Hi and welcome to Engineering Earth. In this video we're going to review the components of the energy balance equation and discuss how they are applied to open channel flows.

We've already studied the principles of energy conservation in chapter 5, and up to this point we've applied those principles, primarily to internal pipe flows. But these are general principles that can apply more broadly to other types of flow, like flow in open channels. So first please recall that the definition of total head is the sum of pressure head, velocity head, and elevation head and that the definition of hydraulic head is just that combination of pressure head and elevation. So let's talk about how we will apply this in an open channel. Let's say I have a fluid that's flowing in an open channel. So here we're looking at the channel cross-section, so maybe the direction of flow is coming out of the screen towards you. So here is the channel bottom, right here and it's located some distance above our um our datum. So if I measure that distance right here that distance, z, is going to be our elevation head at this point in the channel. So of course I know that the fluid flowing in my channel has to be in liquid phase in order to have you know the free surface developing here that interface between a gas and a liquid. And I know that the gauge pressure right here at that free surface has got to be zero. How do I know this? Well, because the absolute pressure is atmospheric, so that's going to be zero gauge. And so down here at a point at the bottom of the channel, right down here. At this point I know that the pressure is going to be equal to the density of the fluid, the gravitational constant, and the height of the fluid column above that point right. So that height h would be from the free surface down to the channel bottom. And so you notice that this is the depth of flow in the channel. So let's look at something neat here. Notice that I can rearrange our pressure equation in order to derive pressure over rho g equal to h. And of course P over rho G is also the same thing as pressure head. As in the equation above. Um so therefore, the pressure head in an open channel is equal to the depth of flow in the channel, h, now this is just a convention of open channel flow hydraulics. We are always going to refer to the pressure head of an open channel using the variable y. Why do we do this? Well we do it to make it clear that the pressure head is a depth of a liquid in an open channel. So this variable h can be more generally applied as pressure head, it can come from multiple different sources. But when we use the variable y that sends a very clear message that the pressure head is only coming from the depth of flow in an open channel. So it's like a more specific type of pressure head. So then, finally of course we're going to have the velocity head like this, some distance above the free surface of the channel. And so if I wanted to find, map the hydraulic grade line, for instance, it's going to be you know coinciding with the hydraulic head, right here at the free surface of the channel. So here would be the location of my hydraulic grade line at this position in the channel. And then up here at the sum of my total head of elevation pressure and velocity head. This is where I would have my energy grade line. This is where I would find total head, h.

So if we want to apply this to flow along an open channel, the energy balance equations that we used for internal pipe flow are going to be similarly applied. So here's an open channel, now we're looking at it from the side in a longitudinal profile. So down here, this is the channel bed and it is some elevation z above our datum, z equals zero. So at any point within this channel I can find the elevation head, right here. Um and then I've got my free surface of flow right here my flow is moving from upstream to downstream and again at any point in in the channel I can calculate the pressure head as that depth of flow, remember y and then of course I've got my velocity head above that. And so if I calculate hydraulic head at any point along this channel it's always going to be this sum of z and y. So my hydraulic grade line is going to be right along the free surface of my channel, everywhere in the channel. And then my total energy grade line is going to be, above that, a distance of v square over 2g above my hydraulic grade line. So now let's say that I'm going to choose two cross-sections to compare. Let's say that the the one that I've drawn here, I'll call this cross-section number one, and then I'll come downstream over here and I'll compare that to cross-section two down here. So if I want to calculate the energy balance between these two cross-sections, again the total head between these two is going to be equal, less any energy that is lost uh to friction as the flow moves from one to two so the way we've written this in the past: total head at cross-section one minus any energy loss due to friction is equal to the total head at our downstream cross-section 2. That still applies, I could just as easily have written this for an internal flow as, as I've done right here for an open channel flow. And so then if I substitute in the values for total head in the open channel flow then I can write my energy balance equation as the sum of pressure head, which of course is going to be my depth of flow in the channel at cross-section 1, plus velocity head, plus elevation head, minus any energy loss to friction. And now this is going to be equal to the sum of my three energy terms at cross-section 2.

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

Great job class, reaching the end and please reward yourself with a quick 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.