Ben Clairday
Team First
10/06/23

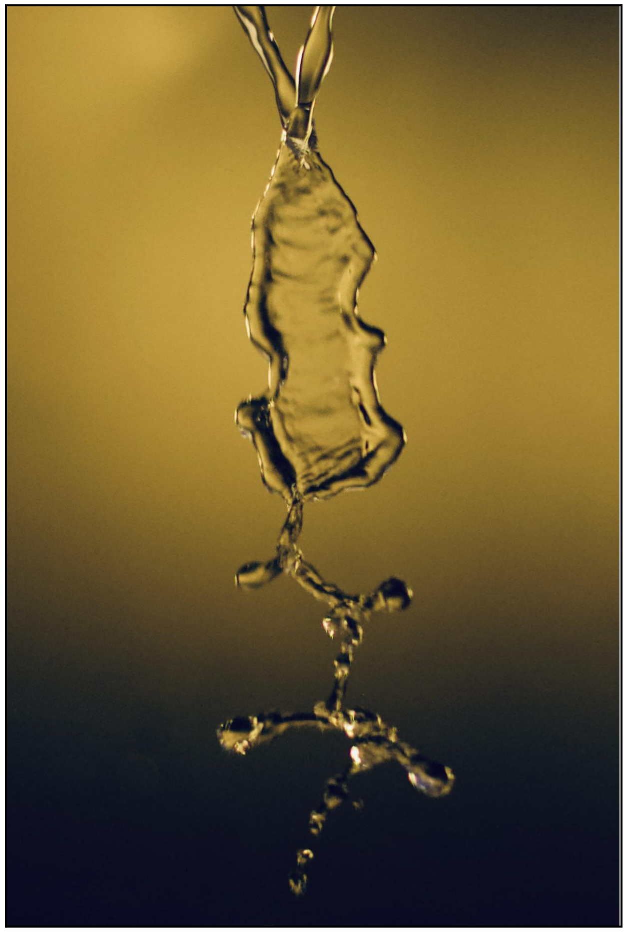

Figure 1: Final image

This report details the work done on the project “Team First” for the course *Flow Visualization* at the University of Colorado Boulder. Flow Visualization is a course specifically meant for engineering majors fascinated in studying fluids and art majors interested in learning techniques to capture fluid flow through images and/or images. The motivation behind this image was to get a fluid flow that resembled fish bones or spread out into a fluid film by having two streams meet (Sharp). Under the right conditions with specific fluid velocities and strobe lighting one can capture this effect. Instead, this group used trial and error for flow velocities that would create the film effect along with lighting from an incandescent light bulb. The supporting team includes Corey Murphey, Venkata Durvasula, and Zachary Turner. Corey acquired the materials needed for this project. Corey, Venkata, Zachary, and the author set up the experimental conditions. Zachary held the lighting during the time these photos were being taken.

The flow phenomenon was created by connecting a ¼ inch inner diameter (ID) tube with a (⅜ inch outer diameter (OD) to the ITLL faucet on the first floor and fitting that to a reducing connector with sharkbite attached to a tube with a 0.170 inch ID and ⅜ inch OD. Two pieces of 0.170 inch ID and ⅜ inch OD diameter tubing were fitted onto the central tube with a t-shaped connector that had sharkbite tube connectors as well. A tube was used for support and duct tape (figure 2). The streams coming out of the tubes were then crossed into each other to get the effect seen in the title image used for this report.

Figure 2: Photo of experimental setup.

