Hannah Newton MCEN 4151-001 9/28/2020

The image is of a slow drip of water from my kitchen faucet. The intent of the image is to display properties of fluid mechanics from an artistic lens. The fluid mechanics I was intending to capture are surface tension and a constant mass flow rate that causes the cross-sectional area of the water to decrease as gravity causes the velocity to increase. The very black background, placement of the faucet, and colors are all intended to contribute to artistic quality of the image.

The flow of this water staying together is due to surface tension. Surface tension is a property that makes it seem as though the interface of a liquid and a gas has a skin. This is due to an unbalance in force along the surface. The fluid molecules not on the surface are surrounded by other fluid molecules that are attracted to each other equally. However, the molecules on interface between the fluid and gas are more attracted to the like fluid and therefore have a net force pulling them in towards the fluid (Munson 2013). In this image, the column of water is held together by these walls created by surface tension. The bottom of the column shows water that is no longer being held together the same way. This is because the water's mass is being acted upon by gravity and the weight force is greater than the surface tension force.

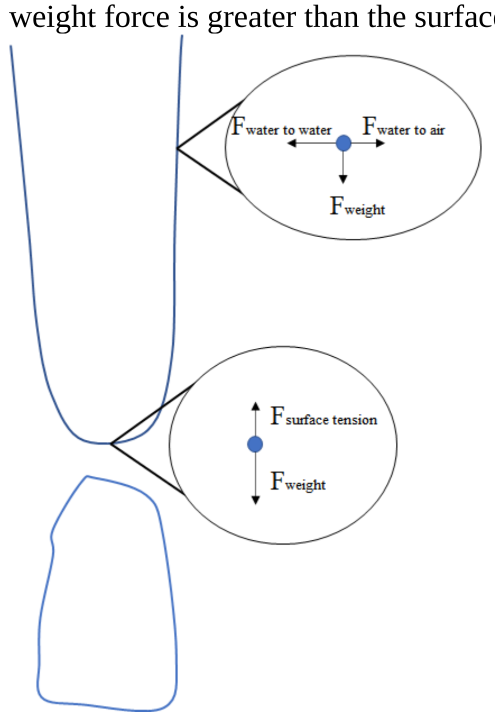

Figure 1, free body diagrams of water molecules that display surface tension's effects

As seen in this diagram, the net force on the side of the column of water is inward, creating a wall like structure. At the bottom, where there are more molecules above a molecule all pushing down on it with gravity, the weight force will overcome the surface tension force.

The other fluid physics that is demonstrated in the photo is the contraction of the fluid diameter as it accelerates. The equation for mass flow rate (NASA) describes this phenomenon.

$$\dot{m} = \rho\, V\, A \tag{1}$$

In this application, it is fair to assume that the density of the water is constant. Also, since mass is conserved, we know that there will be a constant mass flow rate. So, this leaves the area and velocity to be the variables in the equation that change. And since the water has mass and gravity acting upon it in free fall, the water is accelerating. This acceleration increases the velocity. To keep the equation balanced, the cross-sectional area must then decrease. Using the photo and a scale based off the diameter the faucet the radii of the water column can be calculated.

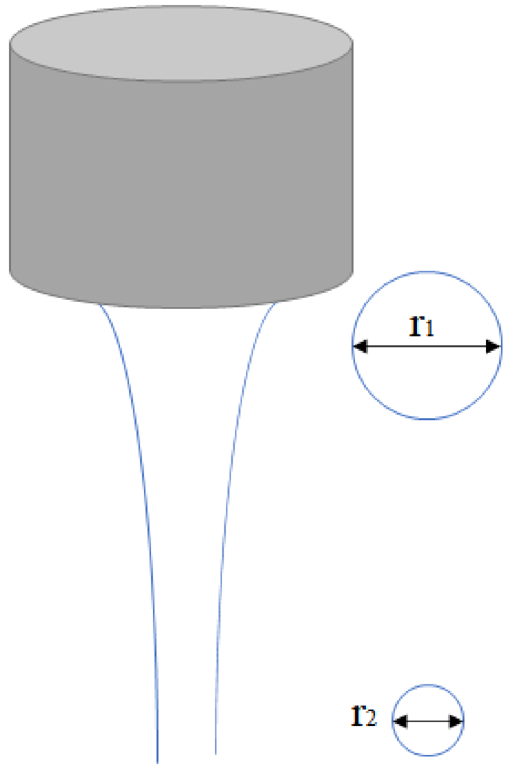

Figure 2, radii of constricting flow

Through this method of scale analysis, r_1 was found 1/8 inch to be and r_2 was found to be 1/16 inch. I measured the mass flow rate of this drip through measuring the time to fill a half cup, 1 minute and 49 seconds. This results in a mass flow rate of $1.13\mu\, m^2/s$. With these two measurements, the velocity of the water out of the faucet is .359 $\mu\, m/s$.

This photo was taken by setting the faucet to a slow drip. Above the faucet, there was a T8 linear fluorescent tube from Philips and in the middle of the kitchen about 8 feet away was a standard 60-watt light bulb. Behind the faucet, black velvet was hung to create the background.

The camera was about 8 inches from the water dripping faucet setup. The focal length of the lens used is 16mm. So, the camera was only a couple inches from the focal length. Getting very close allowed for clear visualization of water and analysis thereafter. The Fujifilm X-T1 that this photo was taken with allows for a maximum resolution of 4896 x 3264 pixels. The aperture was set to +1, the shutter speed was 1/13 sec and ISO was set to 6400. In Photoshop, the image was edited through making the transfer curve steeper in the bottom left, adding contrast. To make the background a more solid black, the black was set, and where the velvet was more illuminated, the patch tool was used to make the background uniform.

The image reveals a bit of mystery, as the water is clear, then motion blurred, then non-visible. Also, the image shows a great contract with the colors and imperfections in the faucet verses the plain black background. The image fulfilled my intent and displayed the physics I wanted to go into. In the future, the image could further investigate surface tension if the droplets were clear after they pull away from the main column of water. Overall, this image fulfilled my goal for it.

Works Cited

“Mass Flow Rate.” *NASA*, NASA, www.grc.nasa.gov/www/k-12/airplane/mflow.html.

Munson, Bruce Roy, 1940-. Fundamentals Of Fluid Mechanics. Hoboken, NJ :John Wiley & Sons, Inc., 2013.