Hello, and welcome to Engineering Earth. In this video, we will review properties of fluid compressibility and steady and unsteady flows, and these are going to help us when we apply the Reynolds transport theorem to analyze fluxes of mass, energy, and momentum through control volumes.

So, let's imagine that there's a river, and I'm standing next to the river at a particular place, and I'm going to observe the amount of water that is in the river, which is my y-axis variable, and how it changes over time, my x-axis variable. So, during the first period of time, let's say that my observation looks something like this. Over the amount of time that I've observed the water in the river, the amount of water hasn't changed. So, this is what we would consider to be a steady flow. If I were to choose three different time periods, just randomly within my observation period, I would see that the amount of water in the river was always the same. And that's because the flow during this time was steady. Anything that is defined as being steady doesn't change over time. For example, if I had a steady job, I would plan to go to that job every single day, it wouldn't change over time. Now, back to my river. Let's say that it rains, and the water comes into my river. Oops, need to go back to my blue color for my river water. And that rain comes into the river and causes the amount of water in my river to increase, and then it drains through the watershed, and the flood wave passes, and the water level comes back down again. So, this second time period that I've been observing the river, this would be considered an unsteady flow. Right, if I were to randomly select three different time periods, you know, the amount of water at each of my randomly chosen time periods could be different. And that's because the amount of water in my river was changing over time, in this unsteady flow.

So, next I want to talk about compressible and incompressible fluids. So, you remember when we talked about that fluid property of compressibility. Let's say that we have a mass of fluid, and it is contained within a volume that looks like this. So, the mass of my fluid is M, and the volume that it's contained in is V. Now, let's say that I apply a pressure to my fluid, and this pressure is being applied to all of the sides of my cube like this. This pressure that I'm applying, I'll call it P. So, the response that I get from the fluid is going to depend on the compressibility of the fluid. So, if we increase the pressure of some fluids, some fluids will compress so that the same amount of mass is able to fit into a smaller volume. So, if I'm working with a fluid that responds in that way, I apply that pressure, and then the volume that contains my fluid becomes smaller, like this. So, I've got that same mass, it's still M, but now that same amount of mass that's being subjected to the pressure, now it's being contained in a relatively smaller volume. And, of course, since we know that density is mass per unit volume, we understand that such compression is going to require that the density of the fluid increases. So, in this case, we have gone from a situation where we had a relatively larger volume, that contained a mass, that produced some density, rho, to a situation where we've got that same mass contained in a smaller volume. So, we know that that causes rho to increase, so this is going to have a slightly larger rho. So, remember we also found out that some fluids are able to respond in this way, where if we apply that pressure, the amount of mass is able to be contained in a smaller volume, increasing the density. So, we would consider this to be a compressible fluid. But then there are some fluids that have a different type of behavior. Right, and so, we defined that property of compressibility to describe how easy it is to change a fluid's density in response to pressure. So, in this example, we would call the fluid in the cube compressible since the density of the fluid changed in response to the applied pressure. But what if we had a different fluid that had a really high coefficient of compressibility? We would have to apply huge amounts of pressure to achieve even a really small response to the fluid density. So, let's say that we have that kind of fluid, again in our first cube over here. We have that mass within the volume, and again we apply that same pressure, P. But now, let's say that the fluid volume doesn't change very much, and so the density doesn't change very much. So, we would consider this to be an incompressible fluid. Most liquids could be considered to be basically incompressible. So, just like when we considered that example of seawater deep in the ocean trench, the pressure at that depth was really big, but the density of the seawater hadn't changed very much when we compared it to the density of water at the surface that was just feeling atmospheric pressure. That's because the seawater was basically incompressible. So, in that example, if you'll remember, we calculated a very large coefficient of compressibility.

Thank you to the National Science Foundation for supporting this work under Grant 2335802.

Great job reaching the end of the video. Please relax and enjoy a moment of zen. I study fluid mechanics because I love water and healthy aquatic ecosystems. Whatever your passion is, I hope it motivates you to continue your study of fluid mechanics.