Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Introduction to Experiments in Flight

Lecture 05
CG and Climb Experiment
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So my name is Rajesh Kumar and I'm a PhD student in the Department of the research engineering at IIT Kanpur. So today I will be talking about aircraftwoment and CG estimation. So in this lecture we will try to learn how to weigh their craft and how do you estimate the CG right, so this is the topic aircraft weighment and CG estimation right. So let us talk about the real aircraft. You know like we do the experiment in this lab, so I have taken the example from the aircraft which is called Piper Saratoga.

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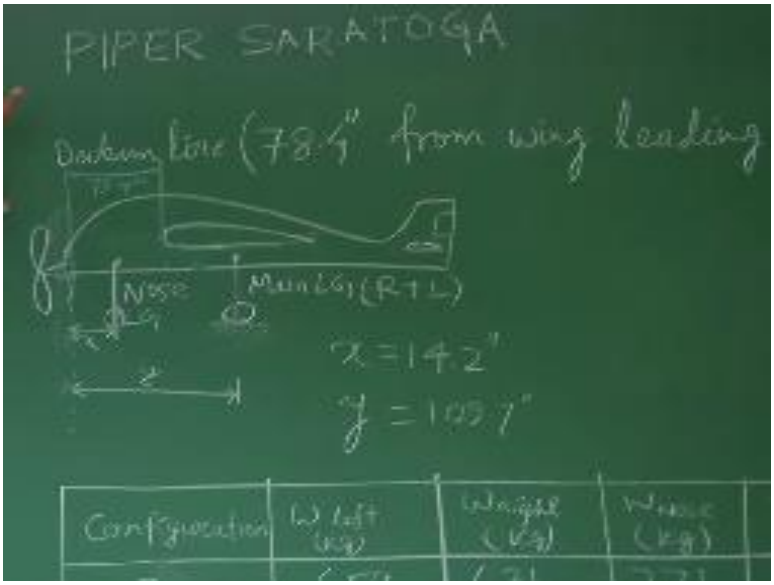

This one and if you see the configuration it is something like this, so here is the datum line and the datum line is 78.4 inches from the wing leading edge. So this distance from the reference line or datum line in seven to eight point four inches from this leading edge of the wing yeah and if you see suppose your nodes will landing Jerry is at this location and main landing gear where your left and right fill both are together location is here right.

So I am representing by X and Y so for this aircraft Piper Saratoga we have X equals to 14.2 inches this distance and Y equals to 109.7 inches, which is this distance right, so now how to weight it aircraft so f you see in this lecture I will just show you here by drawing here in the board so your scale will look like this, so one scale will be placed here and these two scales will be like this so for now here you are putting the right wing, left wing and node wing from the distance.

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So these are the wing scale so you have to mount or your bring aircraft are aligned as per this wing scale, so here you will be putting your landing gear node landing gear, right landing gear and left landing gear. So this scale will show you the measurement of the corresponding weights you know like at the node you will be able to get the reading for the node, landing wing and

landing here and right landing gear here and left landing here. So for this experiment like if you perform this experiment then you have to prepare a table like this.

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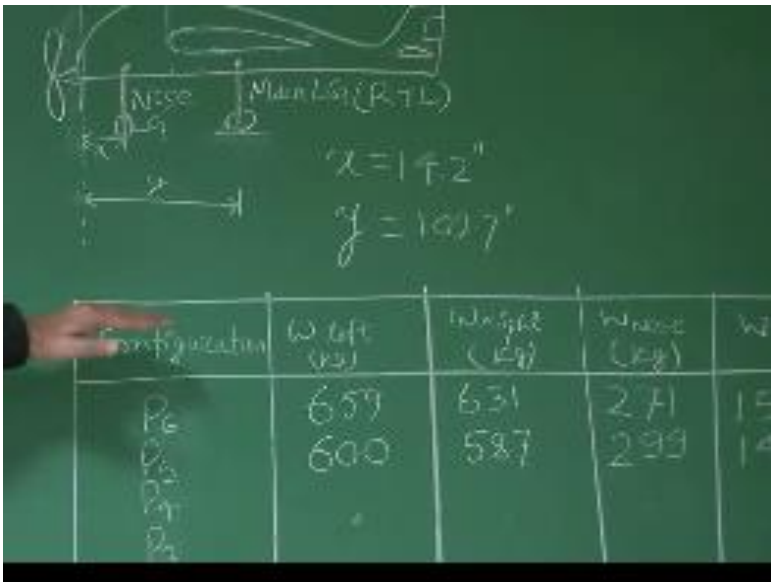

So configuration and then you have to take the weight for the left wheel, right wheel, roge wheel, weight, total weight and then XEG and so now how do you plan this experiment like if you want to estimate the CG and you also want to weigh the aircraft in this fashion so how will you plan it so. If you see the sitting configuration inside this Piper Saratoga will look like this, so here you can see 6 passengers can accommodate in this.

