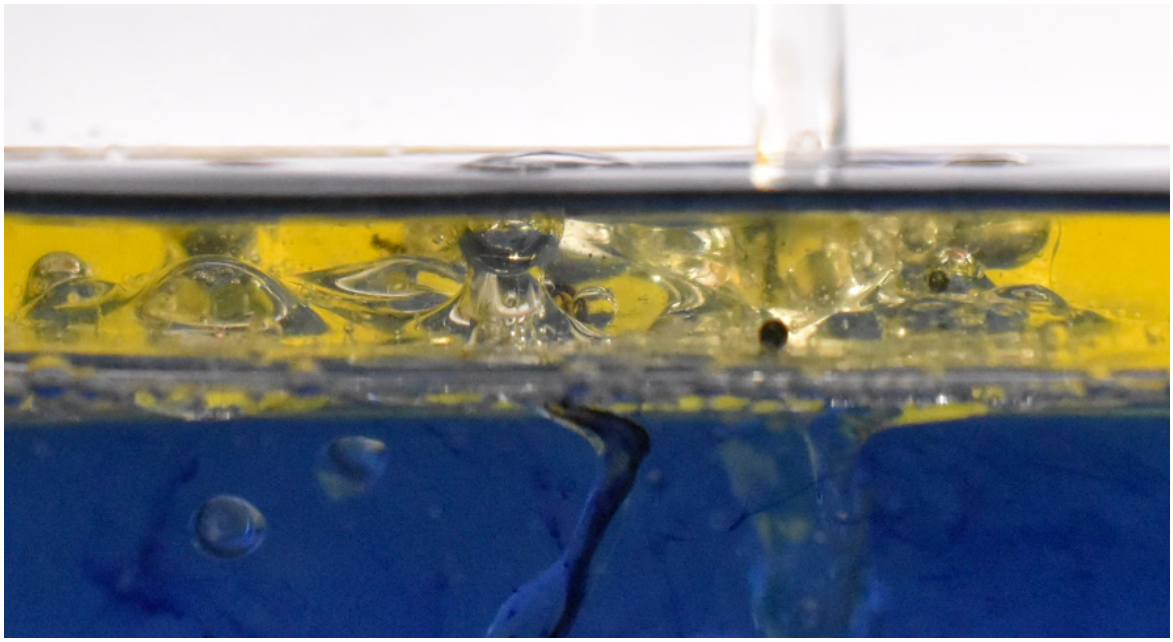

“What if we just add more oil?”

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What started out as an experiment to view the velocity profile of water, through different dye techniques, as a moving plate was on the surface, quickly turned into an accidental visual of a few flow phenomena in oil droplets. After realizing our intended experiment was a failure, the sentiment became “well what if we just add more oil” and a thick layer of oil developed on the water’s surface. Food dye was used in the oil stream on a toothpick to try and pick up thick droplets of dye, the issue of insoluble dye only allowed for a few drops to be made. The resulting experiment captured droplets of air, oil, and water being formed in the thick oil layer.

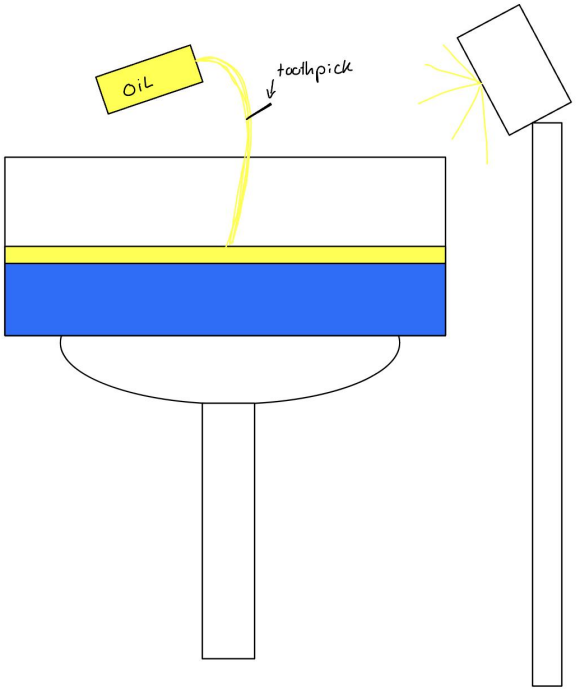

Figure 1: Experimental setup.

This experiment was done in a 15 gallon fish tank with 10 gallons of purple-dyed water and 24 oz of vegetable oil. The Great Value oil container was held approximately 1.5 ft above the water’s surface and was poured in a steady fashion that visually resulted in laminar flow. A toothpick was dipped into purple food dye, from Wilton, and was held in the oil stream to try to pick up dye —it was largely unsuccessful. A large overhead light that produced both yellow and white light was used and was positioned approximately 2 ft above the fish tank. The oil layer ended up being around 1 inch thick, which was perfect to show bubble forming behavior along with clear distortions of the oil-water interface.

