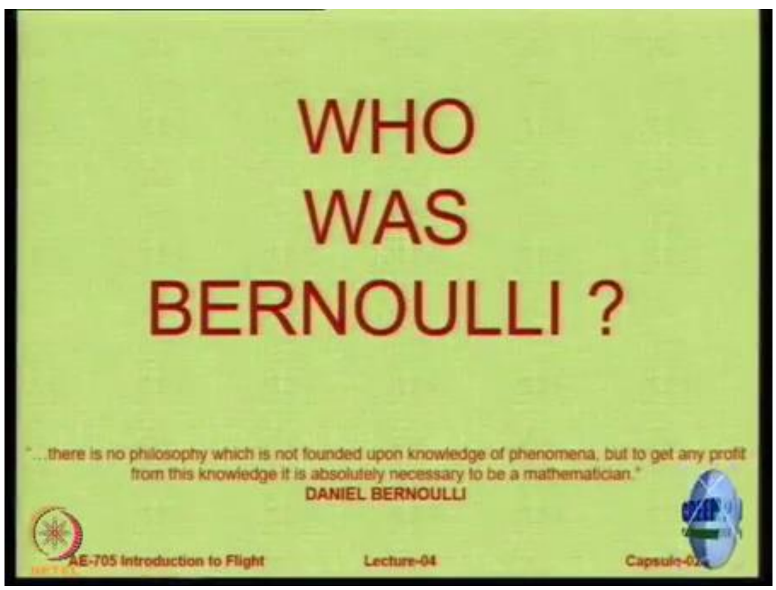
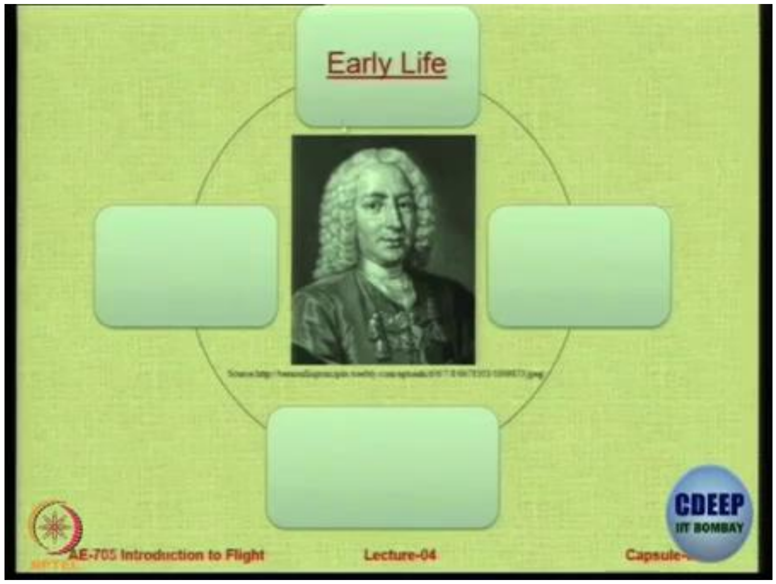
Introduction to Flight
Professor Rajkumar S. Pant
Department of Aerospace Engineering
Indian Institute of Technology Bombay
Lecture No. 03.3
Bernoulli's Equation and Coanda Effect

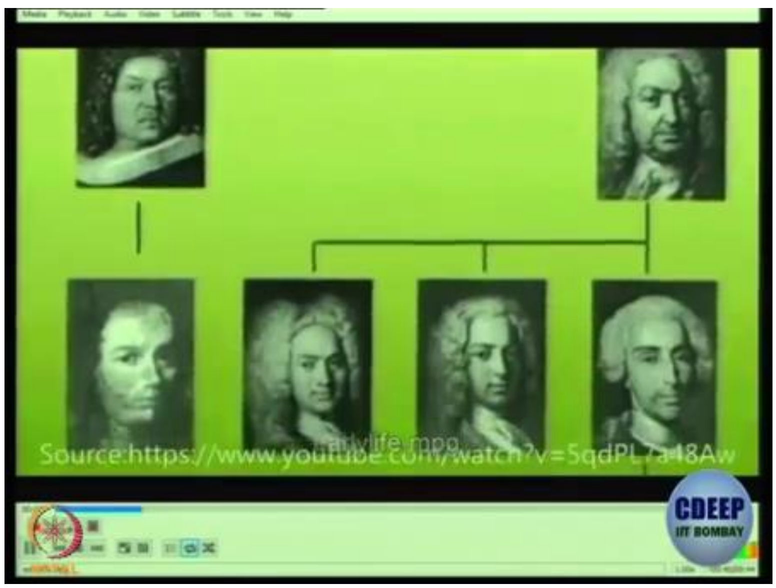
This is the second lecture of the first part of introduction to fluid mechanics and today we are going to look at three giants of fluid mechanics. So, this presentation is mainly going to be looking at some historical aspects after which we try to explain the basic principles behind the work of these three fluid mechanics specialists, okay. So, first let us look at the Bernoulli's theorem and we want to pay tribute to Daniel Bernoulli. So first question is, we should try to understand who was Bernoulli?

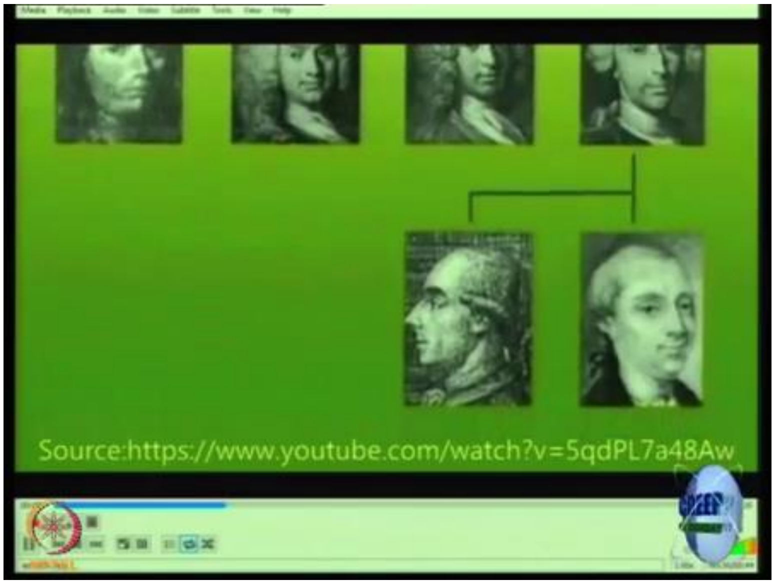
(Refer Slide Time: 0:57)



As you will see very soon there are many Bernoullis, not just one. It is a big family of scientist, okay. So, we all are talking about a specifical Bernoulli. So today we are going to look at Bernoulli's background, history and that will help us understand why he was the way he was? First let us look at some ideas from his early life.


Early Life
AE-705 Introduction to Flight
Lecture-04
CDEEP
IIT BOMBAY


Source:https://www.youtube.com/watch?v=5qdPL7a48Aw
CDEEP
IIT BOMBAY


Source:https://www.youtube.com/watch?v=5qdPL7a48Aw


Source:https://www.youtube.com/w
CDEEP
IIT BOMBAY

Video: The Bernoullis were a celebrated family of scholars from Barcelona.

Professor: It is not just one. As I said there are many families.

Video: From 3 generations it produced 8 outstanding mathematicians. Daniel Bernoulli was one of them. He was born in 1700 in Deutsch city of Groningen where his father Johann taught Mathematics.

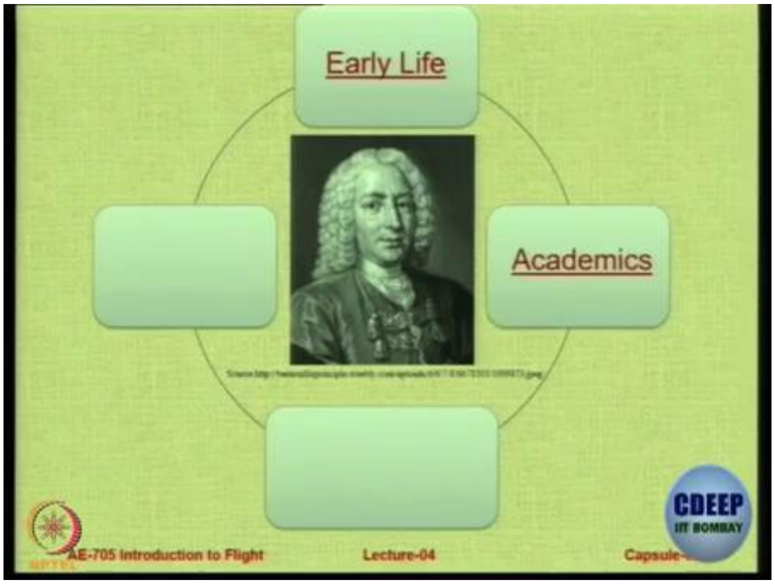
Professor: Can we increase the volume?

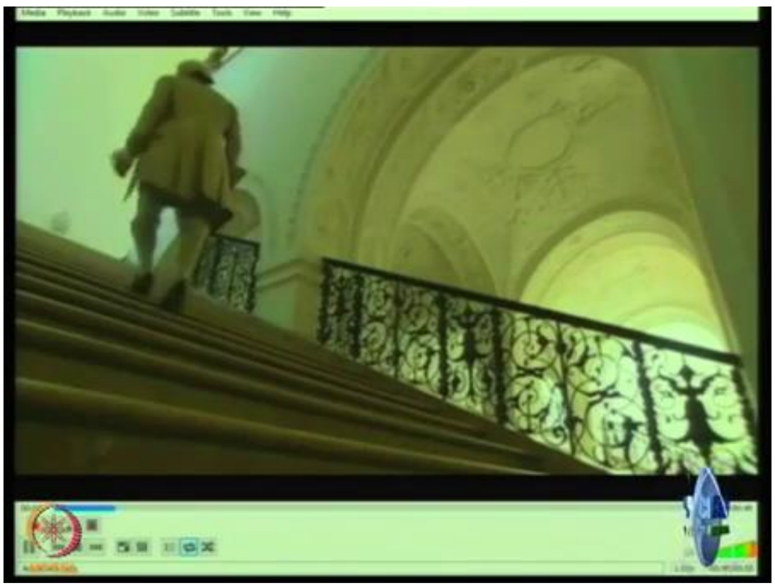
Video: From an early age Daniel received lessons in mathematics from his father.

Professor: So, He is working on the abacus.

Video: And it soon became apparent that he had the Bernoulli talent for the subject. But his father wanted the most gifted of his 3 sons to go into business.

(Refer Slide Time: 2:17)





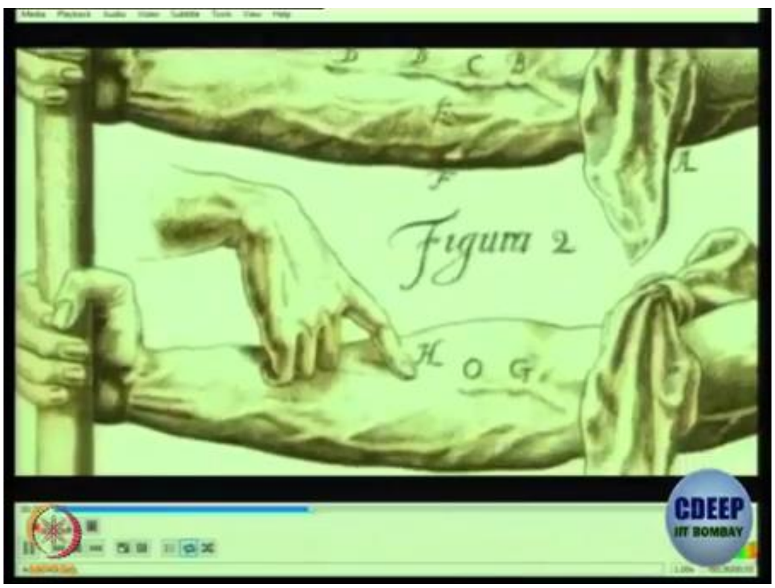


Figura 2
H O G
CDEEP
IIT BOMBAY

Professor: So very typical thing you know, even today parents impose what they think is good for their children on them. So, here we have a young Bernoulli who is accomplished mathematician ahead of his times but his father wants him to do business. So, it is an old story but it is still going on.

Video: In the end, Daniel was allowed to go to university, his father agreed to let him study, but not mathematics.

