Hi everyone, welcome to Forces and Stresses.

In a prior lecture we had discussed dimensionality of force and defined it as a force being equal to a mass times a length per unit time squared. And here we defined that in SI the units of force would be in Newtons, and in US customary units we would be working in pounds of force. So, in the prior video we had contrasted force with mass and in this video, we're going to talk about the relationship between a force and its stress. So, a stress is typically given the variable of Greek letter Sigma and is defined as being equal to a force per unit area. So, in SI units we might represent stress as something like a Newton per meter squared. And just like in SI the units of force are given a special name a Newton, after Sir Isaac Newton, um there's a special name for units of stress in SI units, these are known as Pascals. And so, this unit is named after uh a French physicist named Blaise Pascal, who made important contributions with his work to understanding of pressure, which is a type of stress. Um in US customary units we might be looking at something like a pound of force per square foot or a pound of force per square inch, oops sorry I forgot the square on my feet there. And often times when we see these units they may be represented um instead of by the actual quantities written here by their acronym so for instance a pound of force per square foot may be referred to as a psf and a pound of force per square inch you may see referred to as a psi. So, there are two types of stress that I'm going to introduce: normal stress, which in fluid mechanics is typically pressure, and tangential stress, which um often times is called shear stress.

So you'll recall from another prior video that force is a vector and we defined unit vectors um specific to force that are relative to the surface of an object that a force may be acting on like this object is acting um on the surface of this object at some angle theta relative to the surface. So, if we zoom in here on a differential area of that object surface, which has an area of dA, we can break down the force into its components. So, for instance in the normal direction, here we go I've got a component of force in the normal direction, F sub n, and then in the tangential direction I've got a component of my Force F sub Tau. And of course, just like in the last video uh we could calculate the magnitudes of F sub n and F sub Tau by the dot product of the magnitude of the force and the angle between the unit vector and um and the force. So, for instance my unit vector in the normal might be something like this, here's my normal unit vector and then in my tangential direction I might have a unit vector like this. So, in the case of um so in this case the magnitude of our normal stress, or Sigma, is going to be given by this F sub n component of force per unit area dA. And then our magnitude of tangential, or shear stress, will be given by the shear component of the force per unit dA. So, in fluid mechanics, the forces that we are most often concerned with are forces that are generated by the fluid itself, and we can separate our analyses in fluid mechanics into two groups. So those into which the fluid is at rest, which we call fluids statics. And those of moving fluids, fluid dynamics. So, what does all this have to do with stress? So, the normal stress that is created by a fluid is called the pressure, and all fluids whether they're at rest or in motion are going to generate a pressure or be defined by a pressure. On the other hand, um, it's the movement of the fluid that generates tangential, or shear stress. So, when a fluid is at rest all of the layers of the fluid are moving at the same rate relative to one another which is velocity zero. Right it's at rest so no part of that fluid is moving if it's at rest, and so when there's no relative motion between particles of the fluid there's no creation of shear stress. Um so if a fluid moves, often times it doesn't move in the same way that a solid does where every molecule of that fluid moves in the same direction at the same velocity. Um, rather that differing relative motion between particles of fluid is what creates the shear stress and that requires a different analytical technique, versus a static fluid where all of the particles of fluid are moving at the same velocity zero. So, our fundamental analysis strategies for fluid mechanics all relate back to this important quantity of stress that we've defined here so again. Just as a review, we've got our stress normal to a surface. In fluid mechanics this is going to be the pressure of the fluid, and this is going to be something that we analyze whether or not that fluid is moving. But then in a moving fluid we have this shear component of the stress, which we additionally are going to have to take care of in moving fluid analyses.

So, thank you to the National Science Foundation for supporting this work under Grant 2335802.

Great job reaching the end of the video and please 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.