The effect seen in the photo can be explained by several effects and forces acting on the two streams as they meet. The main contributing forces besides gravity are the force due to the fluids pushing each other, cohesion due to intermolecular forces such as the Van der Waals force, and centripetal force. These three forces interact by the two streams meeting, altering the movement of each other while creating a thin film as the intermolecular forces bring the fluids together. The cohesion acts upon the fluid so it is brought into a point which leads to film formation. The film is also created due to the surface tension of the water. The film is ultimately destroyed and leads to an unstable single flow with a zig-zag pattern due to Plateau-Rayleigh instability.. Of course, there are certain conditions that need to be met for these conditions to happen. One of which is when the Reynolds number is sufficiently high, the jet collision generates a thin fluid sheet that evolves under the combined influence of surface tension and fluid inertia (Bush et. al). A reynold's number is calculated with the estimated stream speed of the water in the tube as 5 meters/second [m/s]. The distance the water traveled as it left the tube was about 0.10 meters. The kinematic viscosity of the water is roughly $1.004 \times 10^{-6} \frac{m^2}{s}$. The Reynolds number can the be calculated as:

$$Re = \frac{uD}{\nu} = \frac{5 \frac{m}{s} \bullet 0.10\, m}{1.004 \times 10^{-6} \frac{m^2}{s}} = 498008,$$

which is indeed in the turbulent stage. Thus verifying that the water film is created by two turbulent streams.

The visualization technique used was two fluid flows meeting in front of a black backdrop, lit up by an incandescent lightbulb in a metal cage that made it possible to direct the light (figure 3). The other lighting was fluorescent lighting from the ceiling lights in the ITLL on the CU Boulder campus.

Figure 3: Light source used.

This image was taken with a Canon EOS 40D DSLR on a 50 mm lens. The settings used were an ISO of 800, shutter speed of 1/2500s, and f/1.8. The camera was about 0.5 meters away from the fluid flow. The image was manipulated by using a “vivid cool” filter through apple photos. The filter brightened up the image in the top half of the frame and made the yellow more intense than it is in the unedited image. The unedited image is included in this report (figure 4).

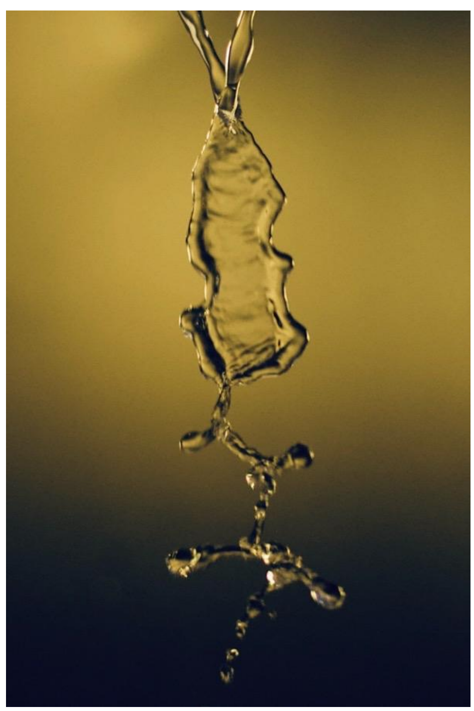

Figure 4: Unedited image

The image reveals an interesting pattern created as the two flows meet. The fluid physics is quite interesting in which a film is created through cohesion, then ultimately destroyed due to the Plateau-Rayleigh instability. The physics are displayed decently in the photo, but could be improved by trying to round out the rim of the film to show the importance of the surface tension and cohesion. In the future it would be interesting to experiment with fluids with varying viscosities, to see how that affects film and fluid chain formation.

References

Bush, John W.M., “Fluid Chains and fishbones”, Accessed 9/17/23.
https://thales.mit.edu/bush/index.php/2004/03/14/fluid-chains-and-fishbones/

Bush, John W.M. and Hasha, Alexander E., “On the collision of laminar jets: fluid chains and fishbones”, J. Fluid Mech. (2004), vol. 511, pp. 285-310. DOI: 10.1017/S002211200400967X.

Sharp, Nicole, “Fish Bones”, FYFD. Accessed 9/17/23.
https://fyfluiddynamics.com/2013/02/when-two-liquid-jets-collide-they-can-form-an/?doing_wp_cron=1694984936.6303589344024658203125