Indian Institute of Technology Kanpur

Course Title

Introduction to Experiments in Flight

Lecture-01
Weighment and Calculation of CG

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Good morning friends, welcome back to this wonderful session as you recall we have completed courses on airplane performance, airplane stability and control and also some insights on stability augmentation system and as I told you all these things are preparations for running a course on aircraft design. But before we go for a new course on aircraft design, I thought let me take a short course 10 hours module which will give you exposure on introduction to experiments in flight, because you will appreciate whatever we do in classroom on blackboard or green board.

We need to know, in practice, can you validate this as is correct. What are the issues, when I try to do an experiment to validate whatever physical understanding we have got so it is important extremely important that we conduct some experiments to see how good we are in understanding are developing the laws of physics. And once I talk about experiments generally in our education system there has been a lacking viewing stress in experiments although last few years.

We are all conscious and we are giving deal with but it takes time it takes infrastructure it is not so simple especially, when you want to do something with aircraft with a huge infrastructure you can play in you need air strip unit licensed engineer so many things pilot, unfortunately I attic and put has that facility and most of the engineering colleges were running aerospace engineering they would be referred to get a slot on IT Kanpur to undergo this course.

But then, it is not possible to conduct these courses for all the colleges there is a man power limitation time limitation. And there is a cost involved that is why I thought when we attain last

module I will give a lecture on the introduction to experiment, that you know how to conduct the experiment, what experiments we conduct how to get the value out of it. Once you have prepared for that and if there are requests I can you cross the NPTEL to arrange a facility in terms of finance in terms of other sport.

So that you can come here a particular slot and jointly you can do this course on the experimental side, but this course is preliminary, meant for giving an understanding what are the experiments and how important are they, and how simply should be able to do it right. So let us come back to whatever we have learned so far we have learnt family some aspects of airplane,

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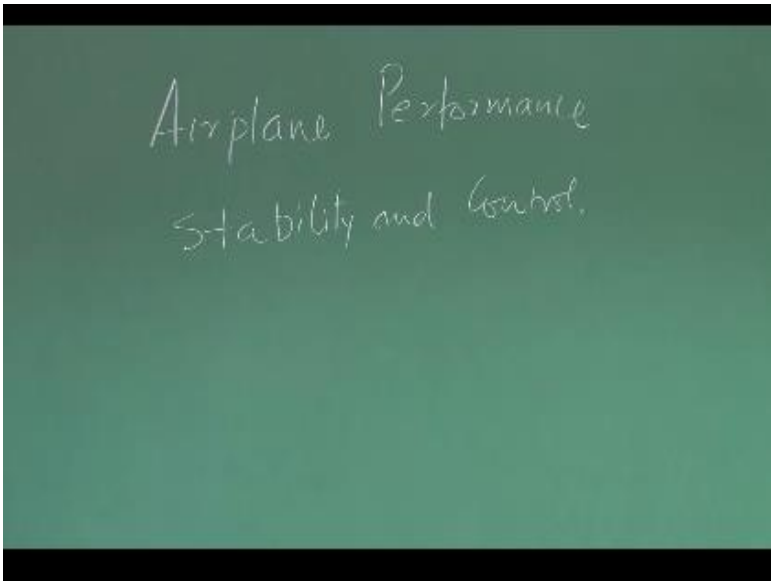

Performance, we have large drinks on stability and control and if you recall when you talk about the airplane performance, we were mostly focusing on cruise. And few many words of course you know client was integral part of your tools because once a month you want to go to an altitude we have to climb initially have to go for a takeoff then climb cruise and defend landing etc. And if I look at cruise, I know in cruise the trust equal to drag if you see here there are four forces that are responsible to define a cruise. Of course we are assuming that when I am talking about cruise I am assuming the aircraft is statically and dynamically stable right.

