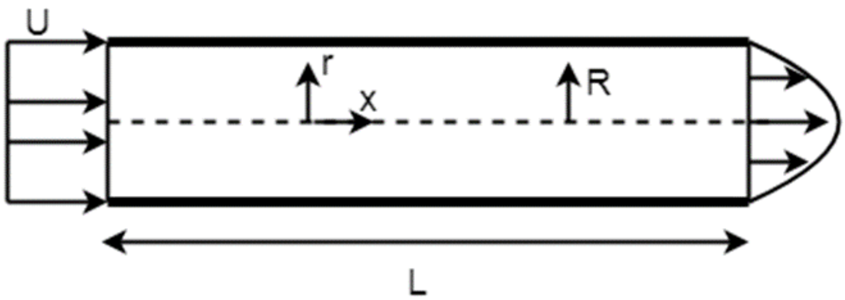
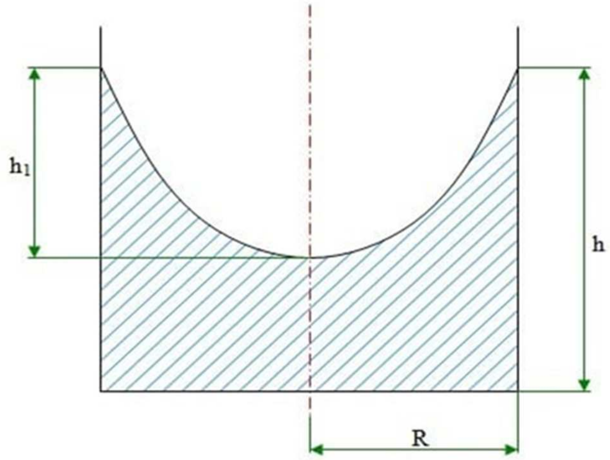
The Short Mathematics of Water by Eva Moradi:

Are you thirsty? Do you fancy a glass of water? As you place your glass of water down on the table, have you ever pondered on its very existence and whether maths has got anything to do with how it behaves? No, probably not. It is a beautiful, tranquil compound that brings great strength to our bodies and minds, providing the fresh glass of water as you awake, or the cleansing shower to kick-start a busy day, or the water that flows through our homes, heating us. As a scientist you might chose to study its chemical structure or behaviour in different states, but not its mathematical tendencies. Well, here we are pondering over the very matter of it. Is water mellow and meek, or is it ridden with deep mathematical concepts, springing with sums and patterns? Let's begin…

Firstly, we analyse water flow. Haruki Marukami, the Japanese Author, said "Just as water flows from high to low over the shortest possible distance, figures can only flow in one direction." This is obviously a metaphorical comparison to numbers, but as a mathematician, I ask you, does water flow "from high to low over the shortest possible distance"? Uniform flow is the regular movement of water across a distance. This distance must be constant for uniform flow. It occurs when the length of water 'flowing' and depth at which is does 'flows' is equal. Already we delve into the mathematical concept of shape. Uniform flow would take place in a rectangular shaped container but not a trapezium shaped container. "But why?", you may ask. Well, if we split our rectangle up width ways, with area x, let's say, into three even sections, we would obtain x/3, x/3, and x/3 because the height and length of each section will always be equal for each equal split. If we split our tricky trapezium into three, width ways again, still with an area of x, we would not obtain x/3 three times, despite the three sections still summing to x. In simple terms, uniform flow is not obtained here because a trapezium's area cannot be split up into lots of the same shape with a depth and a length that are equal. The same would apply for a triangle. This is also due to the fact that water travels in a direct and horizontal line through a channel. Water does not take a triangular route of travel. But you might be thinking about how this would mean water in our oceans does not have uniform flow as there are slopes and gradients in the sea, causing irregularity in depth and height. You would be right! This calls for a different mathematical calculation. The Manning Equation is an equation invented by Robert Manning himself. It considers the fact that water does not always flow through 'passages' with a constant depth. The Manning equation also helps us to determine rate of water flow (i.e., how much of it is travelling and how long it takes to travel). The equation looks like this: $Q = (A \div n)x\, R^{\left(\frac{2}{3}\right)} x\, S^{\frac{2}{3}}$. Yes, I know, it is quite off-putting, especially if you are currently just enjoying a relaxing sip of water. However, there is one variable in this equation which I especially like, and that variable is the S. S is equal to the channel slope in the direction of water flow. This is the gradient of our slope which the water will travel over. What I like is that it proves that maths is the ground of which the water flows upon. This gradient increases the water's rate of flow, due to the downward and positive impacts of gravity, but also because without this numerical value of the slope, the gradient would be zero, and if it were zero, so would our final value for the rate of water flow. Maths allows us to consider factors which affect the simplest concepts such as water flow, yet this equation seems quite complex. Mathematics has its very own way of overcomplicating itself, spiralling into circles of deep calculation, however it always manages to uncoil and provide us with a perfect value. And for this reason, I'm very grateful for maths.



I now meander over to water's artistic skill to form mathematical shapes. I'm sure you have heard of a parabola before… 'a symmetrical open plane curve formed by the intersection of a cone with a plane parallel to its side'. Yes, that's the one! Try paraboloid? This is water's unique shape, its very own crevasse, dip, or well. Often you might be able to see this shape when looking into a bucket of water that is spinning, like a whirlpool. If we drew the curvature formed by this rotating water and sketched in a line through the centre of the whirlpool and called it our y-axis, the distance from the curve of water would be proportional to the distance from our y-axis to the curve (or paraboloid) itself.



Given our curvature takes the shape of a parabola, our equation of this water dip will have an ax^2 term in it. This x will be equal to the distance from the rotation axis, otherwise known as our sketched, vertical line at the centre of our whirlpool. Our y intercept of our parabola will be our last term, an integer. This mainly depends on how much water is in our bucket, being spun in circles. When the water calms and seizes to spin, the y = 0, just as if we ironed out a parabola, making it a straight line, it would have not height, also known as no change in y. This shape is known as a meniscus and it is due to water molecules being attracted to molecules of the container, but its unique shape can only truly be uncovered with the use of maths. Just as a whirlpool exists in nature, so does mathematics, making so very beautiful.

Lastly, I shall spill the exciting topic of water's very own ratio. We often consider water as a mass or measurement in millilitres such as when we are using it to cook, however we never consider its delicate and simplistic measurement in droplets. Research done by Barani Designs Meteorological Sensors and Weather Stations found that for every one millilitre of water, there are 20 droplets. As ratio enthusiasts, we could say that water's ratio is 1:20. We're always learning great, numerical water statistics such as how water makes up 71% of Earth's surface. However, when we think about our daily lives, the average person drinks roughly 2 litres of water a day. This would be 2000 ml and therefore 40,000 droplets. It is something to ponder upon the next time your go out for a walk in the rain.

In summation, water is elegant and easy-going but really it surfaces some of the most challenging mathematical concepts around. It seems arbitrary, but water must never be taken for granted, ever. And I would also say, neither should Maths. I hope you've enjoyed your 4,500 droplets of water whilst reading this piece. And remember, water (along with carbon) is the very reason for human existence so we must study it with great curiosity and love for maths.