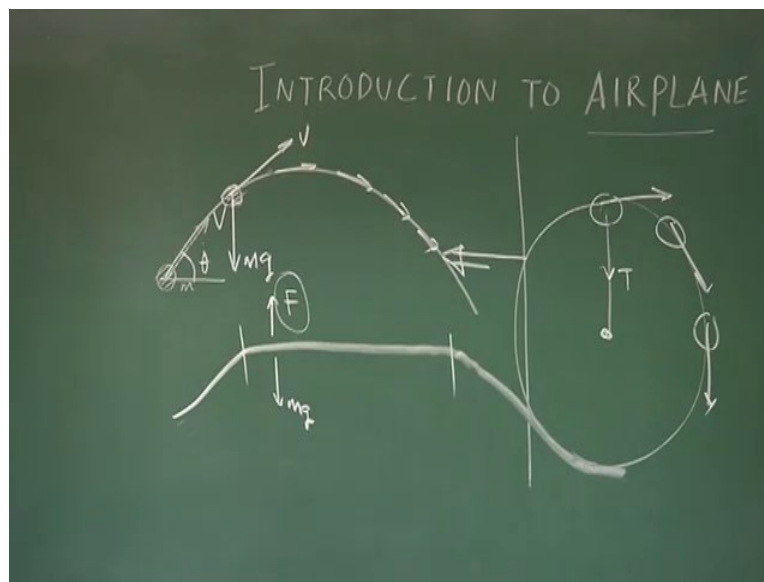


**NOC: Introduction to Airplane Performance**  
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**Lecture - 01**  
**General Introduction: Airplane Performance Characteristics**

Welcome students, as you understand the title is Introduction to Airplane Performance.

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And before I start this course, I try to share what I have learnt, let me tell you a story. I was staying in Delhi during my childhood in a place called Humayunpur which is very close to the airport. And every morning I have to see airplane flying over my house and at the best, I could think, I could wish was, can I get a chance to board this airplane. Can I get a chance to travel using this aircraft? It was a very difficult wish, because so far till that time I have seen film actor, actresses they are moving in airplane, rich industrialist moving in airplane.

So, the almost like, you will get never a chance to board an airplane, but the destiny has something else to say. One fine morning I joined IIT Kanpur in 77 in Aerospace Department and I thought, I have got a golden chance to board an airplane and it was in 78, first time I could sit in an airplane and that airplane is still with us in our hanger which is flight laboratory at IIT, Kanpur and that

aircraft was Cessna 182. We will show you that airplane, but let me tell you honestly all those excitements were not there.

This airplane did not have airhostess, did not have a steward, did not have all those luxury which use to see in a movie. More over it was a course flying that is we have to, we are supposed to do an experiment. So, the pressure was on doing experiment, the fun part was missing and after that I joined Defense Research and Development Organization, where no were aircraft was seen, where I was working. It was missiles, it was rocket artillery rockets, aircraft bomb, so I was too far away from aircraft and I was sure that my desire to be near aircraft was almost vanishing.

Again as destiny has to have plays its role, one fine morning I found I have become faculty in an IIT Kanpur and I was the faculty in charge of this hanger, which is flight laboratory and we have 4, 5 aircrafts surrounding me. And for the first time I realize after doing B. Tech, M. Tech and Phd, I hardly understand the aircraft. I nothing surprising that is common thing happen with most of the Aeronautical Engineer who are getting degree. So first lesson which I learnt as a student, as a teacher are you must see an aircraft closely and try to appreciate, what has gone into an aircraft in terms of systems, in terms of components, in terms of instruments.

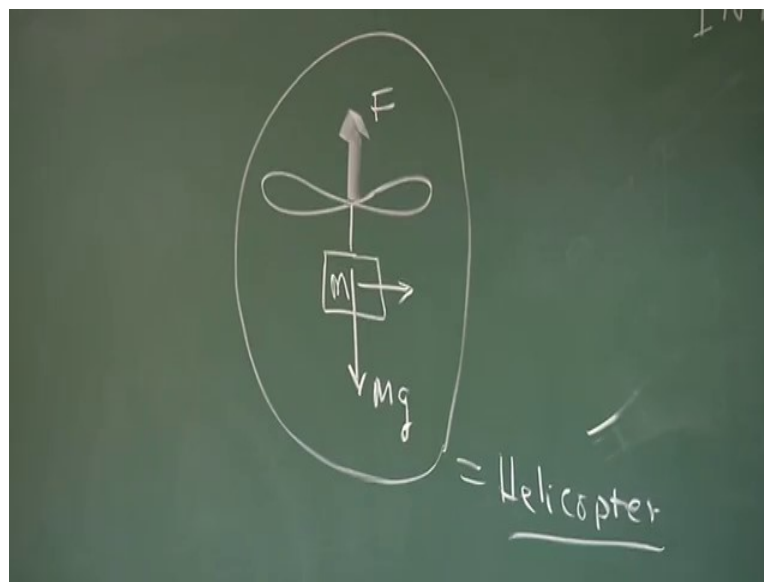
So, we will have one demonstration to you, where we will be showing you all the, the aircraft with all the parts, explain you why they are required. But, before going to that, I come back again to this topic Introduction to Airplane Performance and I will underline two words, one is airplane another is performance. Let us go back to the fundamentals, what whatever we have learnt at the class 11th or 12th. If you recall, if there is a body of mass  $m$  and if I eject it with a velocity  $V$  at an angle  $\theta$ , I know that this is typically an example of a projectile in motion and I will be, smartly you can draw this path and we say the projectile or the mass will follow this path and this is typically a projectile motion.