Now if I look for all these four forces if I order to experiment it as far as trust is concerned this is coming from engine. We are going to do some measurement, how much thrust or how much power engine is developing, that will be primarily governed by the environmental condition and also how they engine has been made. What is the thermal dynamics associated with the engine. Therefore you will find when you want to measure crust or power let me say power for power for a propeller IC in backup typically. Our aircraft there Cessna 206 finest etc, they are different measure what is the power being delivered.

We call it power available at any altitude this will be function of RPM, and manifold pressure, and of course. We will find outside air temperature also will decide I will PM you know manifold pressure loosely contain this is the pressure at which clearly a mixture is happening. And outside air temperature dogs are there ambient temperature. Once we know these things sometimes flying and I am through a dial gauge, rpm gauge I not done what is the RPM for a manifold pressure gauge. I know what the manifold pressure is, and I am measure the outside air temperature then to Indian chart, engine characteristics which is supplied by the manufacturer.

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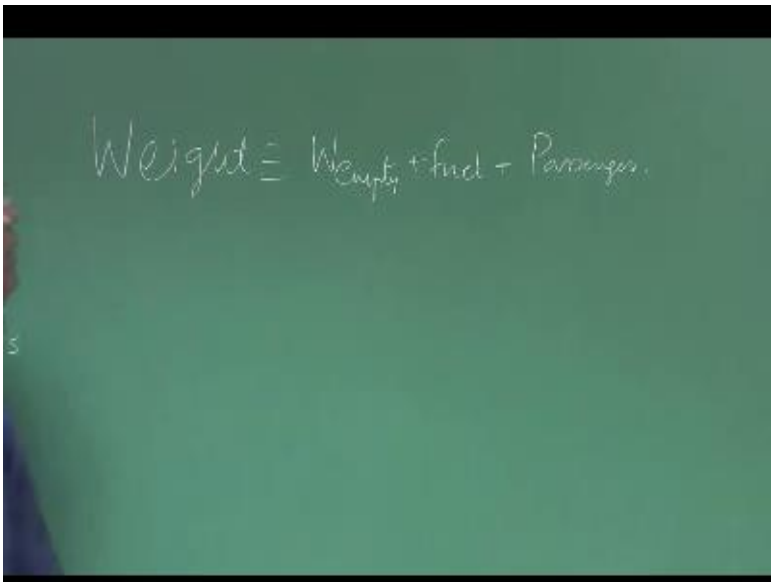

I can easily find out how much power under that condition, it was delivering right. So there is not a big deal but their trust is specifically for a jet engine, mostly all experiments are with a propeller driven, I see right so we talk more about power. Now as far as weight is concerned if I do not talk about weight, weight will be wet empty weight. Then well then passenger is the primary component, when they talk about work of the aircraft it is empty weight, fuel weight and the passenger weight.

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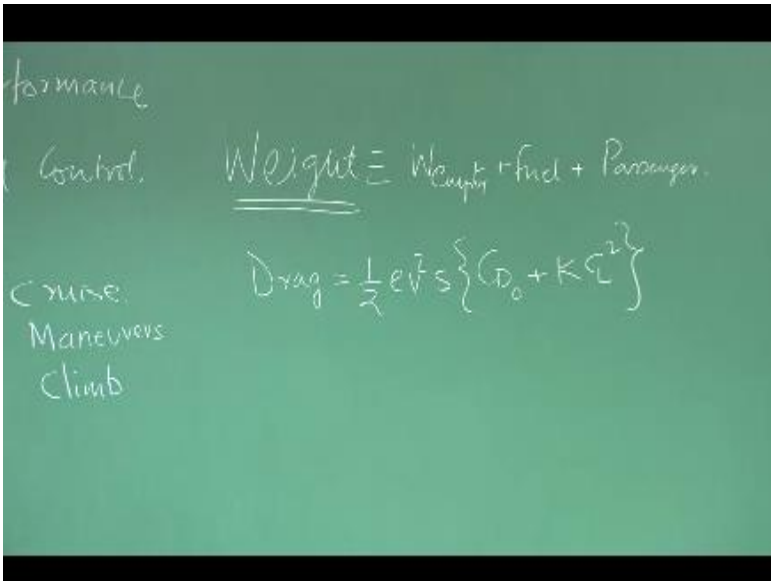