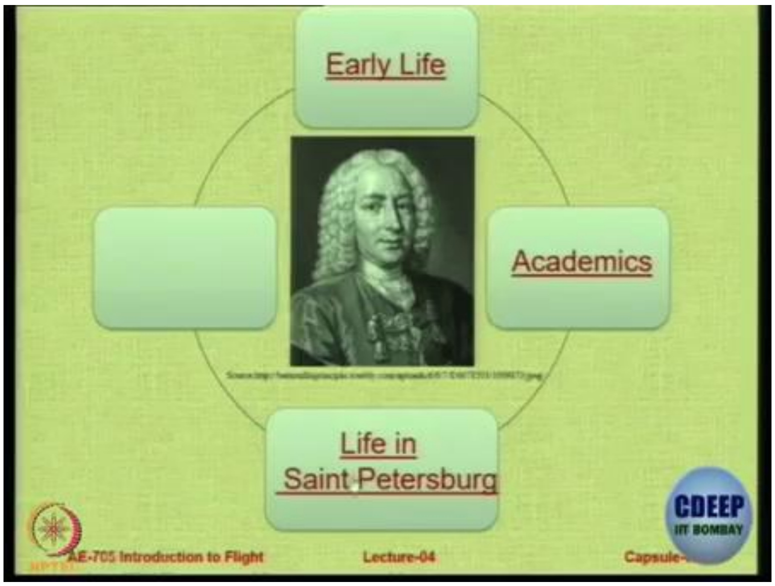
Professor: But, there is a catch. Not maths.

Video: At fifteen, Daniel Bernoulli started to study medicine first in Basel, later in Heidelberg. The young student's interest was particularly aroused by a work by the english physician William Harvey on the motion of the heart and blood. In it, Harvey described for the first time, how blood circulates in the body. And Daniel developed a special interest in the way in which fluids in motion behave.

Professor: You will see very soon his experiment with his own blood in Bernoulli's Theorem

Video: At the end of his Studies in 1721 he returned to Basel until it Doctorate on related subject 'The mechanics of breathing'.

(Refer Slide Time: 3:22)

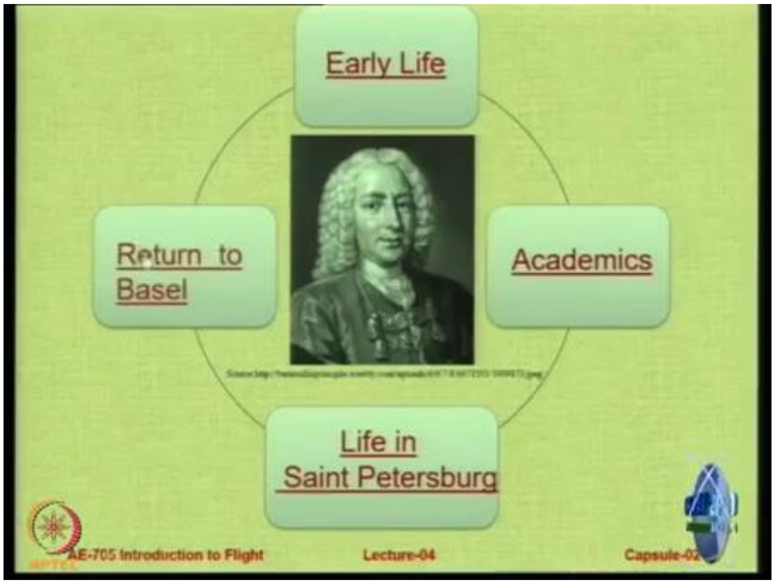


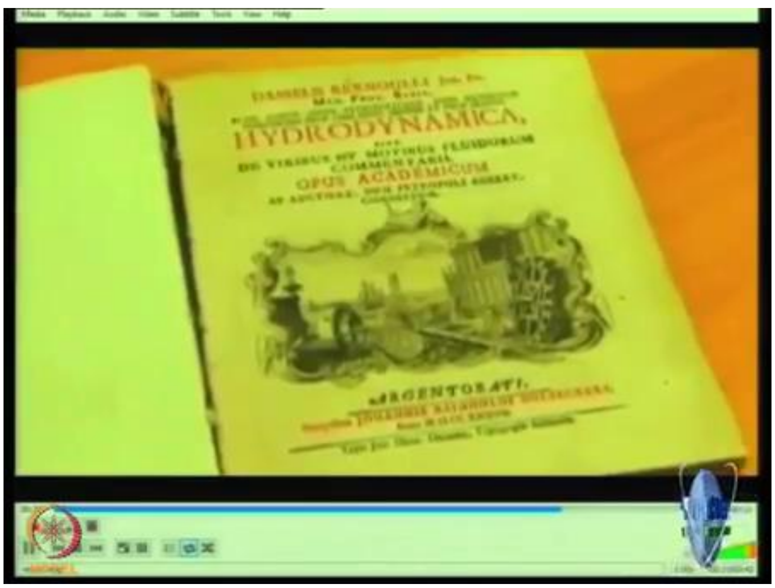

CDEEP
IIT BOMBAY

Professor: Mechanics of breathing that was his PhD topic, okay. Alright now, after that he went to Saint Petersburg,

Video: He received a letter from Empress Catherine the Great offering him the chair of mathematics at the newly established academy of sciences in Saint Petersburg. One thing the Empress wanted Bernoulli to do was apply his special expertise to the construction of cascades and fountains for the Peterhof palace. At that time dramatic water features were all the rage, it will cost throughout Europe. Arriving at Saint Petersburg in 1725, Bernoulli designed terrace basins based on his early experiments with water pressure and flow rates.

(Refer Slide Time: 4:12)





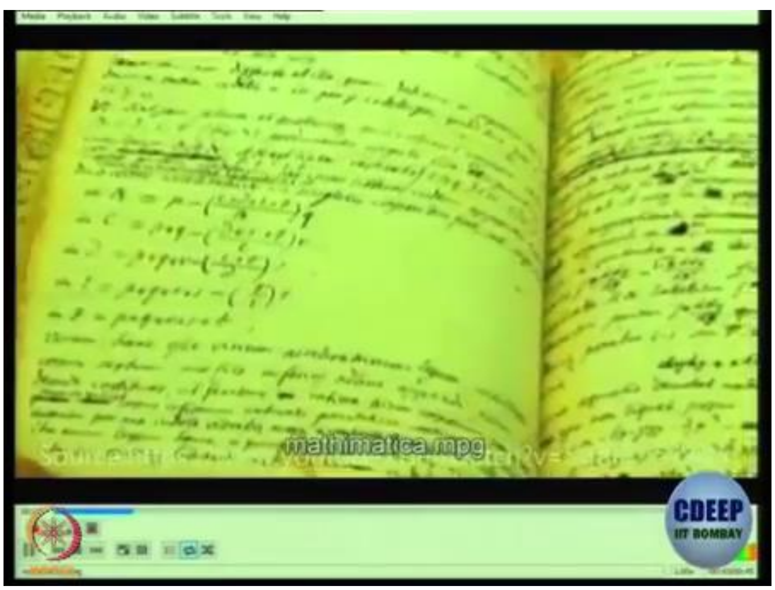
Professor: You can see he used his knowledge of physics to design waterfalls and then finally he returns to Basel.

Video: Bernoulli received a message from Basel university offering him chair of anatomy and botany. In 1734, when Daniel submitted an entry for the grand prize of the Paris academy of Science, he found himself competing against the work by his father Johann. The two were declared joint winners and Johann Bernoulli was furious that his son should be rated as his equal. He broke of all contact with Daniel. In 1738, 5 years after it is completion his work hydrodynamic was published in Strasbourg. In an attempt to apiece his revered father, Daniel described himself on the frontispiece as the son of Johann.

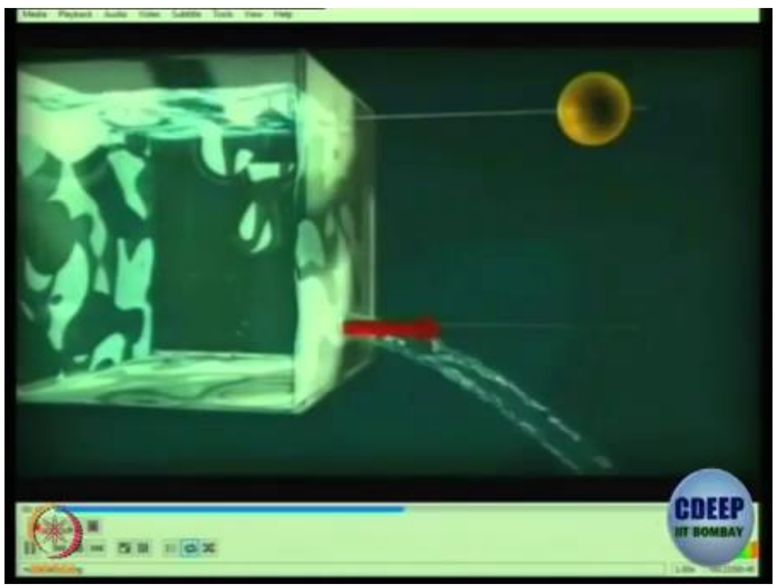
Professor: Okay, so this is a father-son rivalry. Interesting thing is, here is a person who is offered a chair of mathematics and then a chair of anatomy by another university. And here is Bernoulli family and this is our Bernoulli, Daniel Bernoulli, whose theorem we will have a look at today, okay He lived for about 82 years.

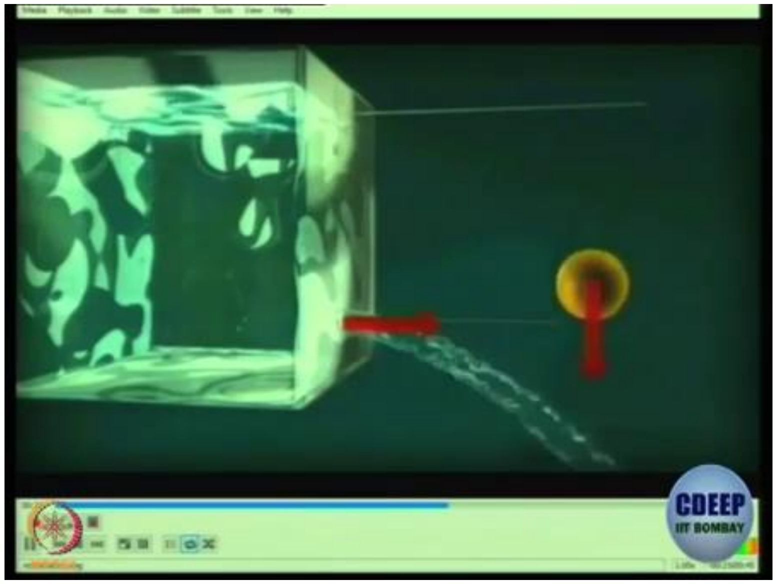
And there are many interesting documents that he has published.

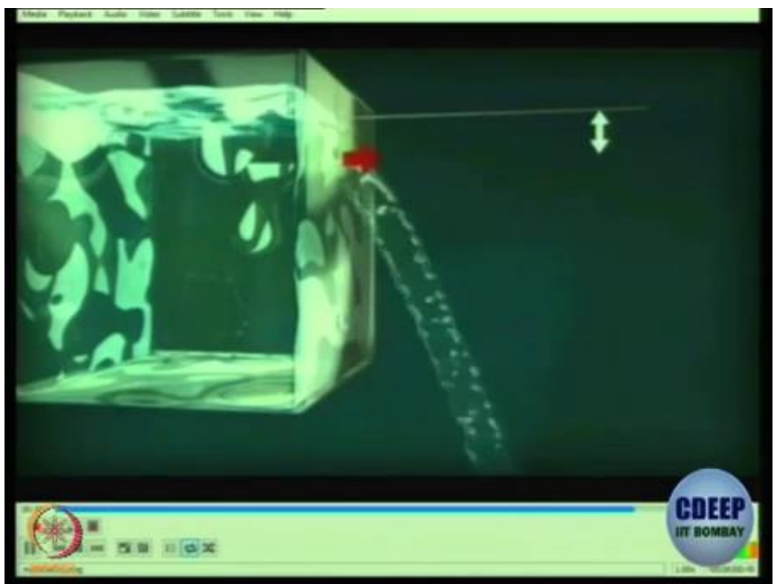
(Refer Slide Time: 5:36)