The formation of the bubbles and turbulence are the product of two major fluid principles at work: Taylor-Rayleigh instability and Plateau-Rayleigh instability. These principles are not defined by any non-dimensionalized number and describe how fluids of different densities behave and consequences of its own surface tension. The more famously known Taylor-Rayleigh instability describes that fluid motion will result from two different substances of different

densities trying to reach static equilibrium. This phenomenon is shown through the bubbles of oil, and air that diffused into the water through turbulence, that are rising from below and are breaking into the oil layer.

The Plateau-Rayleigh instability, as stated before, is a by-product of a fluid's surface tension in a stream. In this case, the oil stream penetrates its own oil layer and the water. Surface tension effects will cause a “breakage” of the stream into small we particles to minimize surface area. This phenomenon is independent of the secondary fluid’s properties (i.e. water and air) and is strictly the oil’s surface tension. In the image, this is shown by the middle column of air & oil that is forming an almost mushroom cloud-bubble. The surface tension effects will eventually cause the top bubble to completely detach from the base, and the base will return to a horizontal position.

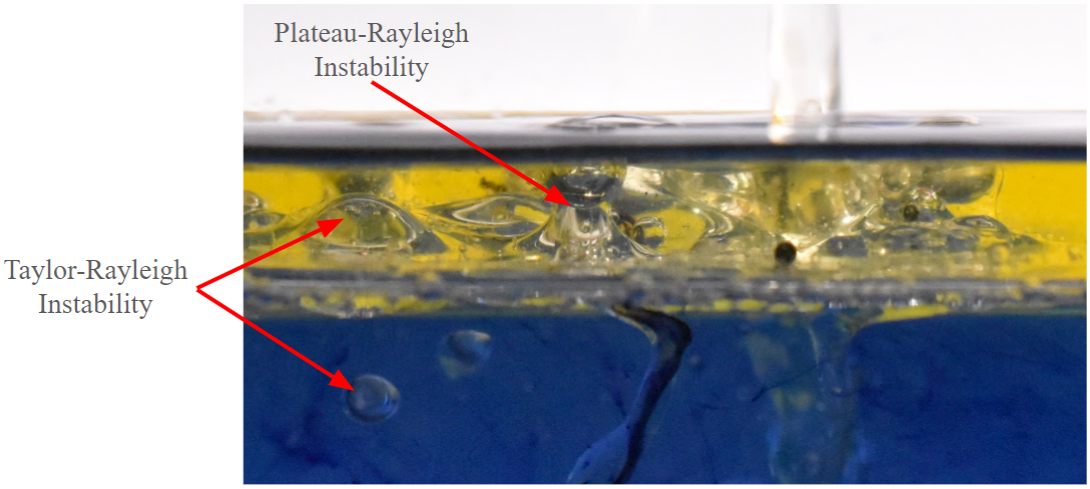

Figure 2: Fluid instability example location of occurrence.

While this was not a still experiment, as evident from the fluid motion, for once a screenshot of a video was not used to capture the motion. The lighting aided the clarity of the shot significantly and so light after effects were needed to enhance colors. This photo was taken on a Nikon D5500 with a Nikon AF-P Nikkor (18mm-55mm) lens with the following settings: f/7.1, 1/800 sec, ISO 6400, and EXP 0. There was significant trial and error with the settings to capture the colors of the oil and water while also ensuring focus was on the drops and not the glass, as it tended to do. The original image size was 6016 x 4016 pixels, but it was reduced to 952 x 530 pixels to create a more appropriate aspect ratio of air-oil-water ratio. The original image was mostly blue and white and did not allow for the details in the oil to be clearly visible. To represent the colors as close to what was seen in the experiment, Darktable was used to increase the global vibrance to +14.05% and global saturation was increased to +10.74%. Originally, more settings were changed –like black/white relative exposure and local contrast– but they enhanced the grainy look already from significant cropping.

The original experiment that was planned was to pay homage to the many flat plate problems studied in both undergraduate and graduate fluid dynamics classes, but the

experimental setup was not tuned to capture the fine dispersion effects. However, the frustrated attitude that resulted in an obscene amount of oil being put into a fish tank resulted in some interesting phenomena, both are not often thought of but are encountered frequently in everyday life. I am happy with the final image and I believe that even though it is not striking, it is very interesting! The oil layer is “relatively” thin and acts as its own little world, reflecting the light source across the different interfaces. The focusing of the camera on the glass instead of the oil or dye behind it presented a frustrating challenge that I feel ruined some of the effects within the water, but it is because of the blurred details elsewhere in the image that the focus is easily drawn towards the center oil layer. Such an unintended accident lended a helping hand artistically and made it a photo instead of just an image.