Fluid Mechanics
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Lecture – 01
Introduction

So, in the first part of this course you are going to look at Mechanics of Fluids.

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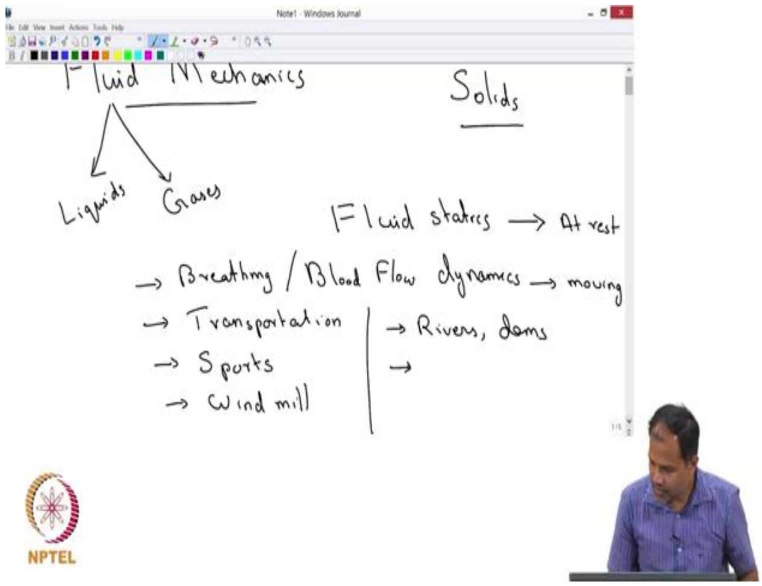

And in the second part, you will look at situations where the fluids come into contact with particles; there is interaction between particles and fluid and that results into much more complicated, but complicated scenarios, but that are often encountered in life. So, what do I mean by fluid mechanics or what are fluids first of all? So, typically we have fluids as constituted by liquids and gases, as opposed to solids.

So, what is the difference between solids and fluids? So, all of you know solids have a definite shape, they do not change shape according to the container or the shape of the container in which it is situated. Or more precisely if you apply a force on a solid the solid would deform, it will change its shape and it will reach a new shape. But if you are applying a force on a liquid or a gas; for that matter on a fluid the liquids and gases they will continue to deform, they will continue to move as long as the force is applied.

So, that is the main difference between solids and liquid fluids. So, fluid mechanics there are two things that we would like to look at; there is fluid statics and then there is fluid dynamics. So, fluid statics is essentially study of the fluids at rest and dynamics is fluids that are moving or are in motion. So, these are the two branches of fluid or two divisions in fluid mechanics. So, where do we encounter fluid or where is this study important? So, fluid mechanics is or fluids you encounter very often all around you.

So, imagine at the moment you are breathing you are the; you are inhaling the air you are absorbing the things that are required in your lungs and then the rest is thrown out right. So, you there itself the fluid mechanics come into action or look at the life ok; your entire body it is the blood; the blood is moving all around taking things to the required parts of your body.

So, and you know that blood actually travels through small and narrow pipes which are distributed throughout the body of all shapes and sizes. So, again you have a fluid that is flowing throughout your body and then again fluid mechanics actually plays a big role. So, so just to list the applications for example, breathing, blood flow or any kind of transportation that you think about.

For example, if its air transportation aero planes or ships or even for a racing car all of them move in a fluid; it would be either water or air. And whenever these things are moving in that particular fluid it basically experiences a drag force, a resistance to motion ok; so that is where the fluid mechanics come into the picture.

Lots of sports whether its cricket football you know tennis or swimming everywhere again you know for example, in cricket the ball interacts with air around it which decides the trajectory of a cricket ball. Or when you are swimming you are again moving in a fluid and then you need to optimize your swimming stroke since that you can get the fastest or the highest speed.

Ah Then things like for example, wind mill where you know; where you are trying to extract energy cases like rivers, dams then and so on ok. So, everywhere around if you look at you see some kind of a fluid and then fluid mechanics become important. So, this is a first course in which we will try to introduce you to various; what are the aspects that are important when you look at the motion of the fluids, how do you know what are the forces that are required to move a fluid from one point to another? So, that is the aspect that we are going to concentrate.

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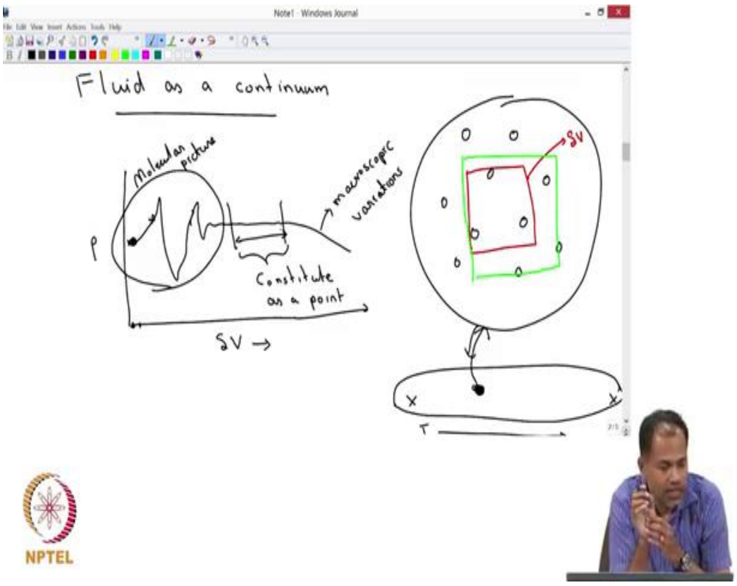