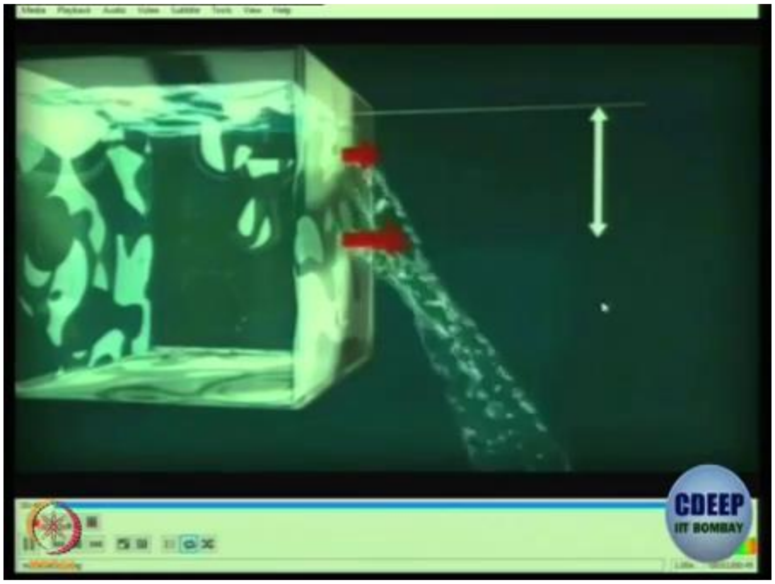



CDEEP
IIT BOMBAY


CDEEP
IIT BOMBAY

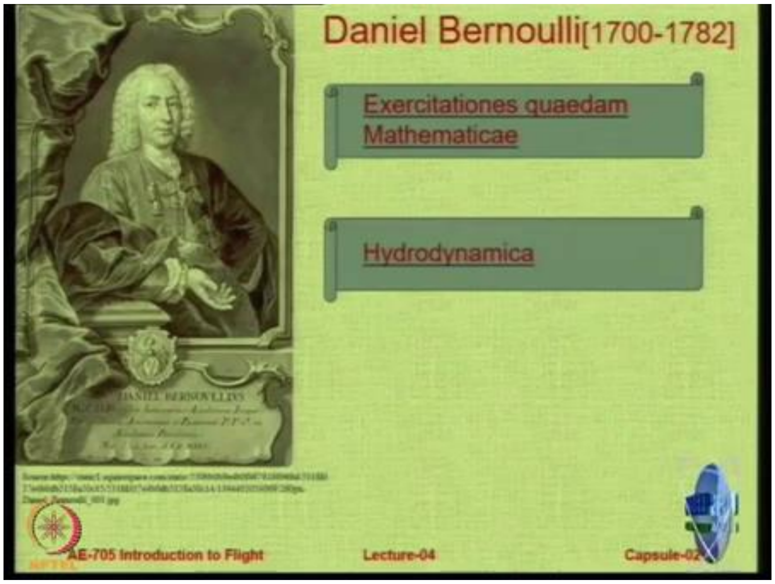

CDEEP
IIT BOMBAY


CDEEP
IIT BOMBAY



Video: These mathematical exercises included a study of the velocity of flowing water. Bernoulli analyzed the behavior of water flowing from a hole in a container. He noticed that the speed of the outflowing liquid depends on the height of the water column. It corresponds to the velocity of an object falling freely from same height, so it also has the same energy. In the case of water, pressure is converted into kinetic energy, the less the difference in height, the lower the pressure. The greater the difference in height, the greater the pressure and flow rate.

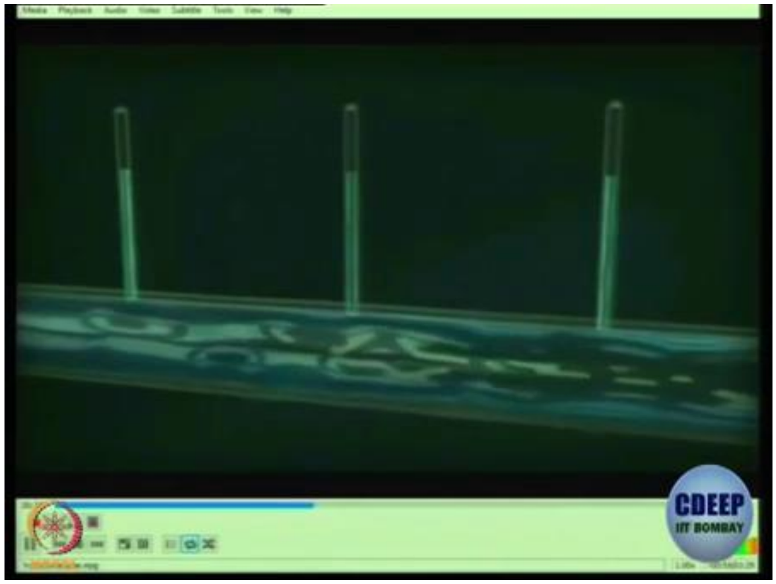
(Refer Slide Time: 6:31)

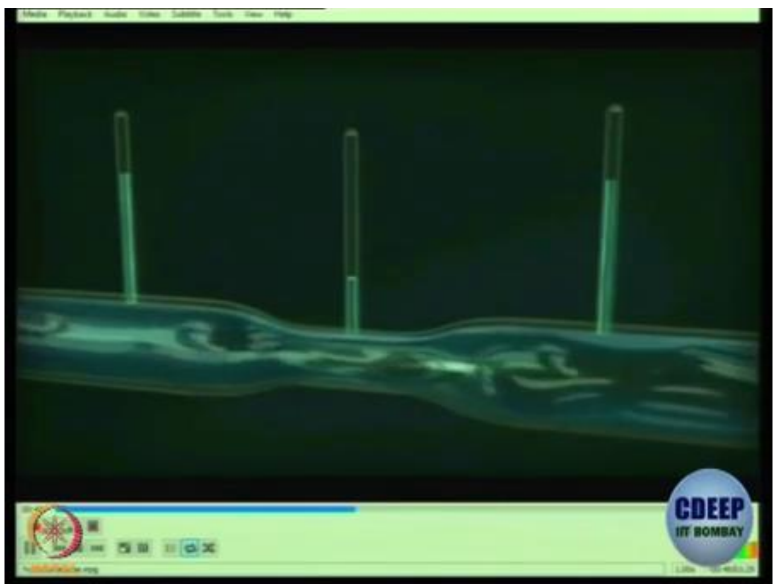


Professor: So these are his basic observations and then he wrote his most celebrated work.


hydrodynamicae.mpg
Source:https://www.youtube.com/watch?v=5qdPL7a48Aw
CDEEP
IIT BOMBAY


CDEEP
IIT BOMBAY


CDEEP
IIT BOMBAY


CDEEP
IIT BOMBAY


CDEEP
IIT BOMBAY


CDEEP
IIT BOMBAY

Video: First he experimented with pipes of different diameters and found the flow rate increased where cross sections narrowed. Bernoulli found the explanation for this in the continuity principle, which states that the volume of water that flows through a pipe in a given time is the same at every point, flow rates at narrower points have to increase to enable the same volume of liquid to be transported.

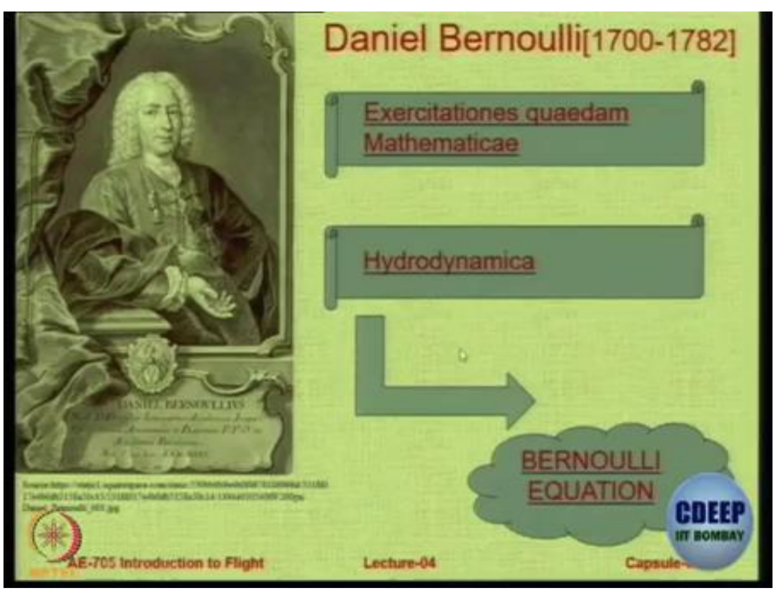
Professor: You can see the pressure is rising at the place where there is a nozzle and velocity is large.

Video: According to the lower consolation of energy, this acceleration requires a force which needs to come from somewhere, that is, it causes a reduction in energy somewhere else. Daniel then studied pressure in fluids in motion. And what he found, was the pressure rises as velocity declines and increasing flow rate results in a decreasing pressure. Bernoulli, thus found a connection between flow rate and the internal pressure of the fluid. His equation which sets the two in relation to one another, describes the law of conservation of energy for fluid in motion.

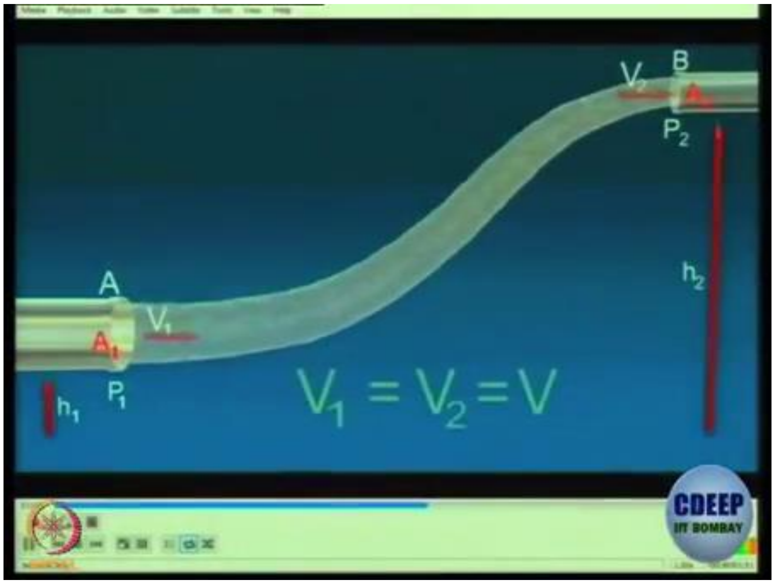
Professor: So, now he uses his knowledge of medicine to check the pressure of his own blood vessels.

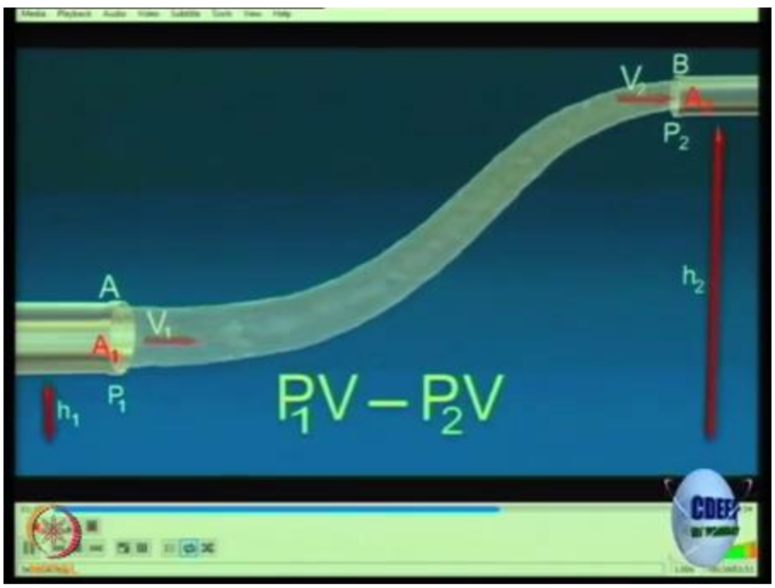
Video: As a doctor, Bernoulli also found an immediate application for his findings. He used them to study blood pressure. Here, he experimented with fine open ended glass tubes, which he pricked straight into arteries. He found his experiments with water confirmed, slow flowing blood is under high pressure, fast flowing blood under low pressure.