Why weight is important you could see here, after all when I am cruising at an altitude, the weight is more I need lift more right. Lift more mean either I achieve that lead by speed or angle of attack. So the performance will be largely governed by the weight of the airplane so if we wait measurement is not correct then your performance estimation will not be correct. So we need to know how to measure the weight, which is one, and then if we see this aerodynamic force drag and lift. For drag you know that, drag I can write as half Rho v square s CD not + K CL square right.

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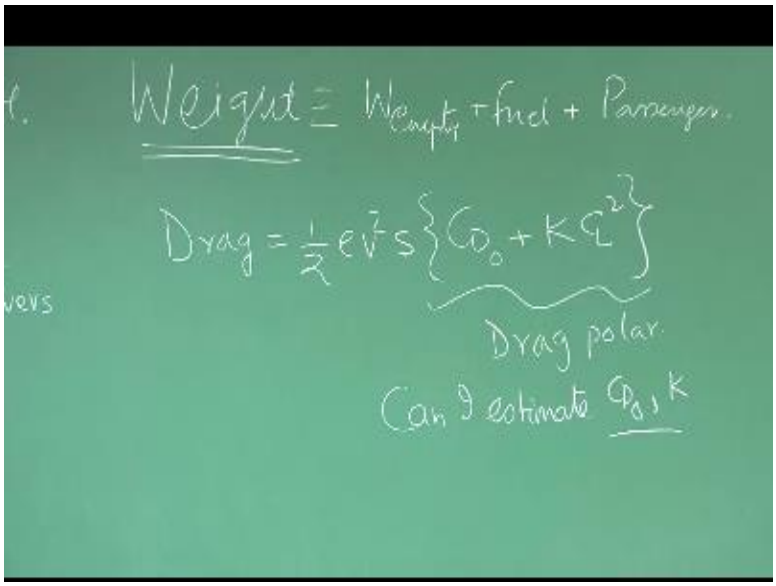

And you know also this, that CP 0 plus KC l square this is called drag polar. Referring to extract the drag polar of the airplane, through experiments, flight experiment what essentially means through experiment, can I, can I, estimate CP0t. And kill if I can estimate the D 0 and Kate through experiment that way. I am extracting the Dracula of the airplane because, I am assuming that this airplane will follow a parabolic type drag polar equations as very important right. So one experiment will be how do I estimate CD naught and key or Indian state or return.

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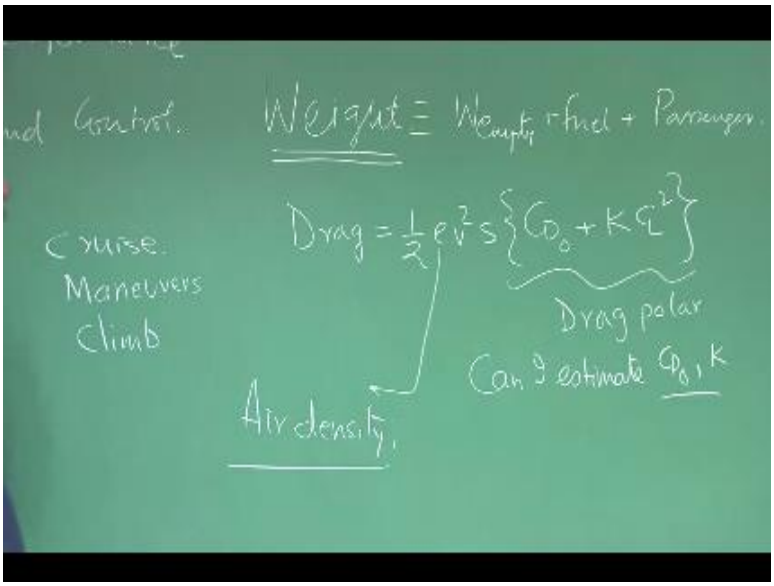

I can say how I can estimate drag polar of that airplane, so what are the things here in Dracula, if I want to CD0. And key if you see here half Rho v square is what Rho is, Rho is the air density. So if here delta T how will I estimator how to calculate this density of air, when is flying as a multitude. One important thing you know we will be following.

