Example Problem Law of Friction

SPEAKER Bob Holmes: Okay, in this session we're going to talk about using Newton's Law of Friction to solve a problem. In this particular case, we're gonna solve for the dynamic viscosity of an oil. In the problem on your screen, you'll see there's a block that is being towed across a thin film of oil. This oil has a depth of 0.01 foot and is being towed across at a constant velocity of two feet per second. So it's uniform. There is no acceleration of that block. And if you'll remember from Newton's Second Law, that the sum of the forces is equal to the mass times the acceleration. If we have zero acceleration, that is the velocity is constant in movement or the block is constantly moving across at two feet per second, the value of acceleration is zero. So we can say that the sum of the forces is equal to zero.

Now, we know that the force that's being applied to the block is two pounds. We have a resisting force between the block and the oil, that's abbreviated F sub-tau, we can add those two together. Where the force that's pulling is positive and the force that's resisting, F sub-tau, is negative. We add those together and we can say that they equal zero. So F minus F sub-tau is equal to zero, or F sub-tau is equal to the F. Now this resistance force, F sub-tau, is then equal to two pounds. But really, for Newton's Law of Friction, we need a shear stress. We don't need the resistance force. So if we take the resistance force, F sub-tau equal to two pounds, we divide that by that cross-sectional area of the bottom of the block. That area which is in contact between the block and the fluid, we've said that's 1.5 square feet. So if I take that, divide it by that cross-sectional area, I get a shear stress of 1.33 pounds per square foot. So I've got the first part of my Newton's Law of Friction, I needed a shear stress.

Now, I also need the rate of deformation, the DVDY, or the delta V over delta Y. The delta Y, that's just basically the depth of that oil. In this particular case, it's 0.01 foot, okay? So the delta Y is 0.01 feet. The delta V, we have to make some assumptions. First of all, as we're pulling that block across the top of the oil, we assume that there's no slip between the block and the oil. So that oil at the very top of that surface is moving at the same rate as the block that is being towed across at a constant velocity. So we can assume that the velocity of the oil at the top is two feet

per second. We also assume that there's no slip between the fix boundary at the very bottom of that oil layer and the oil. So at that point, the oil has zero feet per second as the velocity. So I can subtract the two feet per second from the zero feet per second and that becomes my differential velocity, my delta V, or DV, that becomes two feet per second.

Now I have all the components I need for Newton's Law of Friction to solve for the dynamic viscosity. If I plug in the 1.33 pounds per square foot into the value for tau 346, if I plug in two feet per second into the value for DV, I plug in 0.01 feet for the value of DY, through some algebraic manipulation, I can solve for the dynamic viscosity, which has a quantity in this particular example of 0.00665 pound-second per square foot. So we've used Newton's Law of Friction to solve for the dynamic viscosity of this oil. Now if I wanted to solve for the kinematic viscosity, all I would need to do is divide the dynamic viscosity by the density of the oil, the rho, Greek letter rho, and I would have the value for the dynamic--or the kinematic viscosity for this particular oil. That concludes this example problem using Newton's Law of Friction.