What actually happens here? As I launch this body, there is a gravity which is  $mg$  which tries to pull this body and this body has a velocity  $V$ . What is the effect of this force on this velocity? Let us again go back an example, it is a very popular example. When I move a stone using a string, you see that this body will move in this direction. What is happening? The velocity vector, this velocity direction is changed and who changes the direction, the tension in the string.

So, now, if I again come back, there is the velocity vector and there is a force, gravity force pulling this body down. So, you expect as happened here, the velocity vector changing direction, at some point it will hit the ground, right? But, if I want to design an airplane, I do not want this scenario. What do I want? I want, it should go something like this, sustain for some time and come down, this typically, I will look for such a motion of the body. If I want to do like this, what should I have? Whatever gravity force is trying to pull this velocity vector, I need another force which should counter this velocity or counter this gravity force, right.

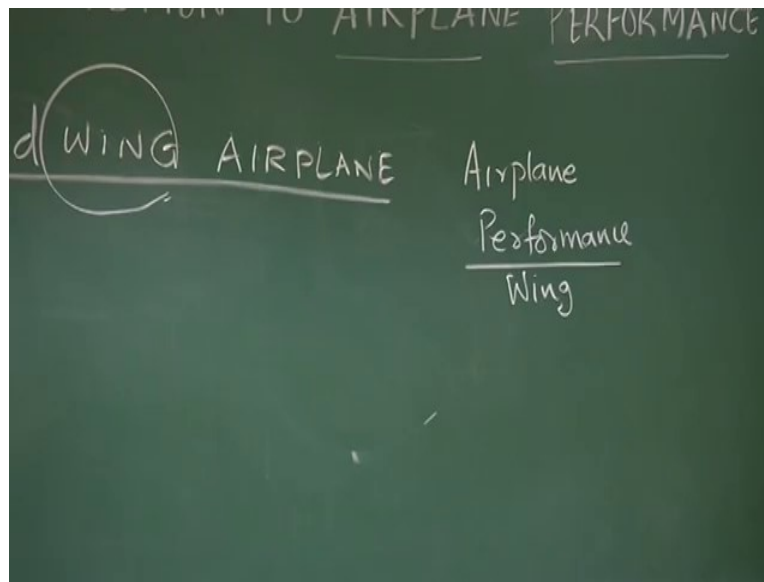
Somehow, I have to generate this force, if I could generate this force comparable to this force, then turning of this velocity vector will be minimal. And if I balance it, then there would not be any turning, it will go straight right, with this idea to generate a force, so that I can move a longer distance.

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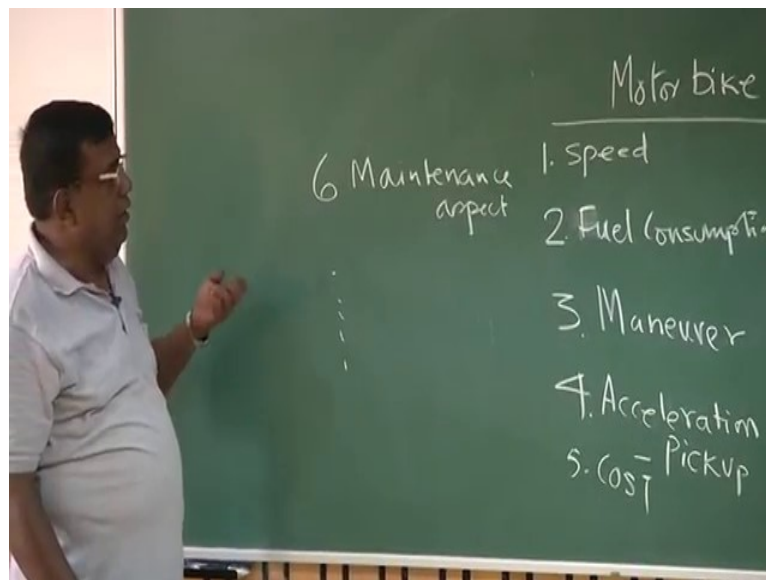
Initially a concept came which is the body, I put some blade here, some propeller and that propeller will generate force ( $F$ ) and this should be able to compensate the gravitational force or force of gravity ( $mg$ ) acting on the body of mass  $m$ . This is typically the concept behind, what. This is a concept behind designing of helicopter ok. But, most of the part when you talk about airplane performance we will not be talking about helicopter, we will be talking about fixed wing airplane.