So basically p1 and p2 they are meant for the pilot and co-pilot and rest of the passengers they can sit in this order late p3, p4, p5 and p6 yeah. So now you can also study like by putting the weight or by removing the weight how your CG is going to travel how your CG varies or changes so for this experiment we, we have suggested configurations in this way like you take the empty configuration where there is no passengers like no p1, p2, p3, p4,p5, p6.

So I will make it p0, p0 when aircraft is empty. In the sense like no passengers and so in this table if you see p not left side landing gear weight it came around for 28 in kg, 393 kg, 321kg

and total weight 1142 and XCG zone, I will tell you that how to calculate the XEG so it is it will come from the very basic physics like if you have all the details there XEG can be calculated very easily.

So you can write XEG is equals to weight of this I will say NW and total weight actually, so I will write RW + LW which will be the weight for the right wheel and weight for the left wheel. So if I can write right wheel and left wheel and if you multiply this with the distance actually Y which is the distance between datum line two main landing gear Y and divided by total weight NW + RW left elderly. So this is very easy to calculate.

So you know like even get XEG by using these numbers so for from the experiment you will get NW, RW and LW already yeah it should be multiplied with X. So already you know the value of X and Y which is equal to 14.2 inches and Y equals to 109.7 inches where you know this number and of course you know this value. So for this row empty weight you will get 82.856 inches yeah so like that you can plan other experiment when you put only pilot then co-pilot rest of the passengers so configuration can be like p naught p1, p2, p3, p-6. P6 means like all the passengers are loaded actually all are sitting inside the aircraft right.

So once you have all the data you want to fill the table from the data then I will show you that how your CG vs weight will look like in the whole idea is like we should know once you change the weight in the aircraft you remove, you add so how your CG is going to vary. So if you see if I plot it here let us say, so I am putting weight in y axis so this is weight so you need to take n kg and here with XEG unit.

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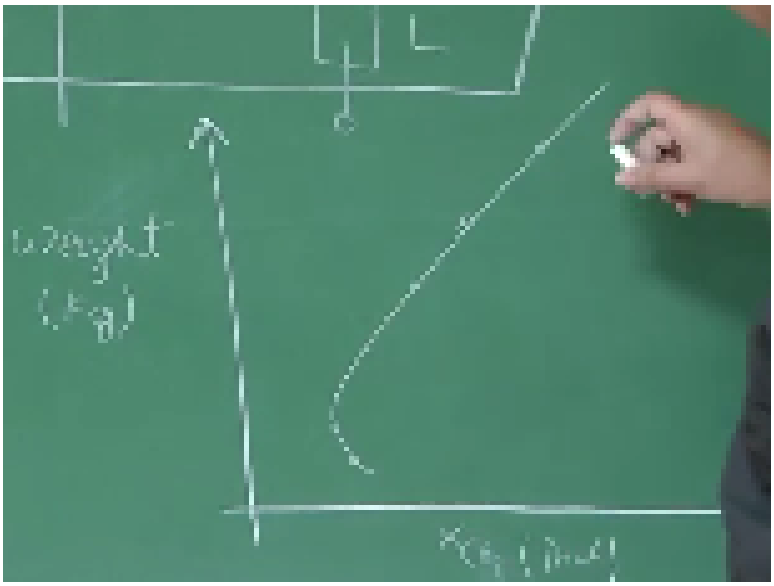

So zero one two three thousand before five and six it will adopts a look like it I'm not putting the numbers you sit in not very jack so but to know the configuration I right here p6 where all the passengers are there inside the aircraft p5, 5 passengers are there p4 , 3, 2, 1 and 0. So from here what is analysis like what is the inference from this graph?