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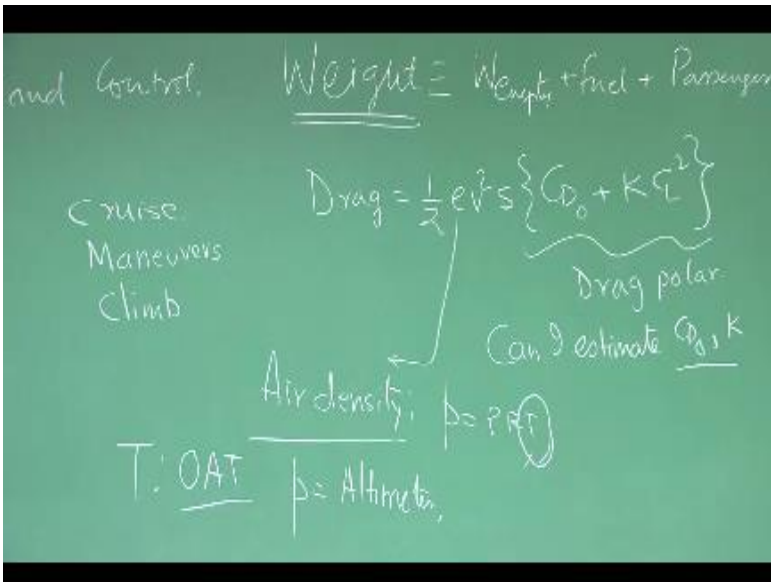

A gas law RT and the speed T, will measure using a outside air temperature indicator, right. This T will be taking help bock outside air temperature indicator which is in the cockpit. And whatever pressure, pressure you know this altimeter is based on the static pressure under standard atmosphere assumption. So from these two values, I will be able to get that density as Rho equal to 3 by Rt.

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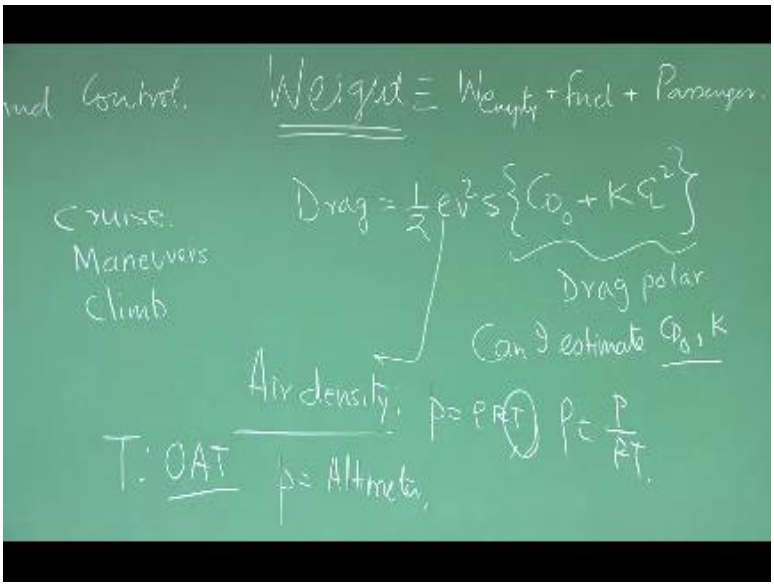

So I am just bitching this so, that you know what are the measurements required. So in a nutshell what you see here before we really do the analysis, or other are discussed the procedure. We know very well that I need to know how to measure the weight of the airplane, I need to know, how to measure outside and temperature, speed altitude. So that I can find out that Dracula okay, with this understanding. Let us first understand how to make sure the weight of an airplane.