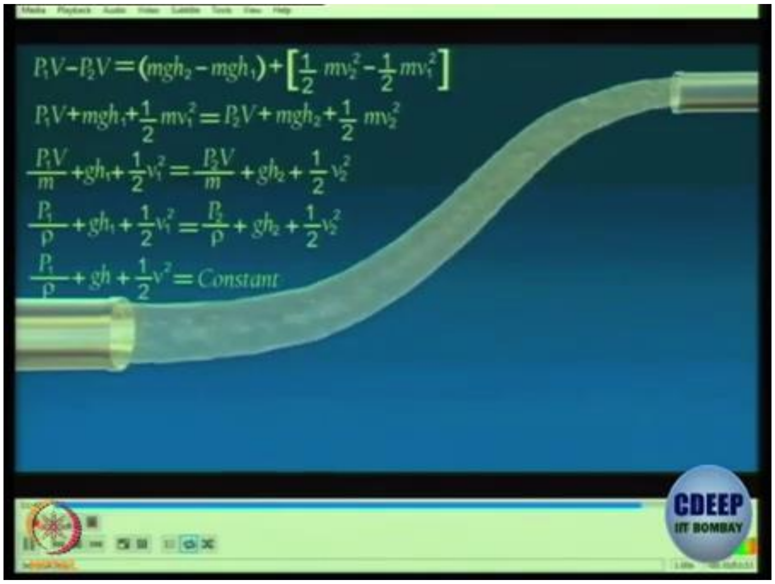
Professor: So, that is how you determine the blood pressure. There is a particular speed at which the blood should flow and where the speed of the flow is less, you have higher blood pressure, where the speed of the flow is less, you have lower blood pressure. So, one way of helping a person with high blood pressure is to reduce the density of the blood. So, there are some drugs or medicines which are given to people, who have high blood pressure, so that the blood becomes thinner and then it can flow faster, so the pressure will fall down. So, even in medicine we use Bernoulli's principle. So let us look at Bernoulli's Equation.



(Refer Slide Time: 8:51)







Video: When fluid flowing through a section of pipe with one end having smaller cross section than the pipe at the other end.

Professor: So, this is a simulation which shows two pipes of different diameters.

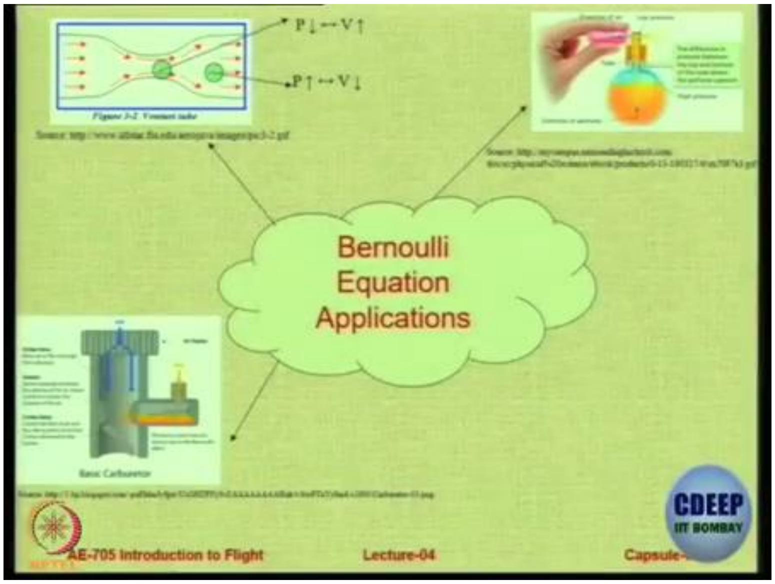
Video: The velocity of the fluid in the constructed end must be greater than the velocity at the larger end. Bernoulli's equation applies conservation of energy to formalize this observation. Consider a tube AB of varying cross section A1 and A2 and at different heights H1 and H2, liquid is flowing from A to B. P1 > P2. Here, A1 > A2, so V1 < V2. The force on the liquid at A and at B. Now, the work done per second on the liquid at section A and at section B, V1 = V2 = V, equation of continuity. Net work done, $Work\ done_{net} = P_1V - P_2V$.

Professor: The difference in the work done is the net work done.

Video: The net work done per second is equals increases the potential energy and kinetic energy per second from A to B according to law of conservation of energy.

Professor: So this is a very simple derivation of Bernoulli's equation which assumes incompressible flow, it assumes a few things. You noticed that it basically allow the conservation of mass and energy.

(Refer Slide Time: 10:51)



So, what are the applications of Bernoulli's equation, there are many applications. The first one is flow through venturi tube, which we have already seen that as the velocity in the venturi tube in the neck increases, the pressure there decreases, okay. Then it is used in bottles that we get to spray a deodorant or after shave or a perfume. So, what we do there is we create, there are some bottles available but there is a small air air bag attached, when you press that airbag, the air is made to go out and because the air goes at higher speed it creates a loss in the pressure or a suction pressure which draws the perfume molecules and throws it out, this is such bottles are available.

There are many applications in automobile for example, the carburetor. In the carburetor you have this valve, which the throttle valve, which when opens creates pressure difference and that sucks the and then Bernoulli's principle is also use to explain the generation of lift. In a separate lecture we will talk at lift generation and there we will touch upon this particular principle in more detail, okay. Now you can derive the Bernoulli's equation, we have done it in the video and I will try to upload this video on modal page or at least the link on youtube from where it is obtained.

You can derive this equation for two assumptions either for the incompressible flow in which the density will remain constant and more important the total derivative $D\rho/Dt$ will remain constant or you can do it for compressible flow, but I am not going to derive it in the class, I am going to leave it for you to self-study, okay.

(Refer Slide Time: 12:46)

I will proceed further to discuss another interesting principle, which is the Magnus effect, okay.


Magnus effect.mp4
CDEEP
IIT BOMBAY


CDEEP
IIT BOMBAY


CDEEP
IIT BOMBAY

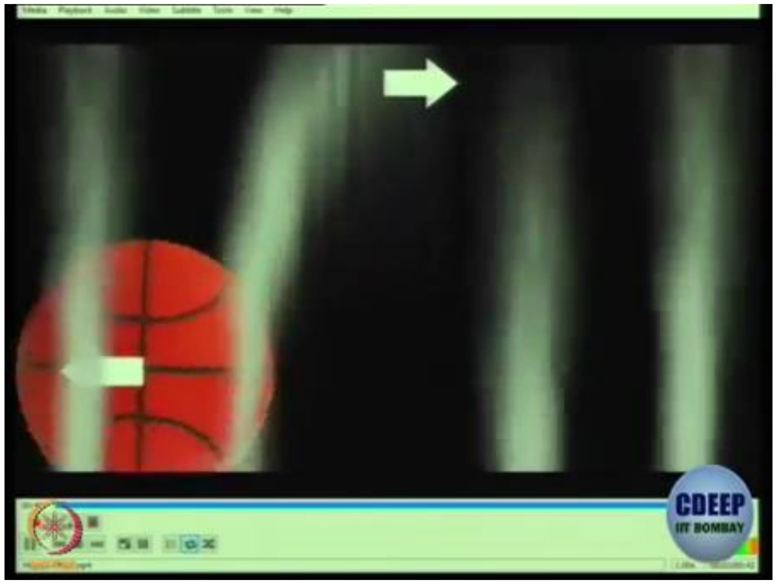

THE MAGNUS EFFECT


CDEEP
IIT BOMBAY


CDEEP
IIT BOMBAY


CDEEP
IIT BOMBAY


CDEEP
IIT BOMBAY



The Magnus effect is an effect that acts on balls or bodies which are spinning. When a spinning body moves through an object, then there is a pressure difference and we will see very nice videos explaining this effect as well as describing. Now when you have a spinning body and because of the spin there is a pressure difference then obviously there will be motion in one direction, okay. And therefore the trajectory of the spinning object will change. So, let us look at a nice interesting experiment which shows.

Video: I literally just dropped it with a bit of spin. I did not even throw and it just took off. I had no idea that I was gonna to do that. And this is where I comment. The basketball was subject to the Magnus effect, which effects all rotating balls or cylinders as they fly to the air and it works like this. As the basketball picks up speed, air on the front side of the ball is going in the same direction as its spin and therefore it gets dragged along with the ball and deflected back. Air on the other side is moving opposite to the ball spin, so the flow separates from the ball instead of getting deflected. The net result is the ball pushes air one way, so the air applies an equal force on the ball the other way and this is known as the Magnus effect.

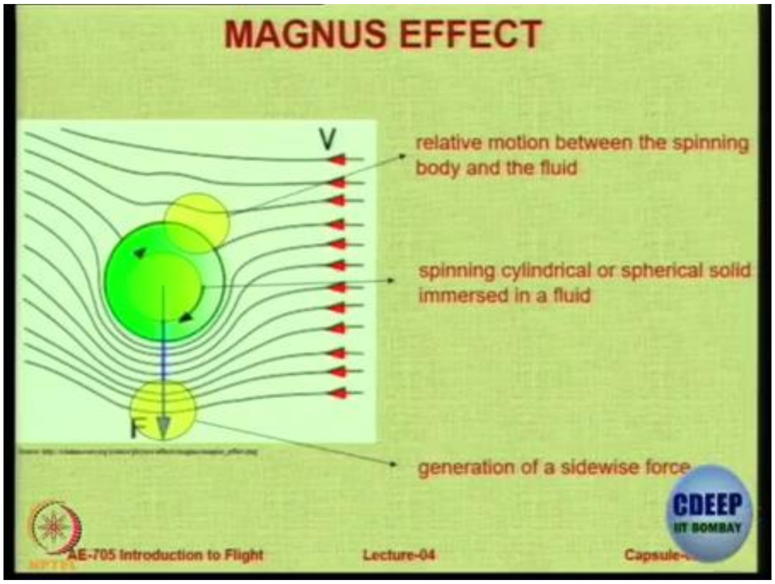
Professor: Let us see once again, so this person has spun the ball forwards, okay.

Video: I literally just dropped it with a bit of spin. I did not even throw and it just took off. I had no idea that I was gonna do that. And this is where I comment. The basketball was subject to the Magnus effect which affects all the rotating balls or cylinders as they fly to the air.

Professor: This person has spun the ball forwards, so it is going up.

Video: As the basketball picks up speed, air on the front side the of ball is going in the same direction as its spin and therefore it gets dragged along with the ball and deflected back. Air on the other side is moving opposite to the ball spin, so the flow separates from the ball instead of getting deflected. The net result is the ball pushes air one way, so the air applies an equal force on the ball the other way and this is known as the Magnus effect.

(Refer Slide Time: 15:01)



Professor: This is, this is used, this is used many ways, okay. So here is the principle, essentially just to remember there will be a motion towards the direction in which the ball is being spun, okay. So, if it is a cylinder or a spherical ball, because of the difference in the relative motion between the body and the ambient air you can get a force.

(Refer Slide Time: 15:29)

Another example let us see this very interesting example or a demonstration. We we have seen this in many football matches. That is how it works.


Lets see how footballs are curved
CDEEP
IIT BOMBAY
AE-705 Introduction to Flight
Lecture-04

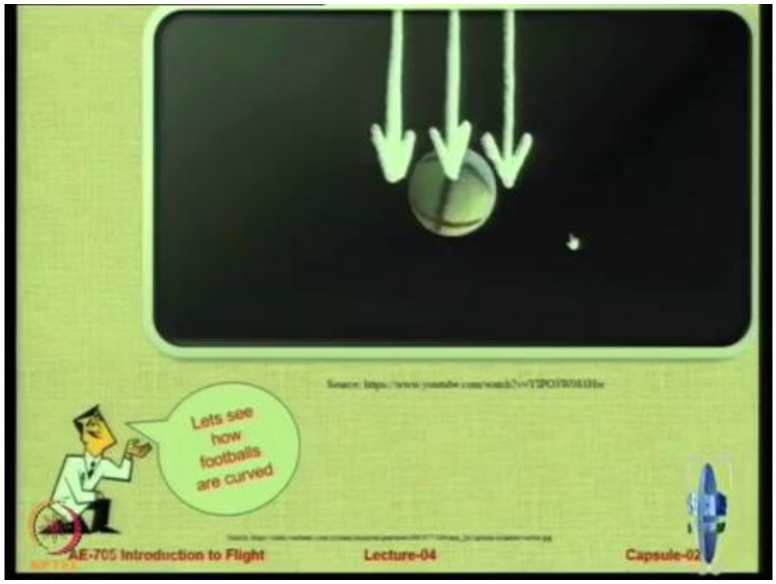

Lets see how footballs are curved
CDEEP
AE-705 Introduction to Flight
Lecture-04


Lets see how footballs are curved
CDEEP
IIT BOMBAY
AE-705 Introduction to Flight
Lecture-04