If you see how your CG is travelling you see like once you have empty aircraft without passengers then your CG is sitting somewhere here may be here so once you started loading the passengers like once your passengers p1 and p2 are inside the aircraft you see that your CG started travelling this direction it shifted towards forwarding and then when you have passengers in these places p3 represents that p1, p2 and p3, p4 for passengers p5 and p6 like that so you see that your CG is traveling towards apt so that is how your CG varies.

Once you put the passengers or for the you load the aircraft with the weight so you are CG will travel like this so yes this is what we can learn from this experiment and we can do the analysis of the CG variation with the weight. So now we will be talking about to find the rate of maximum rate of climb using this aircraft right so in the previous lecture we came to know how to find CD not K using Cessna 206 H aircraft. So now I will be talking about determination of

maximum rate of climb. The experimentation gets this little finishes of maximum rate of climb so for this experiment also will use the Cessna 206 H.

So I will write Cessna206 H right, so what is the task in this experiment like what we will do how will you find the maximum rate of climb so for that we know if you see the flight suppose now you're aircraft is flying at this level yeah and then you have to climb it certain height may be he started with H1 altitude now you have reached to edge tool tissue so if you see DH /DT that this time actually delta T or DT as on kelly H2-H1 / DT.

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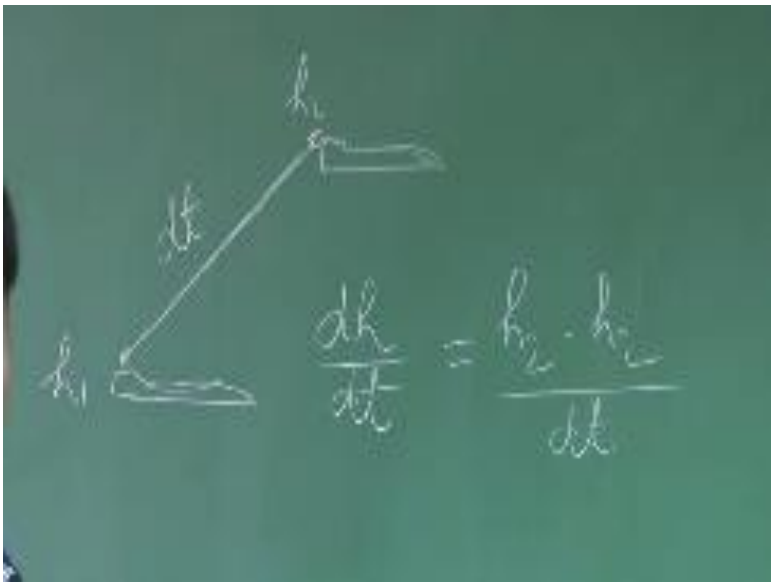

So this will give you the rate of climb right so and of course you have done some climb here at certain speed right. So this rate of climb will be for that particular speed right, so now you got this rate of climb at some speed actually at some velocity okay so now to get this maximum rate of climb it means we should try to achieve the climb at different, different speed so there you will get to know where is the maximum rate of climb or at what speed you can achieve the maximum rate of climb.

So how will you plan this experiment so I will explain to you now, so it means if you want to perform this experiment then from the table if you see then we should know about at what velocity we are going to fly and you are inside their craft with your pilot? So you will get to know at what altitude it is being flown right so H1, so you should know each one and then till what height you have to go so you have to blanch for different height so that will be H2 right.

So be you know V H1 H2 and then you should sit with the stopwatch or some like maybe you can use your watch to note down the time, so that will be your DT all right here so where you will get to know about the difference like how much time it is taking from H1 to H2 you will know and once you have H1 and H2 then calculate DH/DT that is essentially your rate of climb (R/C) right.

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Now so now you see in this table very simple experiment right so you have to note down the velocity, H1, H2 and the time then you can calculate DH/DT. So here I will show you one of the experiment so where you have velocity in not 95,100.105 and then 110. So initial altitude verge 500 feet and H2 was 1000 so 500 to 1000 all the experiment 500 right.

Right you see now like here it is flown at the different speeds but it was 500 to 1000 feet, so ΔH or DH is 500feet. So time taken for each verge just I will write the number numbers of course it is in taken so 37.89 seconds, here it is 42.27 seconds and 49.19 and 55.06 seconds and if you calculate corresponding R/C all right and you have to see a the unit right so or with the proper unit.

