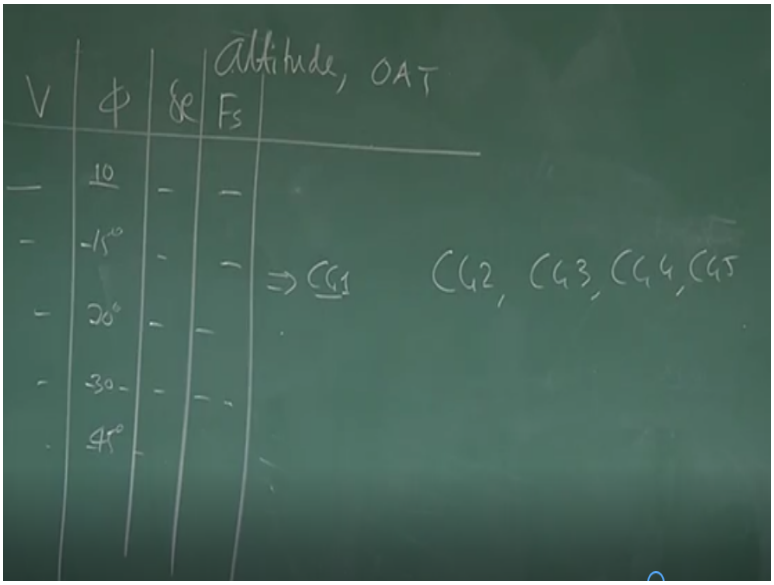

I go to an altitude and go for a turn with the bank right, and as usual I note down the altitude. And note down the outside air temperature, and then I note down what is the V, what is the PI, what is the Delta E, I am putting what is the FS, stick force this measurements I make clear, and as I told you elevator wing measure using a potential meter, and stick force measure strain gages, so if you visit here we can show you.

Now I have for different different V I have this sets of value right, For 1 batch I say this course point to CG 1, I repeat this, same experiment for CG 2, CG 3 as I have been doing for other case, So different combination clear, I take 2 passenger I go for a bank turn, I take 3 passenger so different CG 4 passenger Different CG, 1 passenger different CG like that for different CG configuration I fly, and I generate this data.

Let us say this could be fifteen degree twenty degree, 30 degree, forty 5 degree okay, and Measure what is Delta E required what is the V, and what is the stick force I am getting some now If I want to calculate the neutral point stick fixed, I know it is the CG location at which D Delta E by DN is 0.

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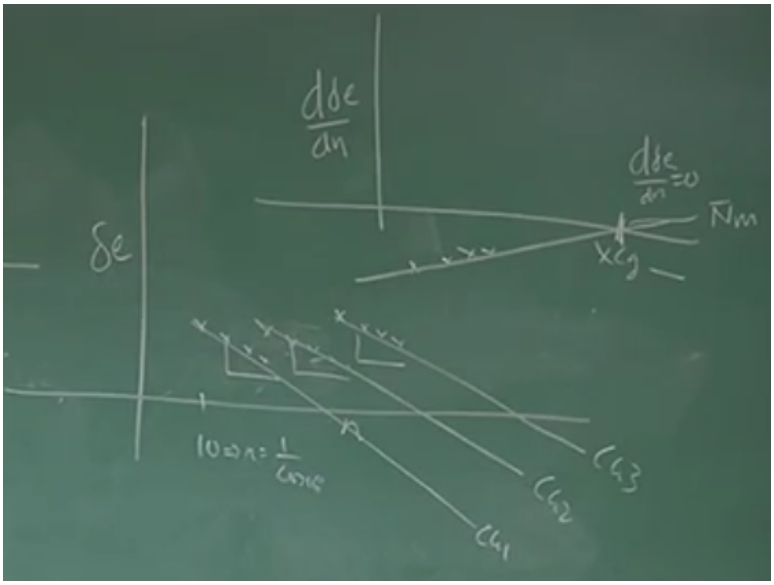

So what I have to do very simple, I will again Delta E and N I will see that for different N, whatever I am measuring ,That I am computing using 1 by COS PI right. I generate this straight line, this is CG 1 and another set for CG 2, and another set CG 3 up to CG 5 that is what I am doing, I am for the CG 1 combination 1 flight, What is the Delta E I am measured, I put it here and what is the load factor I am getting because of different bank angle, for 10 degree some Delta E.

So for 10 degree means, 10 degree means 10 = 1 by COS of 10 degree, so I know the end and Delta E required. Accordingly I am plotting them, for different CG I plot this, then what I do I again take the slope, rope and then I write, D Delta E by DN versus XCG, so this slope I put here, so another slope, so another slope, I join them so, this is the CG location, at which D Delta E by DN = 0, so this is NM stick fixed maneuvering part clear.

Delta E end from 1 by COS PI, I plotted like this for different CG location, take the slope and cross plot extra plot you get stick fixed neutral point, for a stick free what you have to do, you should be smart now, you know stick free maneuvering point is that CG location.

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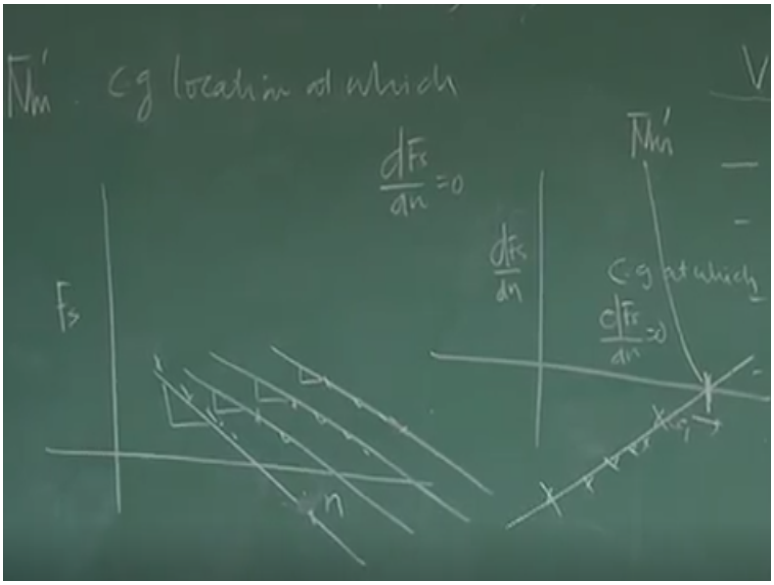

Say NM prime is that CG location at which DFS by DN = 0, there is no problem in that. We have already, measured FS through our stick using the strain gages, so I will plot again FS VS N for different different CG location, as you have d1 for Delta E, then I take the slope, I plot DFS by DN VS XCG and 5 6 point I will get, join them and this is the CG location, and the CG location at which DFS by DN = 0, so this is NM Prime.

I repeat we have already measured FS, and N I know so first plot FS and N , for different CG location, I join Them take their slopes I cross plot the slopes ,corresponding different CG location, then I join them straight line extra collate, cut the XCG axis is here, And this is the point that CG location at which DFS by DFN is 0.

So that is why definition is stick free maneuvering point, this is the simplest way of calculating N0, N0 prime, NM and NM prime, okay, we try to solve some examples but I taught for completion of this part, I must also give you some flavor how do we do experiments alright.