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We will be talking about fixed wing airplane. We have now introduce another new term, wing. So, we have got three terms, one is airplane, another is performance and third one is wing. Let us first see, what do you understand by the term performance.

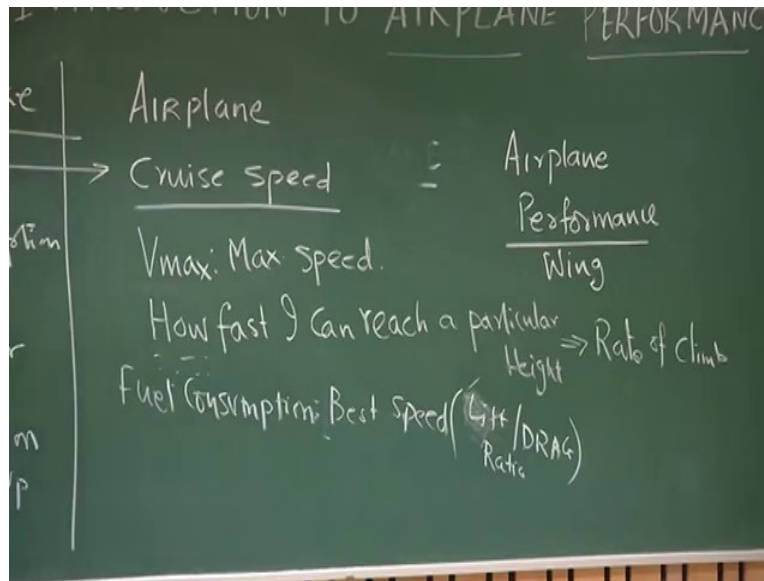
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Let us think, suppose you want to buy a motor bike. If I want to list out the performance of a motor bike, what we should look for. Number 1, it's speed, second it's mileage or we say fuel

consumption, third one maneuver, fourth a young man will like the word pick up. How fast it can speed up and of course, most importantly cost and if I add few more, I would like to see this maintenance aspect. There could be many, many other performance parameter a young man will try to look for.

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If I now translate this into airplane, how do I translate this requirement, performance requirement of speed for an airplane? For a motor bike, we will be telling what is that speed at which the I get the maximum mileage that is the fuel consumption is minimum. I can also ask myself, what is the maximum speed I can run this machine, drive this motor bike. Similarly, for an airplane I will have a similar question which I called cruise speed that is, what is the speed at which I can efficiently cruise from one point to another point in air?

We will explain you, what is the meaning of cruise, we can also think of  $V_{max}$  ( $V_{max}$ ) that is, what is the maximum speed. Then, for an airplane I can also say how fast I can reach a particular height, loosely I will be calling it as rate of climb. There will be many such questions will come to our mind as we evolve this course. When coming to fuel consumption for an air craft, for fuel consumption, think of a motor cycle or a car. If you want to have a best fuel consumption or then there is a speed, a define speed, at that speed if you drive your machine you get the best fuel consumption or the minimum fuel consumption.

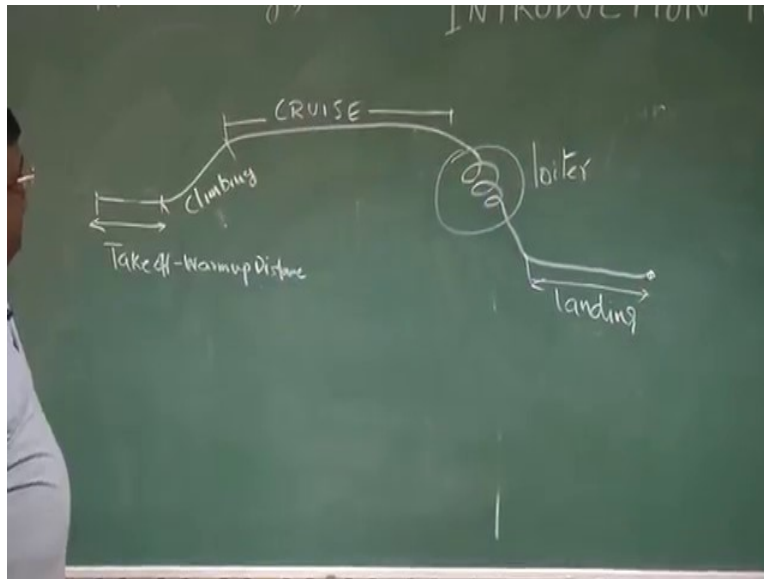
Similarly, for an aircraft, from a fuel consumption point of view you have best speed, loosely we will see we will talk about some ratio called lift to drag ratio. Meaning there by, if I really want that my fuel consumption should be low, I need to fly at a particular speed which will correspond to the one of the typical lift to drag ratio, which will be discussing as we progress. As for maneuverity concern, for a motorcycle maneuver you mean, you are going straight like this bank, the motorcycle take a sharp turn, like a young man or a young lady will do.

