

Hi everyone, this video discusses the fluid property of density and explains its relation to force and stress in fluids.

In Chapter 2: fluid properties we define the property of density, which is given by the Greek letter rho, as the combination of mass per unit volume. So, if we're looking at density in SI units our mass might be represented by kilograms and our volume by a cubic length of cubic meters for instance. If we're working in US customary units our mass units might be something like a pound of mass and our volume would be a cubic foot. Um, so density is related to force of weight by Newton's second law. So, we define the product of density and gravitational acceleration, g , which we use as the specific weight of the fluid which is given by the Greek letter gamma and this is the weight per unit volume. So, gamma sometimes I'll call it ρg because that's what it is. Um you may also hear this referred to as the unit weight because that is what it is, it's the weight per unit of fluid. And because weight is a force this is also the force that's exerted by the fluid per unit volume.

So, let's just take an example of a substance, let's say mercury at 25°C so if I look up the density of mercury at 25°C , for instance this is something that you could look up in appendix one of your textbook. What I might find is that the density at that temperature of mercury is 13,534 kilograms per cubic meter. And therefore, the specific weight, or gamma, of mercury at 25°C is that density times the gravitational acceleration. And if I look at my units, I've got a kilogram multiplied by a meter per second square, and of course I've got my cubic meters in there. Um and I can see very clearly that I've got Newtons in here, so I'll do a quick unit conversion. So, my specific weight of mercury is therefore 132,769 Newtons per cubic meter. So, every cubic meter of mercury is going to have a weight of 133,000 Newtons approximately.

So, let's say I've got this 1 cubic meter of mercury, and I know that the force or the weight of this mercury as we've already said is about 133,000 Newtons and it's going to be acting downward like this. So, if I am located at the bottom of this cube of Mercury right here of course I'm going to be feeling the weight of all of that mercury on my body and, as we learned in prior lectures and videos, stress is the force per unit area. So, the weight force is acting downward and it's going to distribute over this 1 meter square area of the cube bottom and therefore, my stress in this case is going to be my 132,769 Newtons of force over 1 square meter of area. And you remember that we defined this unit of Newtons per meter squared we gave it a special name. We called this a pascal abbreviated as Pa, like

that. And this weight force, as you can see in my force diagram over here that weight force is acting normally to the bottom surface and so it's a normal stress, and remember that we give the normal stress that derives from the weight of a fluid a special name and that special name is the pressure. So, in this case I can say that the pressure of this one cubic volume of mercury on the bottom of this cube is 132,769 pascals of pressure.

Now let's imagine that the volume of mercury is doubled as shown in this picture so that my bottom area is still the 1 square meter, but now I have a column height of mercury that's 2 meters high. So my unit weight of the mercury it doesn't change, this is a property of the mercury. So, my specific weight is still the 132,769 Newtons per cubic meter, but now the force that is created is going to be the combination of this unit weight and the volume of mercury in my, in my problem. So, the weight, or the force created by this mercury has doubled now it's 265,537 Newtons. And again, this is acting straight downward like this, so that if I want compute the stress on the bottom of this cube, this is also going to be doubled. So, in summary, the unit weight of a substance, this is a property of the substance related to the density. But the weight force and the corresponding normal stress or pressure, this is a product of the density and the quantity of the fluid specifically of the height of the fluid.

I'd like to thank the National Science foundation for supporting this work under grant number 2335802.

Great job reaching the end of this video. Please reward yourself with just a moment of reflection. 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.