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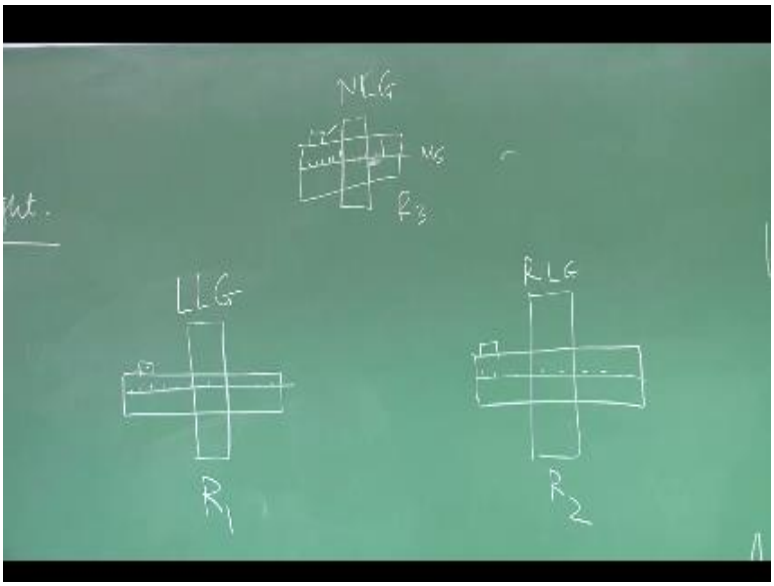

Which is extremely simple? We have three linear setup, I will be showing you a demo also, it is like, the main scale, of the one year and hit the finer scale. Similarly here, similarly here and what happens we drag the airplane and put the nose wheel on this balance left landing. Here all these balance and his left landing gear, and right landing here, on this button there is a nose landing area. The left landing gear, the right landing gear, and nose learning, so by using this value scale you can balance it and no doubt what is the reaction this r1 a reaction here r2.

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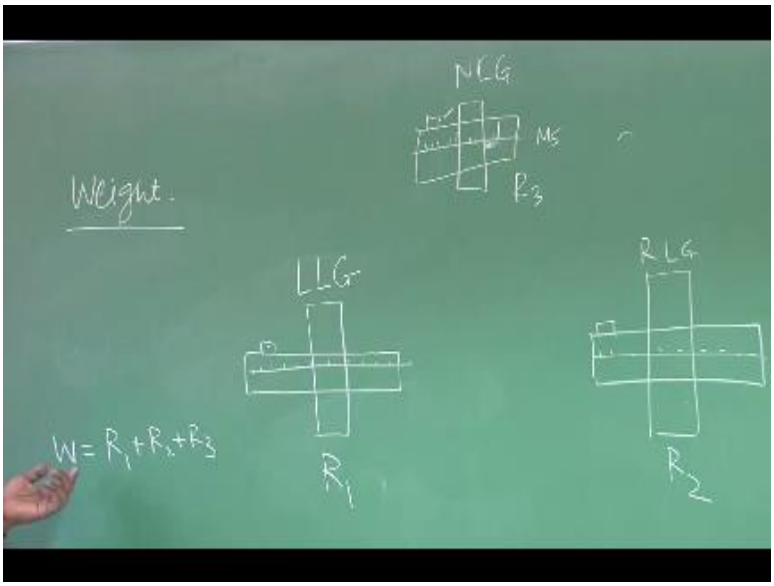

And reaction here r three okay so then what is the weight of the airplane and weight of the airplane will be r1 plus, r2 plus, r3 as simple as that. So when you are going for an experiment with let us say for students in the same flight. So all the four students should fit, inside the airplane, and whole airplane will be dragged so that is nose landing gear left landing yet a night landing error or on the balances. Using the linear scale we measure r one, or two, or three. I simply find the total, and you say this is the, we take off okay.