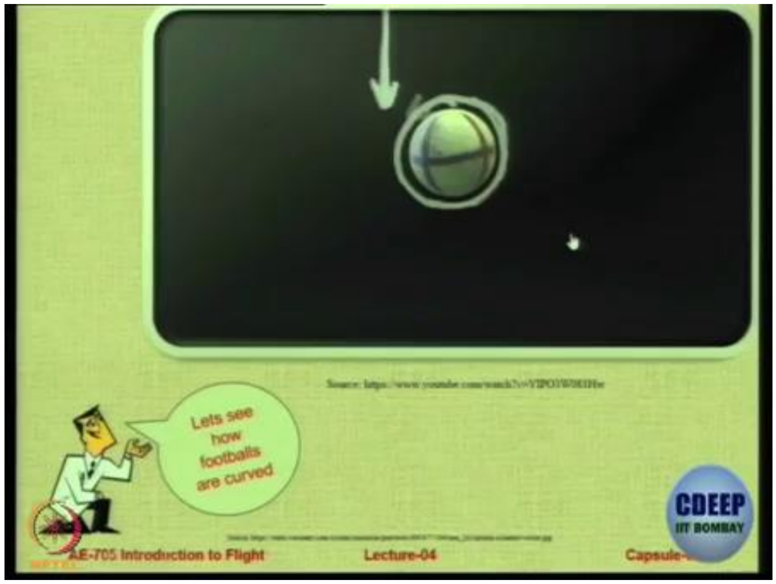

Lets see how footballs are curved
CDEEP
IIT BOMBAY
AE-705 Introduction to Flight
Lecture-04

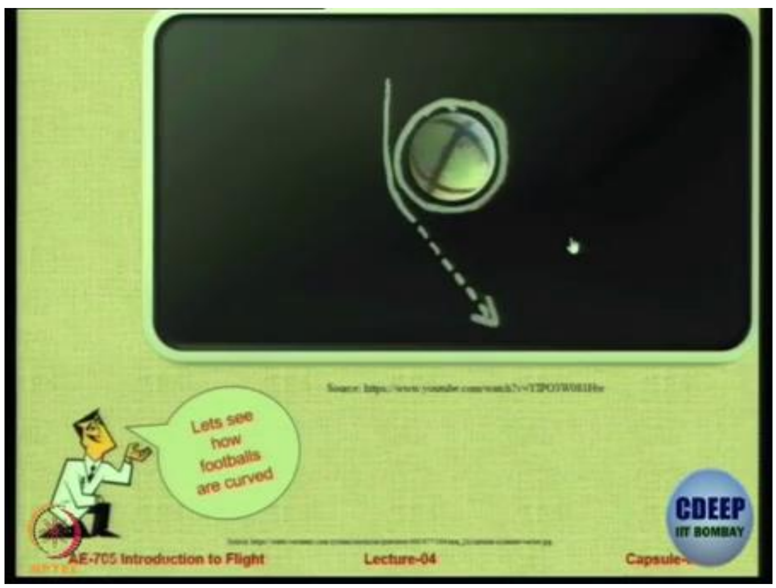

Lets see how footballs are curved
CDEEP
IIT BOMBAY
AE-705 Introduction to Flight
Lecture-04

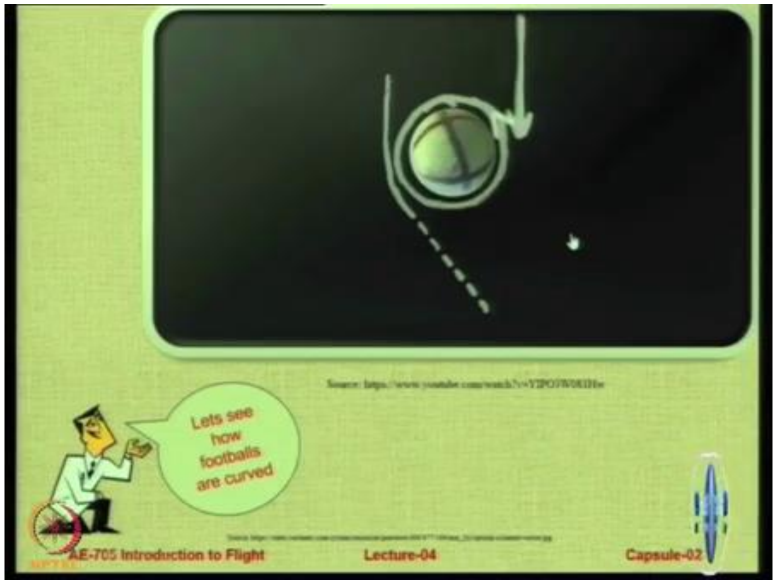

Lets see how footballs are curved
CDEEP
IIT BOMBAY
AE-705 Introduction to Flight
Lecture-04


Lets see how footballs are curved
AE-705 Introduction to Flight
Lecture-04
Capsule-02

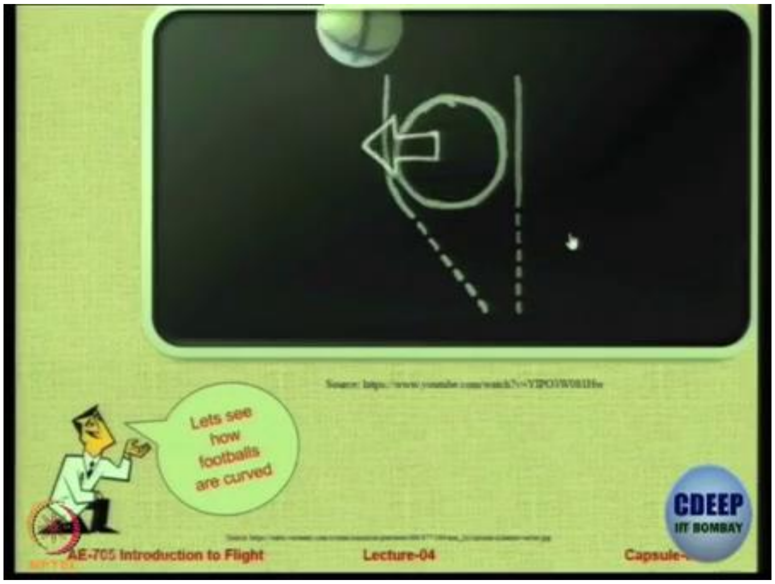

Lets see how footballs are curved
CDEEP IIT BOMBAY
AE-705 Introduction to Flight
Lecture-04


Lets see how footballs are curved
CDEEP
IIT BOMBAY
AE-705 Introduction to Flight
Lecture-04


Lets see how footballs are curved
CDEEP
IIT BOMBAY
AE-705 Introduction to Flight
Lecture-04


Lets see how footballs are curved
AE-705 Introduction to Flight
Lecture-04
Capsule-02


Lets see how footballs are curved
CDEEP
IIT BOMBAY
AE-705 Introduction to Flight
Lecture-04

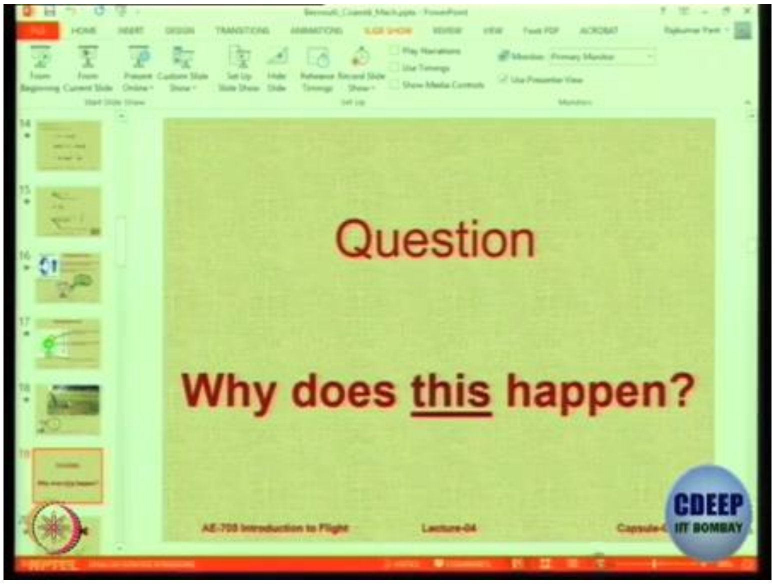


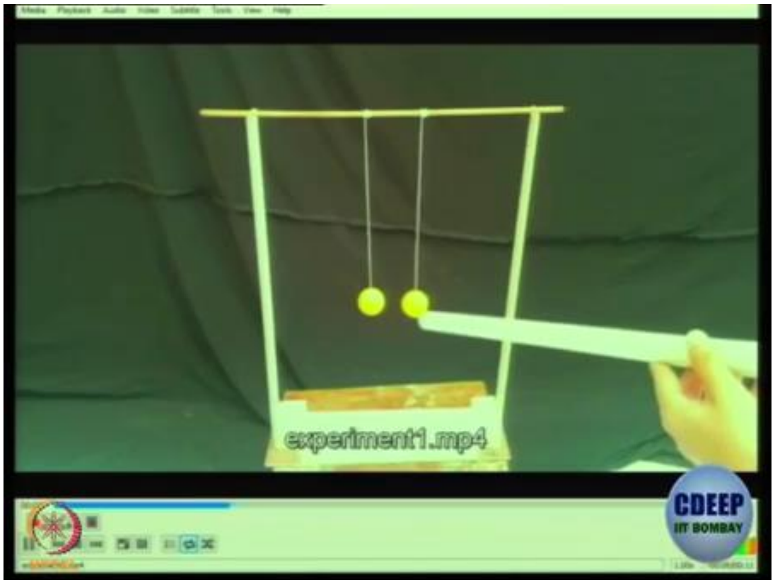
Video: How did you do that? Well it is a pretty standard technique in soccer. We use the inside of our foot to generate spin on the ball, that spin is actually going to make the ball curve into the goal. Let us take look at how that happens? As Kyle kicks the ball with his right foot on the right side, he imparts a spin on the ball. The ball travelling in this direction means the air is flowing across in the opposite direction. But, right near the ball there is a thin layer of air dragged around.

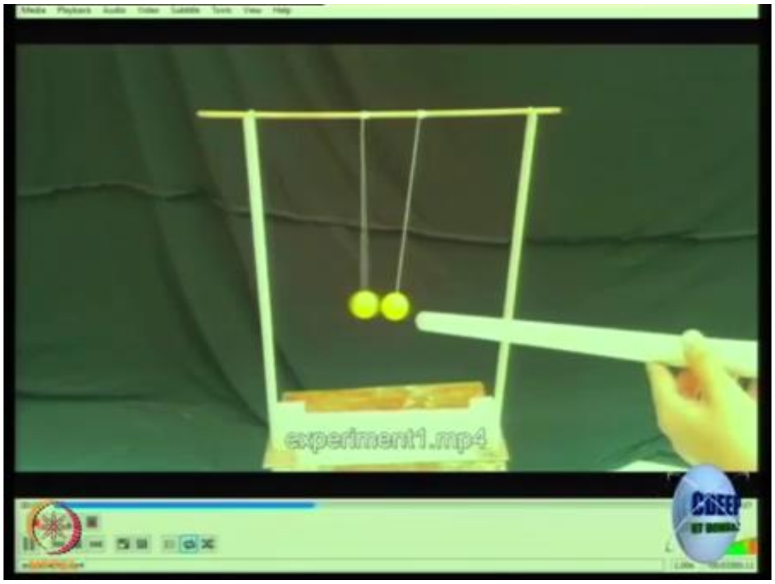
As oncoming streams of air pass the ball, the side moving in the same direction is the spinning ball is accelerated, follows the curve of the ball and is deflected off to the right. The side that is moving against the spinning ball meets opposing air and cannot continue around the ball, it flows down and goes straight, we end up getting a net flow of air to the right and the ball must move left.

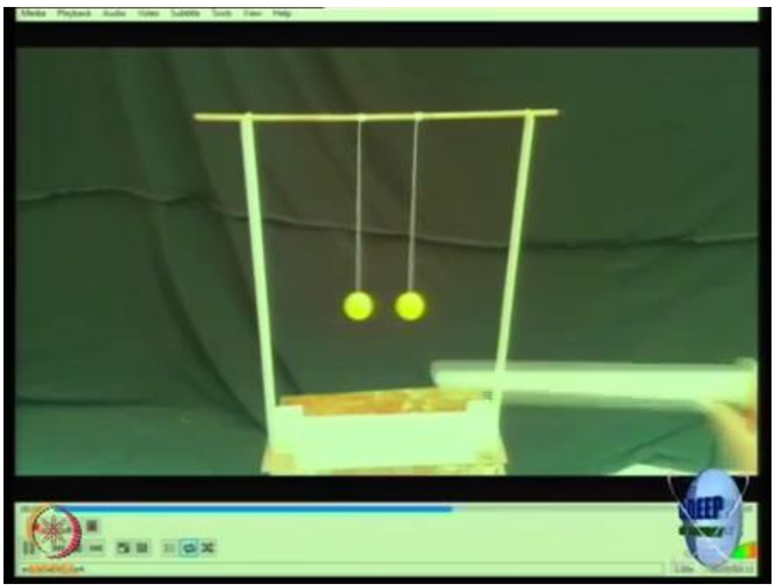
(Refer Slide Time: 16:25)

Professor: Okay, got it. Now let me show you another interesting phenomena and let us see if you can answer why this is happening?