For an airplane, the maneuver typically you mean I am going like this, now I have to take a turn, I bank the airplane and take a turn, I can go to the pull up, I can roll, all such things I should be able to do and there should be pre specified right. And this acceleration, pick up all are linked to this maneuver. Finally, it comes to the cost, cost is a deciding factor depending upon how much you can sell out and how efficiently you can sell it out, how efficiently you can use your money for a particular mission requirement.

Because, do not forget, motorcycle you can drive in any type of road conditions. For an airplane, depending upon it is way, depending upon type of airplane, you need additional thing called takeoff distance. Takeoff or landing, airstrip that is you need to have, for takeoff your landing you need to have a airstrip dedicated. Made for the airplane, you need sufficient length, it need sufficient length of the airstrip for takeoff and also for landing also you need sufficient length.

You may have a big airplane or you may not have an airstrip, so for you that airplane is of no use, because you cannot take it off or you cannot land right. So, whenever we are talking about performance, we will be actually talking about these things in a systematic manner. What are those things? Let us see.

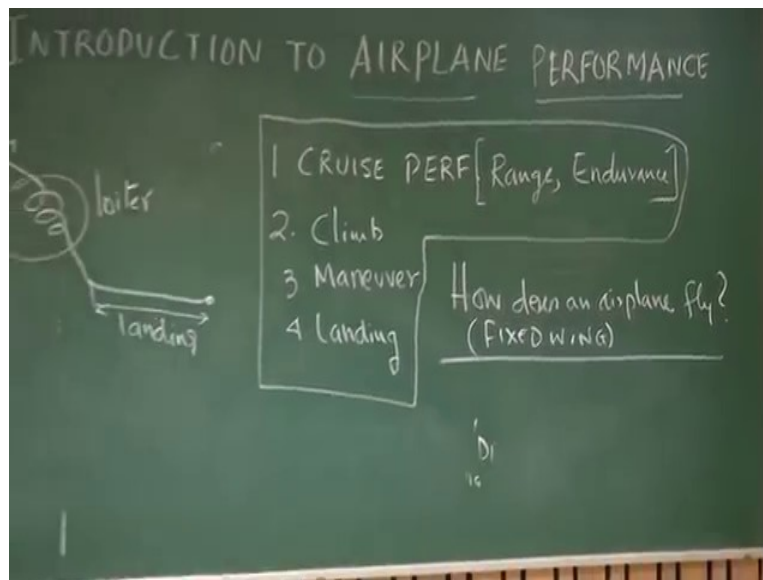
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Let me draw this, let's say the aircraft is here, from here to here we have... We will be talking about takeoff and warm up distance, that is I will be switching on the engine, I'll be doing taxiing then I'll, will have start increasing a speed. After a certain speed I will start climbing, I go like this, I roll the plane, start climbing. So, this phase is basically climbing and this is where we are talking about cruise. This is where, suppose I am over an airport and there is no space on the air strip.

So, what do I do? So, I need to loiter, I need to stay in particular altitude, a loiter till air traffic controller give a permission to land and then, I land and need minimum distance, so that once I apply the break, the aircraft comes to a stop.

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So, in performance also first thing we will be doing the cruise performance, second will be climb, third maneuver, fourth landing. In cruise performance, we will be also talking about range, then endurance, loosely what do you mean by this. Range is, given a tank of fuel, how long I can fly in air right. Endurance, how long means in terms of distance and endurance is for how long in terms of time. For a given tank of fuel, I can fly, I can be airborne.

Climb, you know that for a particular height how much time I need to climb that altitude, what is the best speed at which I should climb. Maneuver, what sort of turn rates, what sort of pull up I can do. Landings, what is the landing distance, I need to have, to land the aircraft safely. So, in my lecture we will go along with, these are the guidelines. But, before we take up these things in detail, we will first go into simple concept, how does an airplane fly.

Airplane means fixed wing, talking about fixed wing. One word of caution to you that, we should not try to see how a bird fly. It is not you are going to relate how a bird fly to, how does an airplane fly, a fixed wing airplane fly ok.