This is the blue take off, but now the question comes now from here, after the measurement. We take it to at runway do the warm-up, and go for a take off and you climb, climb, climb and then go for a cruise So when I am cruising that then the weight is not same weight what I have taken a double take off but for cruise experiment. I need the weight when it is cruising, at which it is cruising. So what do we do we can a stopwatch, carry a stop watch right, and start taking the time from here till it goes to the cruise altitude. And let us say that time is P, and you know what is the fuel consumption of the airplane fuel consumption, next to that is m dot.

So you simply giving calculation to multiply m dot into T so that much fuel has been consumed so whatever w take off we have measured, u- m dot into T. So that becomes your w cruise, for

which with which you an experiment. But yes somebody may our star during crews also house where he is being consumed. So this will not be exactly correct so for that what we do also starting the crews here, and ending here you against dick.

Take that time and take the average value another approach is you go for W take off come land take the weight again and take the average weight. So this things are within our jurisdiction, and we should be aware how much error we are going to commit in this whole process okay. Now so once we know wait you will generally you will ask a question serve the CD is also important when you will be doing the stability experiment there for stability it is not the way it is the location of center of gravity.

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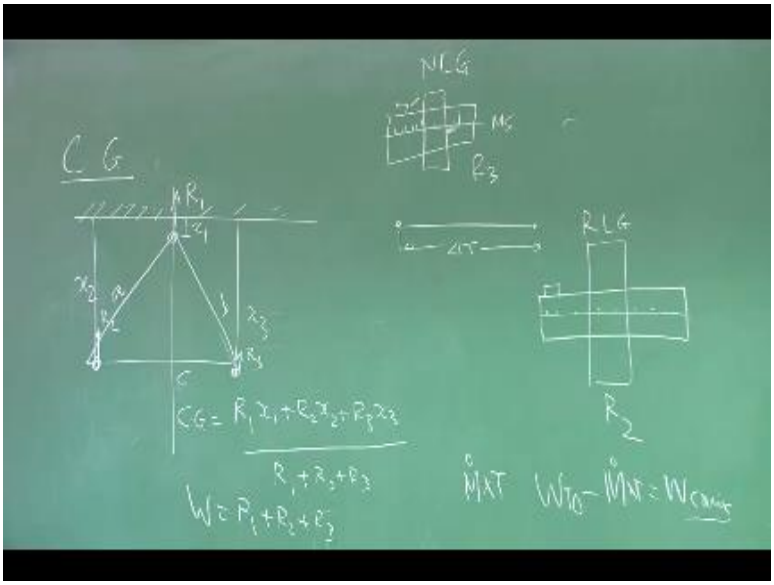

We service the neutral point is important, as we know for astatically and dynamically stable airplane the neutral. One should be behind center of gravity of the airplane at least minimum this right strictly to the static stability condition. So let us how to find cg some of this is your R 1and this landing gear it is r 2 and this landing here it is three, it is very simple. you take any reference line, and you know always the distance e the distance V as resistance3.

This is a distance you get from the aircraft manual, that the separation between the all the nose and left right landing gear. If I know this if it is reference if I know are one or two or three I can easily find out center of gravity along the x axis as if this is your X 1 if this is your X 2 and this distance is X 3 then you know central gravity will be R 1 X 1 plus r 2 X 2left r 3 X 3 by r1 plus r2 plus r3 as simple as that.

So to find the weight and center of gravity what is the procedure take the airplane to the balance note down the reactions are, one or, two or, three total it up to get the weight. So weight will be on one not two not three, and if you have to find center of gravity. I will simply use this equation as simple as, so that is the first experiment we will be doing the moment of their job. It is extremely important that is why we always talk with this procedure how to find the weight of Air okay now, now we are coming to the crews experiment we call it crews experiment let us see what is the meaning of that and how do you do that.

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