And we are going to look at it from the perspective of continuum, so we are going to treat fluid as a continuum. So what do I meant by a continuum? Let us say you have got a microscope and you have some fluid you know air water anything that you like and then you are going to zoom into the fluid.

You are zoomed in so much that you can now see individual molecules. So, you will see that there are molecules that constitute a fluid and you have reached that kind of a resolution in which you can see the molecules. Let us say let me represent some of them, so let us say we do not know how they look like each of the circles; let us say represent molecules at a given or the location of the molecules at a given time.

And my intention now is to plot a graph where on x axis, I will plot volume and on y axis I will plot a density. So, what I am going to do? I am just going to take a small volume, let us say that that is a volume that I have represented as δ V; a small volume where I can see actually individual molecules. And then I am look I am going to calculate what is the density and the way I would have calculated the density; would be I would say what is the total mass divided by δ V and I will give you my density and I will mark that point somewhere ok.

Let us say that volume is this is the point that I am looking at and that is a point that I have gotten. Now, what I will do is that I will increase the volume of this let us say this. So, initially I have chosen a cube which I have marked as red, now I will make it a little bigger and I will calculate the volume again. Now, you can see that when I do that I have got maybe I would have included one or two extra molecules.

But the point is that the number of molecules that you include when you are increasing that volume is not uniform; maybe originally I had 3; now I have increased it into let us say 4, 5. But that does not mean that your density has gone up proportionately; you have increased your volume, but you have changed the mass by a little bit.

And therefore, you would see that you get a density which is different maybe something else ok. And as I keep expanding this you will see that you know there will be lot of fluctuations in the density that you are calculating and that is because you are actually defining your volume in a scale similar to the molecular scale.

So, your volume that you have considered which is δ V is very small that when you are increasing the volume; you will see that you will see that the number of molecules that come up in each volume may be not sufficient to proportionately increase the density. So, that is why you will start seeing a lot of fluctuations.

Now, as you increase your volume further you will see that the beyond some point ok; you have gone let us say up to those kind of length scales where you are not able to see the molecules further ok, you have you have got huge number of molecules that even when you are increasing the volume that does not lead to a change in the density.

So, then what you would see is that these fluctuations will become smaller; then it will become flat. So, that is the kind of density that you are familiar with, that is the density that we measure because when we measure the density we will take a huge number of molecules or in other words we will take a macroscopic volume and then we will measure the density. So, if you measure density in that regime then the density becomes a constant. And it becomes independent of the volume that you have considered, but let us say this is this entire thing is part of a huge amount of fluid.

Let us say this is the fluid that you are considering and let us say temperature is changing from one point to another. So, at the moment we had taken a small amount and that is what we zoomed in and then looked at this aspect. But on the other hand if I continue to look at, so that is the amount that we started with, if I go from one end to the other end. And let us say temperature is increasing in the right direction then what you are seeing is that the density should also change.

In other words, if I continue to increase my δ V, at some point I should see that the temperature will come into the picture. There is a density change and that will result in to and that will result into something of that sort ok. Whether they are the dense whether where you will actually start seeing changes in the density because of the other effects ok.

So, this region where you start seeing the density changes is because of the macroscopic variations. While in this region the density fluctuation is because of the because you are at a length scale which are much comparable to the molecular length scale. So, this is a molecular picture; while on the right hand side this is where you start seeing density variations because let us say pressure changes, temperature changes and so on. In between there is a region where you will see density being a constant and that is the region you consider as in your continuum approach.

So, this region will constitute as a point in your continuum ok. In other words what I meant to say is that if you have a fluid and if you say that you are looking at a particular point in a fluid that point is really not of 0 size that point basically is of this length such that at that point I can define a property to be constant. If I increase the volume of that point, then I am going to see macroscopic variations, but if I decrease the volume of that point, then I am going to see molecules.

So, the basic idea of continuum is that the point is defined on a length scale much larger than the molecular length scale, but much smaller than the macroscopic variations. So, that is the idea of treating fluid as a continuum. So, any quantity that you look at essentially is going to be an average or any point any property that you assign to a particular point, that point will have enough number of molecules that you will not see any fluctuations because of the fact that it is constituted by discrete entities.

So, that is the definition of a continuum and we will treat fluid as a continuum. So, for us then you know every property will be a well defined quantity. And we are going to be staying away from the length scales of molecules at a sufficiently you know and we will stay at length scales much larger than the molecular length scale ok.