Forces on Submerged Objects

SPEAKER Charles Berenbrock: This lesson is on forces on submerged objects. We're looking only at objects that are submerged in water. As you note in this slide, you'll see three various shapes that are submerged under the water. The line with the arrow upside down triangle is the top of the water surface. In this example here, we're talking about fluid at rest. There is no moving water at all. Also all forces are normal to the surface in question. And as you see in this slide, that's a--at the curve surfaces, you'll see that the arrows are coming in from different directions. Well, those arrows aren't normal to that surface in question. Also, pressure increases with depth. And as you probably know as you go swimming or diving, as you go under the water, pressure increases. You feel it in your eardrums. And that pressure varies linearly with depth. Also that pressure is equal at depth.

For example, at a certain depth, you'll--that pressure is always the same. And pressure is uniformly distributed over an area. Because of that, we can say that we can use Newton's second law and say that force equals the average pressure times the area. If we take that equation and invert it and rearrange it, we get--the pressure is equal to the force divided by the area. And further reducing that equation, we can say that the weight of that object divided by the area. And we can do subsequently reductions of that equation, and eventually we get to the point that the pressure is equal to the specific weight of water times the depth of that object. In that equation, you'll see some terms, like gamma, that means the specific weight of water. "W" means the width of that object. "L" means the length of that object. And the red lines are--meaning that we've cancelled out those terms from the numerator from the denominator. Also note that gamma, or the specific weight of water, is equal to the density of water times the acceleration of gravity, which is "G," in this case.

And on Earth here, it is 32.2 feet per second squared. Also, the point of application of that force is at the centroid of that area. And in this case, we're talking about the vertical case. So let's say if we have a long, skinny, object, the centroid will be at the center of that object. If we have a triangular element, it will be two-thirds down from the top of that object. It is where the centroid of that object will be. Also, the static fluid pressure does not depend on the shape or the total mass

or the surface area of the liquid. As you see in these diagrams right here, we have different shaped objects that are holding water at the same level. If we take it at the same depth “Y,” our pressure is the same in all of those objects, no matter how skinny or how wide the object is. And this concludes this part of the lesson.