You can calculate DH/DT here so suppose if you have taken straight and then do you have noted this in S so it will become your feet per second right. So if you see your graph will look something like this yeah if you see here DH/DT vs velocity so it should appear something like this and now from the graph you can observe here at this feet maybe I should write restart you got maximum rate of climbing, so this will give you the maximum rate of climb for this velocity right.

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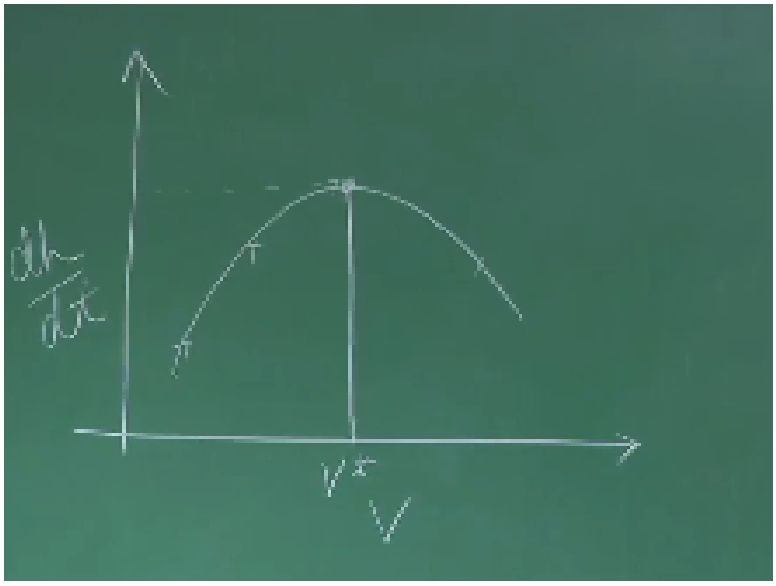

So and in the previous class already we have talked about how to find CD not NK, so from here you got rate of climb so one other way to validate your result can be like this so during this experiment you can also note down. I will use this space here or two more parameter RPM and MP. So with the help of RPM and manifold pressure you will get BHP right.

So we know rate of climb can be power available- power required / weight (Pa-Pr/W), so if you see here so for your power required will look something like this for this key and the HP is power available here it could be here like this so if you see that difference between these two.I should write power required here for our required so this excess power right. So if you calculate R/C so this excess power XS or S is a Texas power/ weight is our rate of climb.

So from here also you can see like where your excess average maximum for that you will get maximum rate of climb so now you can validate your result with this V again you write V star and this corresponding rate of climb but these two may not come same I will not come same because here the reading what you have taken or during the flight so this is basically your pressure altitude.

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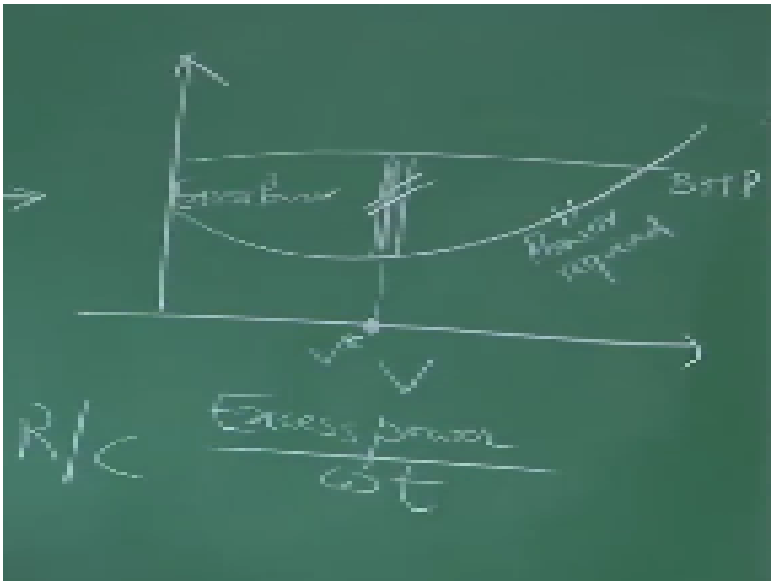

So you have not corrected it for the density so there will be some difference but you can have some corrective action on it so you will be able to get correct results so that is all for this experiment. Thank you.

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