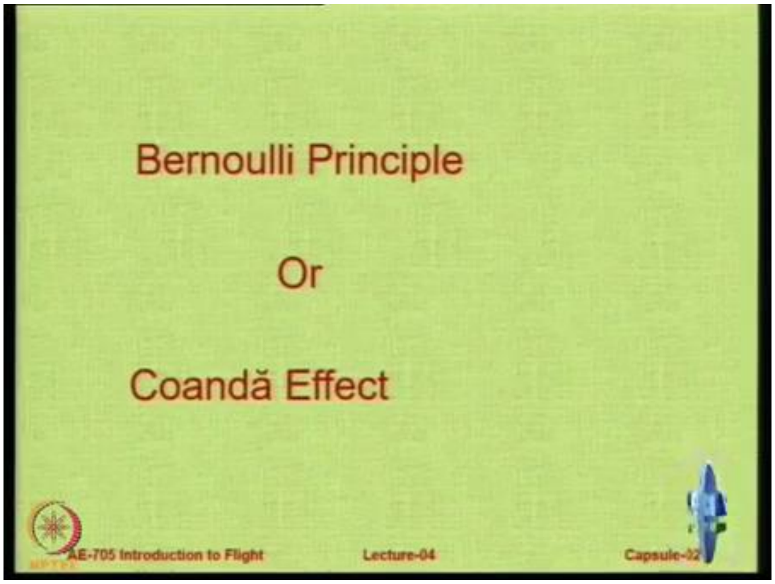




We blow air between these two balls, okay and then they start moving towards each other. This is an experiment done by some of my interns during the summer. So they they tried to pass a stream of air in between the two TT balls, table tennis balls and you can see that they start moving to each other, okay.

So, what is the principle here and why is it happening? It is the same thing. Just a same thing, that on the curved surfaces you are you have a gap between two curved surfaces you blow air there, the pressure reduces and because of that they start moving towards each other.

(Refer Slide Time: 17:21)



Alright, so now the question is, is this Bernoulli's principle or is it Coanda effect? According to Bernoulli's principle, wherever there is high speed there is low pressure and when there is low pressure then things tend to move towards the direction of pressure and according to Coanda effect, if you have. So is this Bernoulli's principle in action or is it Coanda principle in action? And in fact this is a massive confusion if you look on youtube many many videos which try to explain Bernoulli's principle are actually talking about something called as Coanda effect.

(Refer Slide Time: 18:00)

So we will move to the next aspect which is, reason why this happens, okay and that is Coanda effect.

Source: [illegible]

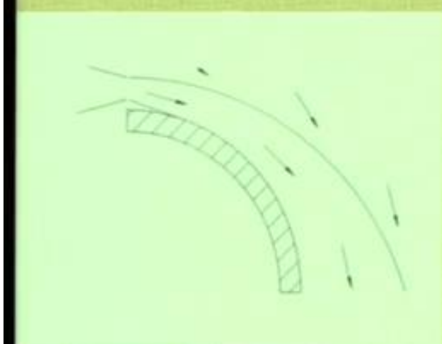
Henri Coandă [1886-1972]

- born in Bucharest, Romania
- interested in the technical problems of flight
- designed and piloted the first jet plane known as the **Coandă-1910**

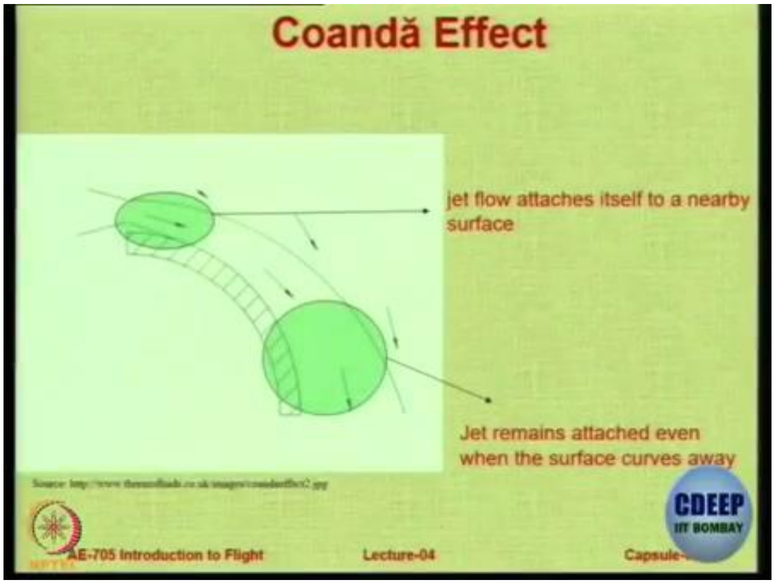
Source: [illegible]

- In 1930, he discovered the Coandă e[illegible]

Coandă Effect



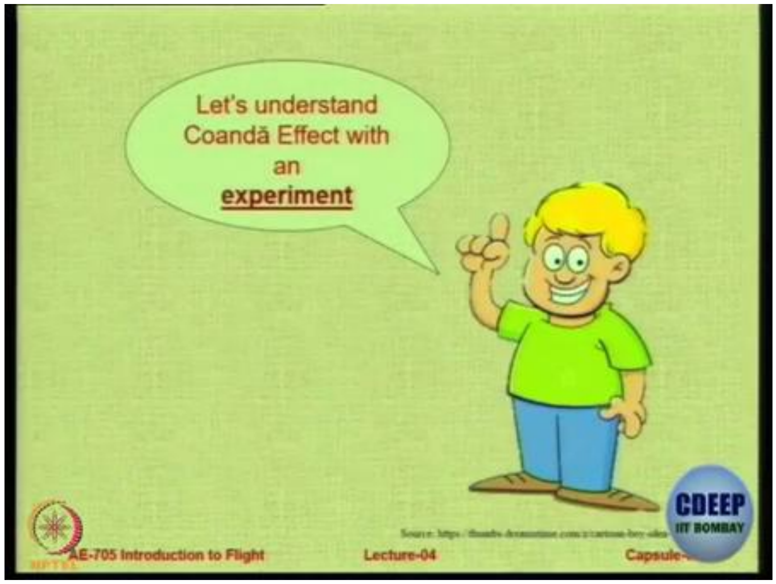
Source: [illegible]



So let us look at this gentleman called Henry Coanda. He was born in Romania in Bucharest, and he was interested in the technical problems of flight. So he made a very interesting aircraft, which was basically a kind of a jet powered plane. Although we do not credit him the person with the first jet engine aircraft, but this was a plane that was powered by jet and look at the year it is 1910, okay.

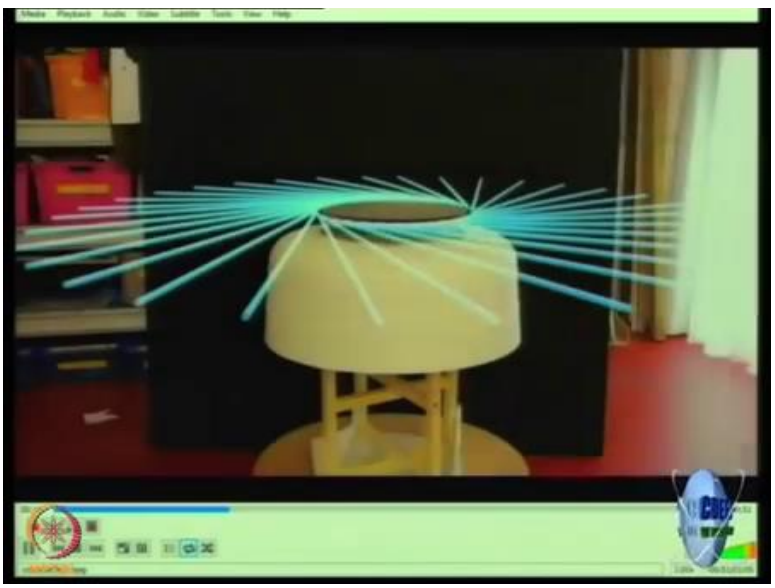
So, in 1930 he has discovered effect called the Coanda effect and let us see what this effect is. The effect says, that when there is a stream of fluid which is flowing along a curved body it tends to stick towards the surface of body, that is the Coanda effect. So, if there is a jet, if there is a flow jet which is along the curved surface, then what you would expect is if you blow a jet, it should go straight, but it will curve, okay.

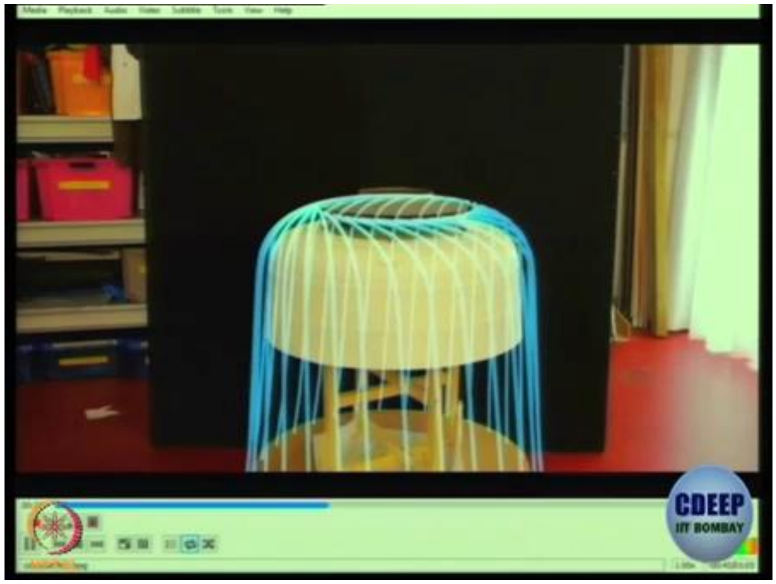
(Refer Slide Time: 19:16)

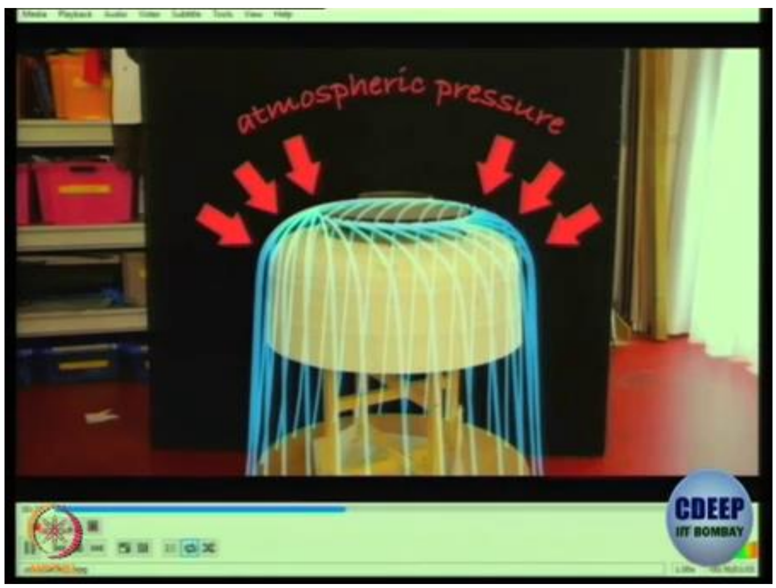

Let's understand Coandă Effect with an experiment
AE-705 Introduction to Flight
Lecture-04
Capsule-
CDEEP
IIT BOMBAY

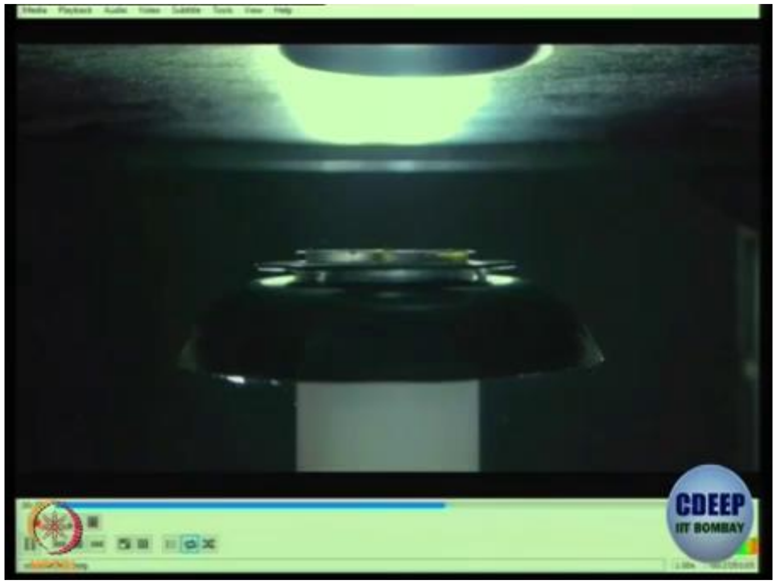

coandaeffect.mpg
Source:https://www.
ch?v=aF92B6Gon3M
CDEEP
IIT BOMBAY


Source:https://www.youtube.com/watch?v=aF92B6Gon3M
coandaeffect.mpg
CDEEP
IIT BOMBAY

