# Team Third Fall 2025

# Oil Suspended On Water

**Nathaniel Wheaton Flow Visualization 5151-001, 11/2/2025**

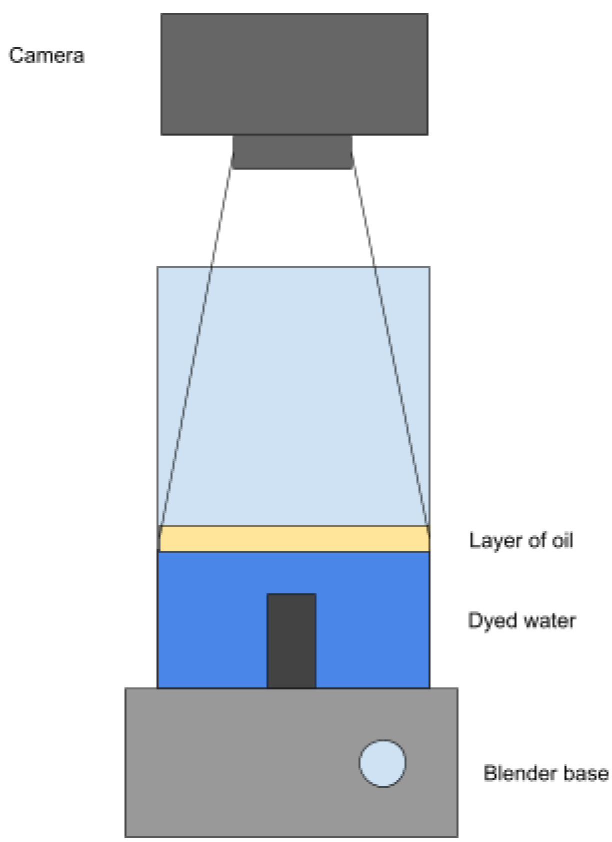
Figure 1: Oil on dyed water seen from above

# Intent

The scientific intent of this experiment is to explore the formation and development of a fluid vortex created by spinning the center point of a fluid reservoir. The vortex shape is impacted by a layer of oil suspended above the water. I chose to visualise vortexes because I have always been fascinated by the fine details in their motion, and decided to continue using a "Theme" from Team First.

# Experimental Setup

I generated a vortex using a blender with the blades removed to rotate the center of the fluid. To visualise the structure of the vortex dye was added to the water, and oil was added to the surface of the oil. The blender was run on a low speed "Dough" which ensured that the structure of the oil was minimally disturbed. The video was taken from above the blender enclosure, the width of the blender was about 12 cm at the height of the oil. The depth of the fluid was about 8 cm. The type of oil used was soybean oil. The width of the spindle is ~1 cm. Over several recordings I added red dye to the mixture, and by the end of the recording process the entirety of the water was red. The flow was illuminated by ceiling mounted LEDs.



# Flow Analysis

The fluid vortex was initiated at the center of the blender, centered on the blender spindle. The flow was generated by the fast rotation of the center spindle. This rotation imparted velocity to the fluid, creating a centripetal force resulting in a core of air at the center of the fluid vortex. During the vortex large “bubbles” of oil can be seen elongating along the surface of the vortex. This large area may be similar to the oil coated bubbles seen by Ji, Yang, and Feng [1]. We can estimate the rpm of the center spindle to be ~100 rpm. the Reynolds number using the diameter of the spindle for our characteristic length and finding the velocity from the rotational rate, using ν = 1.0*10^-6 m^2/s for water.

$$Re = \frac{UL}{\nu} = \frac{2\pi r f L}{60\nu} = \frac{2\pi * 0.005 * 100 * 0.01}{60 * 1.0 * 10^{-6}} = 523.59$$

This relatively low Reynolds number indicates that the region of water directly in contact with the rotating cylinder was laminar. Since the fluid is likely at rest at the very edge of the basin, at lower “Dough” settings on the blender, the entire flow is laminar. Towards the end of the video I attempted to run the blender at its full speed (which may be about 10000 rpm), which would result in a much higher Reynolds number (52,359) which would certainly be turbulent. This can be seen clearly by the mixing of the oil and water, which was much more thorough, and none of the oil “bubbles” were seen in this mode. In the normal mode after a short amount of time ~10 minutes, the flow separated, and the flow could be repeated, however in the faster mode the flow did not separate in a similar amount of time. This is similar to the phenomenon described by Krebs et al [2], where they describe the coalescence of oil with the formula:

$$\frac{dV_s}{dt} = V_t \frac{dn_c}{dt}$$

Where Vs is the average volume of a droplet in the topmost emulsion layer, and dnc/dt is the rate of coalescence rate. From this formula we can see that in a situation where the initial average volume of the droplets in the uppermost emulsion layer is larger, then the time it takes for the oil to completely separate would be smaller, we can conclude that the small size of the droplets in the faster case would result in a longer time for the oil to fully separate.

# Photographic Technique

The video captures the overall shape of the vortex from above, including the air core at the center of the  blender. Some of the fine details are missing from the final image, this is likely due to the somewhat low resolution I created the video in, this is due to the fact that I am inexperienced in taking video using my camera

I used a DSLR camera, specifically the Canon Eos Rebel T3i. The resolution of the video is  1280 x 720 pixels. With a frame rate of 60 frames per second. I used Capcut to edit the video, I made minor adjustments to the lighting and added music from Swan Lake by Tchaikovsky. I mixed several videos together and reversed the flow to create an interesting visual which featured a reversed vortex. Due to the fact that the submitted visual is a video, I do not know how to extract the aperture, focus, and ISO settings.

## References

[1] B. Ji, Z. Yang, and J. Feng, “Oil-coated bubble formation from submerged coaxial orifices,” *Physical Review Fluids*, vol. 6, no. 3, Art. 033602, Mar. 2021. DOI: 10.1103/PhysRevFluids.6.033602.

[2] Krebs, T., Schroën, C.G.P.H., & Boom, R.M. (2012). “Separation kinetics of an oil‑in‑water emulsion under enhanced gravity.” Chemical Engineering Science, 71(3), pp. 118–125. DOI: 10.1016/j.ces.2011.10.057