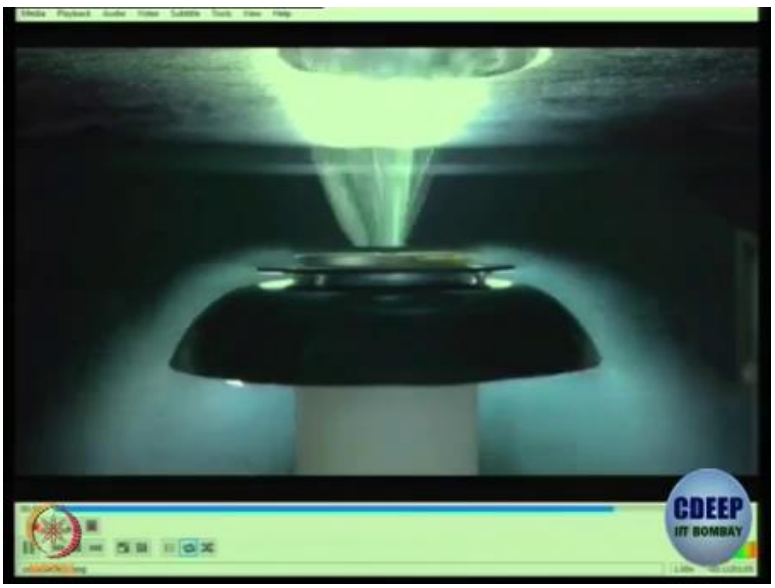



CDEEP
IIT BOMBAY


atmospheric pressure
CDEEP
IIT BOMBAY


CDEEP
IIT BOMBAY


CDEEP
IIT BOMBAY

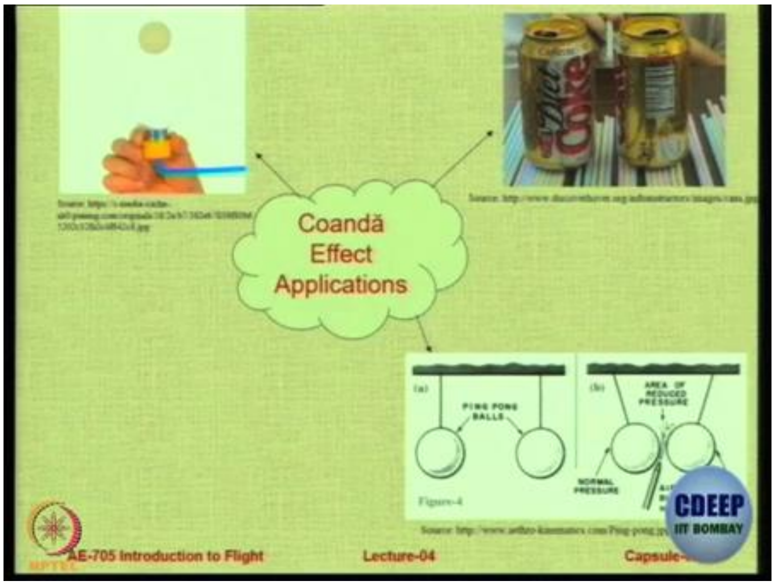


So let us see why this is happening? Let us first, let us first see this effect, you can see here air is coming out from the top schlich and there is this the curved body near the jet and this is what we should what should happen is this.

Video: Let us keep the air flow out of the fan horizontally in all directions but due to the Coanda effect the air bends down to almost 90 degrees. The airflow is been push down by the air above because the pressure of the air in between flow and the curve surface is reduced by the suction of the air flow.

Professor: This is flow visualization the air is coming out and start curving. Notice at low speed at low speed it did not attack. It is only when it became a jet, it is coming out but going down. Now the reason why this happens can be explained very easily by looking at flow along a streamline and looking at the pressure differential between the two sides which will give us an idea that pressure on one side reduces and hence there is a tendency of the air to move towards the curve side.

(Refer Slide Time: 20:46)



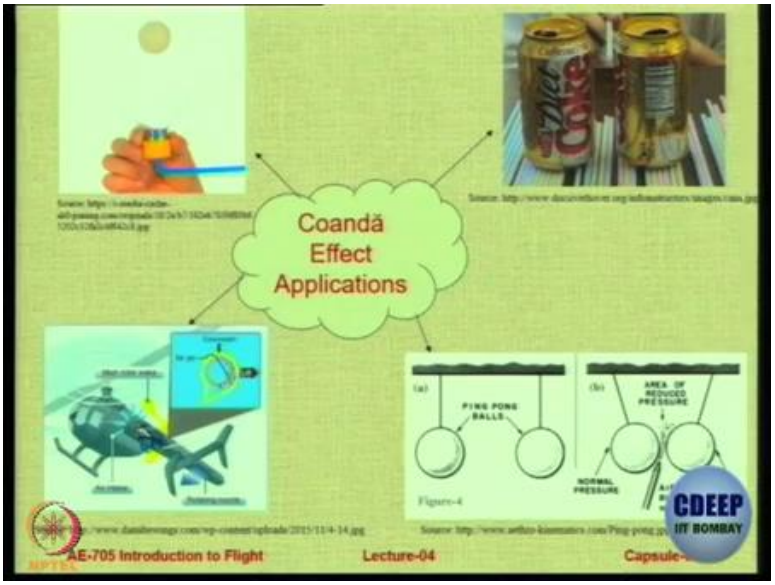
Now we are interested more in the applications of Coanda effect rather than the theory of Coanda effect. These are some application, for example you can make a ball float in the air by just blowing high pressure jet from the bottom. Why does it float in the air, because air will go on both sides and that will make it stable so when it is on both side almost equal the ball may dance slightly and when it goes this side the pressure brings it back and when it goes that side the pressure brings it back.

So, you can actually have a dancing ball just by a jet of stream below it. Alright you can try the same thing, look at just two coke cans or empty cans. try to take a straw and blow the air, if you remove the friction by putting straws on the bottom, you will see that the cans will start moving towards each other. So just by blowing air between two cans, okay.

So, I will be very happy if someone tries this experiment, records the video and upload them on moodle. It will be nice to see this, just take two light weight cans, remove the friction by putting some pillow, like here we have put the straws. And do an experiment and upload on the video. This is what I already showed you. This is a ping-pong ball experiment, where we have the area of reduce pressure and hence they move towards each other. This is something about which I spoke to you, in the first tutorial about components of the aircraft, I mentioned about our visit to helicopter hangar.

(Refer Slide Time: 22:20)

So, I located a very interesting video on how Coanda effect is used to this helicopter.




NPTEL
CDEEP
IIT BOMBAY

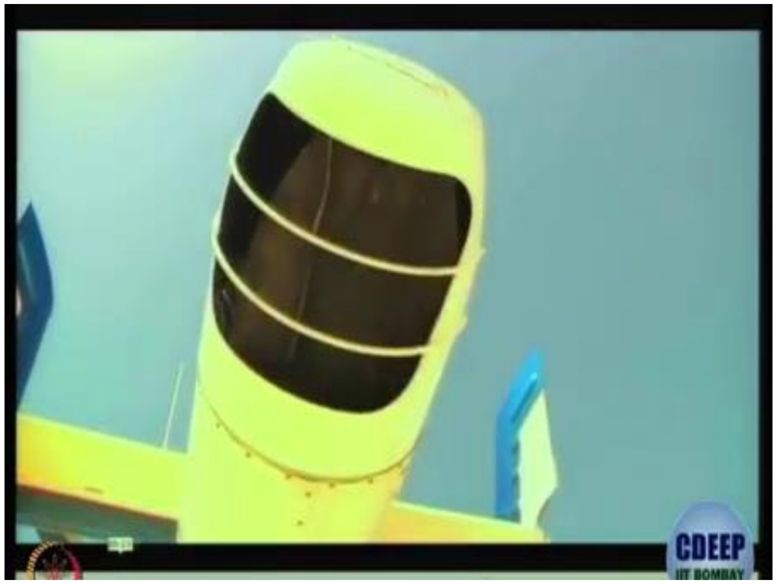

CDEEP


NOTAR
How It Works
CDEEP
IIT BOMBAY


Nick Page
Senior Instructor Pilot
CDEEP
IIT BOMBAY


CDEEP
IIT BOMBAY


CDEEP
IIT BOMBAY


CDEEP
IIT BOMBAY


What are vortex generators?

Video: Number one going all clear on the left, here we go, at about twelve or fifteen percent you are going to get laid off over here.

Professor:, This helicopter does not have a tail rotor. That is why the name is NOTAR, no tail rotor.

Nick Paige: Hello my name is Nick Paige we are here to talk a little bit about the NOTAR on the MD 900 or 902 explore. What the NOTAR is, is a other way of providing anti-torque for the aircraft. How it is generated is the tail rotor which is coarse not on the back of the aircraft is actually mounted forward inside a fuselage up here, it rotates based on a driveshaft much like it would on a tail rotor of of a conventional helicopter. It pumps air down the tail boom, In the tail boom there is two slots running along this right hand side. One here see, if I can use this and the other one right in here. The air is vented out from these two slots and it creates a higher of velocity airflow on this side versus the opposite side,

Professor: So there is pressure difference.

Nick Paige: creating a pressure differential much like the Bernoulli effect on a standard airflow. What it basically works out to, though it is a Coanda effect, it is more than just Bernoulli and pressure differential but, it creates lift after this side here allowing for heading control. When notar fan pitches, is directly connected to the pilot’s pedals as he applies left or right pedal the amount of airflow which pumped in the tail boom is increased or decreased creating more or less Coanda Effect out of these slots.

Approximately two thirds of the heading control of the aircraft is from the airflow out of these slots while out of hover. Then what we have on a very back into this, is rotating cone which also turns when the pilot crew is pushing the pedals and it wents out the remaining one third and it provides a measure of precise additional control to the heading control provided by two slots forward. This is how the aircraft works at a hover as you are transitioning in the forward flight you get about 60 knots, then your verticals pick up much of the load from the notar itself.

In addition to the other aspects of the notar, what we also have here, are vortex generators which have been added to this tail boom along with a 21 inch extension plug. Vortex generators, what do they do? Well as we progress forward down the tail boom you can see more of them and what they do is they allow the Coanda effect to work to a higher lateral amount of hovering speed than would be able to be add without them. What they do is they just keep the airflow from the main rotor adhering to the surface area of the tail boom longer or higher speeds that is how the vortex generators works on this chopper.

Professor: Okay, so if you have understood basically there are two slots, longitudinal slots on one side of the boom and there is a free turbine which is at the beginning of boom inside the boom, that turbine is just throwing air behind. The air is coming out from these two slots, and because of Coanda effect it starts going along the boom curvature and it leads to a pressure difference, so the helicopter boom will start moving towards the direction of the air. In addition, they have provided on the rear side one small rotating nozzle which can be also be used by pilots for providing additional control. Can we do? What do you mean by propulsion?

Student: What is meant by propulsion?

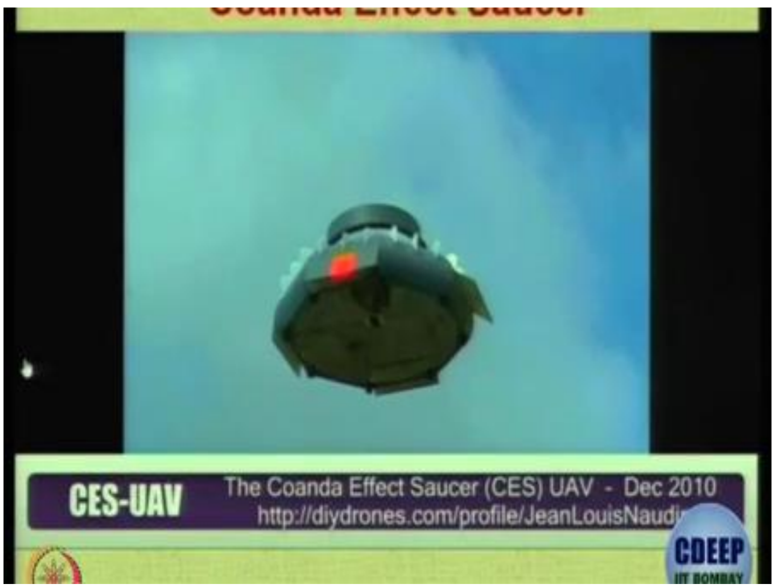
Professor: Yeah.

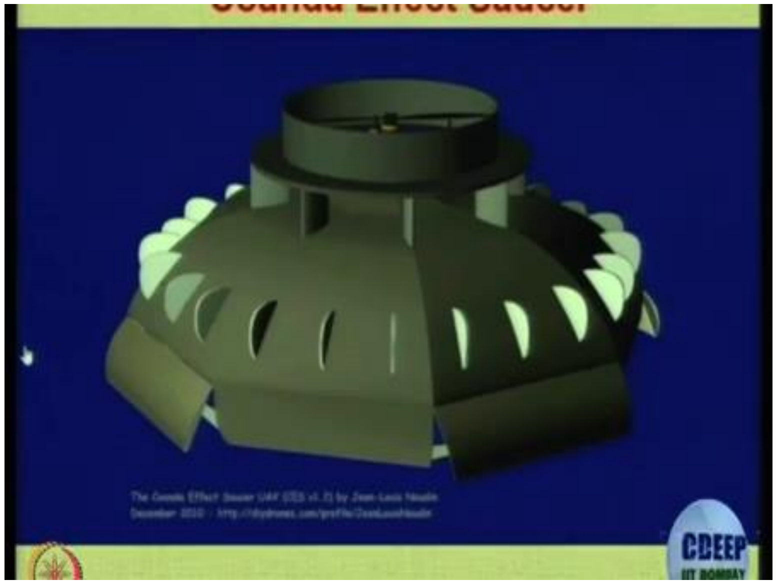
Student: We will have a dome in front of the plane, so that the air is blown in front of the jet sticks with the

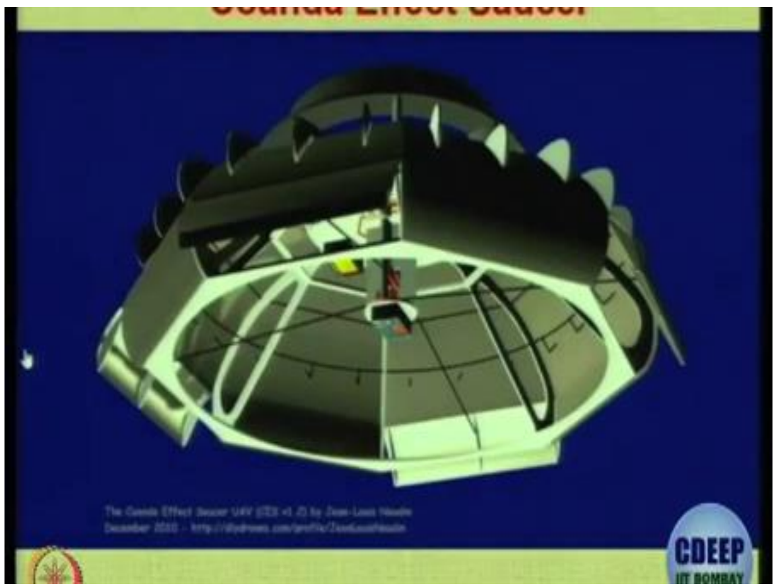
Professor: You can, see you cannot create propulsion but you can create forces. Coanda effect generally gives you force, okay. So, it is very indirect way to producing force, it might be easier to produce force directly this is a very indirect way of producing force. So, what we use, we use it mainly for providing small amount of force, now because of length of the boom we get moment arm, so you can get the required moment. So in principle yes but it will be a more complicated way of producing thrust or a force anybody else?

Okay. Let us let us go ahead. I also found a very interesting video about, I would say a device or an aircraft which flies on the basis of Coanda effect. It is called Coanda effect saucer. And I just want to show you, it is a very interesting video. And for those who are interested the plans of this particular device are available, for those who are hobbies, aero modelers. I will upload the plans on modal page for those who are interested. This website gives you a complete description on how to make it using 3D cutting. There are complete information available.

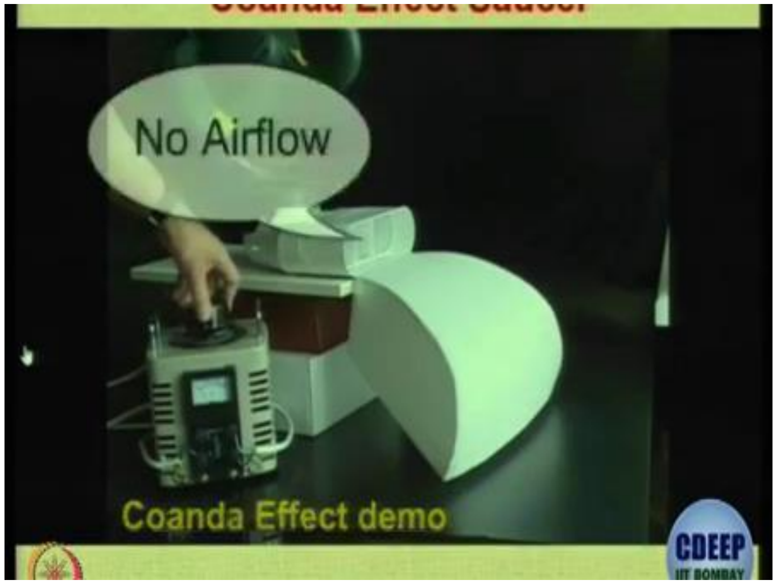
(Refer Slide Time: 28:00)

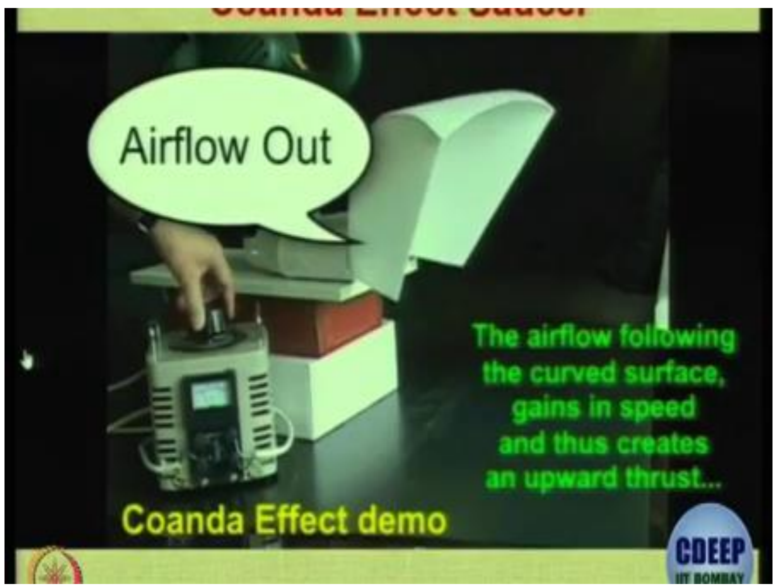


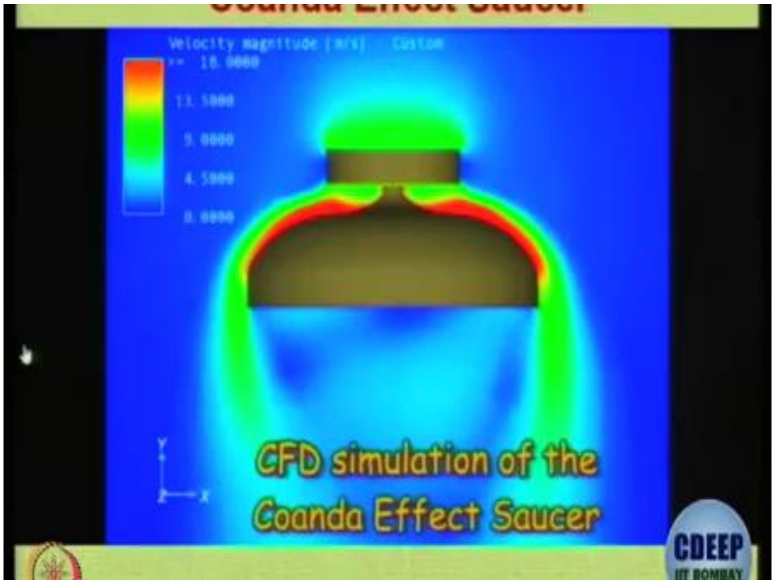

CDEEP
IIT BOMBAY


CDEEP
IIT BOMBAY

The Coanda Effect has been discovered in 1930 by the Romanian aerodynamicist Henri-Marie Coanda (1885-1972).
He has observed that a steam of air (or a other fluid) emerging from a nozzle tends to follow a nearby curved surface, if the curvature of the surface or angle the surface makes with the stream is not too sharp.


No Airflow
Coanda Effect demo
CDEEP
IIT BOMBAY

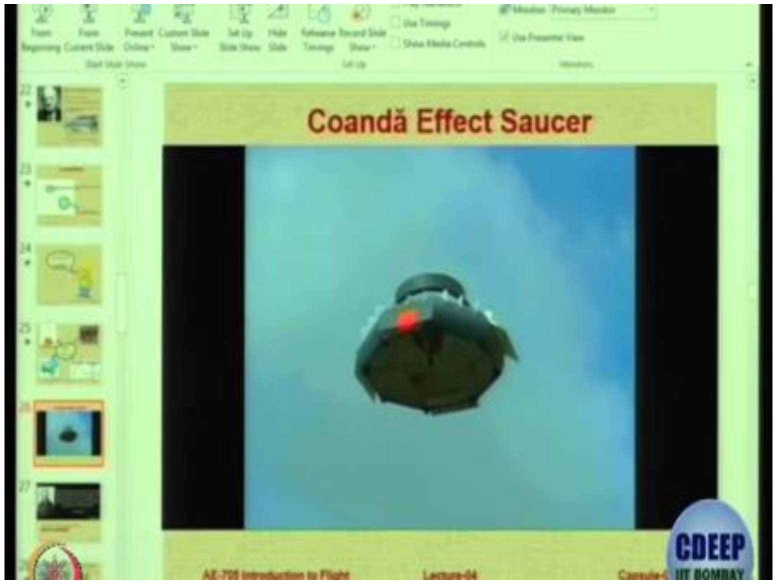

Airflow Out
The airflow following
the curved surface,
gains in speed
and thus creates
an upward thrust...
Coanda Effect demo
CDEEP
IIT BOMBAY


Velocity magnitude [m/s] Custom
>= 18.0000
13.5000
9.0000
4.5000
0.0000
CFD simulation of the
Coanda Effect Saucer


Now the model is real


CDEEP
IIT BOMBAY


CDEEP



So this is a patent which was given by Henry Coanda a very good example of Coanda Effect. You can see that using a simple Vacuum cleaner you can show that when the air is coming out from that nozzle because of the curved surface there is a pressure so it just goes up and when there is no air coming out because of gravity it comes down. So, you can also check this effect, so you can see where the velocity is very large the value is shown in the red colors and where the velocity is low is shown in greener colors, okay.

Now this is a model which has actually been built and very soon we will see videos of these aircraft being flown by remote control by the pilot. I think it is a very fascinating it is very fascinating model if someone is interested in aeromodelling, I would urge you to make something like this. It is really interesting. I remember in the aircraft design laboratory which I conducted few years ago one student wanted to make something like this. You can see there are flaps on bottom which allow you to give a lateral velocity.

So this particular Coanda effect saucer will not have very long range probably but it will have extremely good ability to stay at one place so if you want something which can hover at a for a long time at one place, this may be a good thing to try out. But you can see it is very difficult to balanced it because of the forces which will be fluctuating, So then, if there is somebody interested in providing stabilization system this is another very challenging platform. Try to make something that can go up and remain rock study at one particular place.

Interesting project, the principle used here to generate the lift force is a coanda effect. So, there is a single rotor in the center and there is a kind of a covering around to create a jet of the air. The jet of the air goes out of the bottom of that thing and go down, there are these straighteners to allow it to go like a jet and that gives it a force and then you have these flaps to give it lateral imbalance, okay. This is something which enthusiast can make.

Alright, now we move, yes?

Student: Sir how do they control it is rotation like what is providing anti-torque?

Professor: There is no anti torque required here because the air is coming out equally from all sides. There is a central rotor and there is this kind of wall around it with a small gap. So, the air is being sucked by the fan and thrown out equally on all sides of this particular saucer along the sides. So there is nothing like, there is nothing like rotation here. Plus, there are those small vertical members on the all-around the side to channelize the flow, so where it comes down straight. Any tendency because in whirling fan there is always a tendency of even the coming of in whirling fashion.

So, to cancel that they have put those vertical members all around. That straightens the flow, okay. So that it is, you do not there is no side force but you create intentional imbalance by moving those flaps which allows you to move on one side or the other. It is a good project I think someone should try to make it in their free time.