

Questionable Uses of Milk, Oil and Pepper

Flow Visualization ATLS 4151

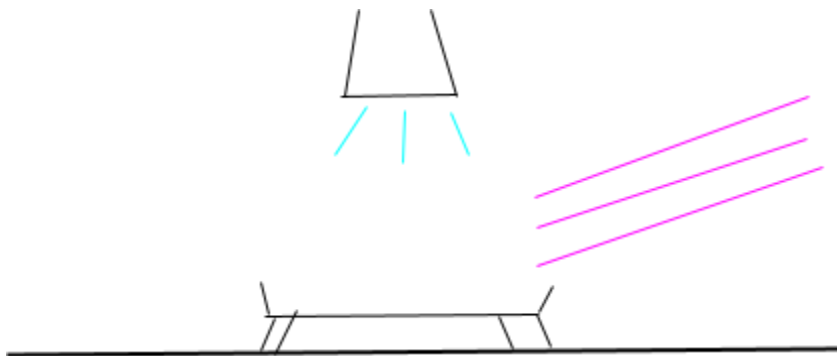
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9/26/2025

Introduction

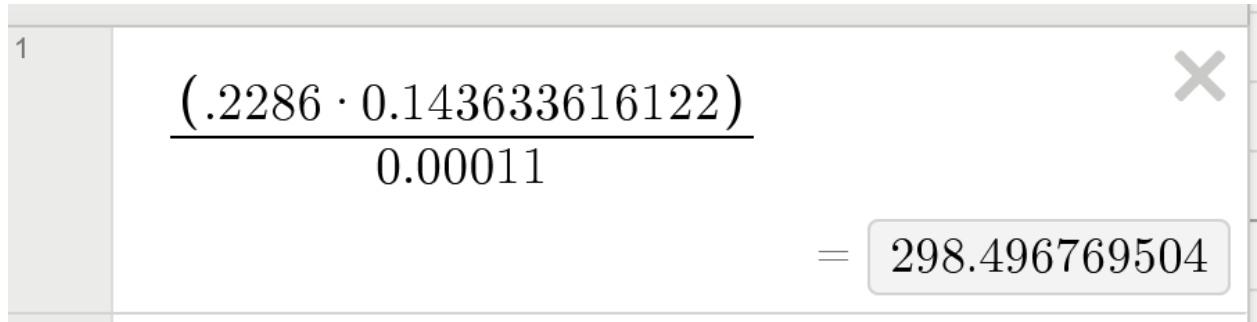
Almost everyone who has driven a car for a long time has probably had some similar experiences. Mainly on a hot day, cranking the AC and waiting in irritation as it attempts to cool the heat box down, only to face the slap of disappointment when it barely does anything. Whether this is psychological or not, I have no idea. But! This line of thinking led to some interesting questions around how varying density fluids interact when acted upon by an outside force, unfortunately at the time there wasn't much in the way of a feasible setup to display a phenomenon of air mixing. So my thoughts, as most people's do, (with a few steps in between) drifted off to the incredible, stunning, mystifying concept of oil spills. Oil upon water, trapped inside ocean currents that shaped its flow and bounds. Immiscible fluids and an idea. Crude oil wasn't something on hand at the time, however the pantry and fridge provided some alternatives. With the goal of seeing how immiscible fluids act under even pressure in a closed system cowabunga it was.

Setup



The setup used was a 9 x 13 glass baking dish set on top of once inch spacers over a glass table. A lamp shone down onto the center of it in an otherwise dark room. (light blue for light) while a fan blew air (pink) at a downward angle over the top of it. Which produced a constant force in one direction that collided with the walls of the baking dish in a facsimile of what the larger scale vortex would be. In general the mixture of fluids was moved, collided with the walls and then flowed back along the side, forming one

large swirl as a result of Newton's basic laws of motion and the principles of solubility between the mostly polar milk and the non-polar oil. (watermedia.org) Enough milk was used to coat the bottom of the pan (about ½ cup) and ¼ of a cup of oil was added along with a tablespoon of cracked black pepper.


$$\frac{(.2286 \cdot 0.143633616122)}{0.00011} = 298.496769504$$

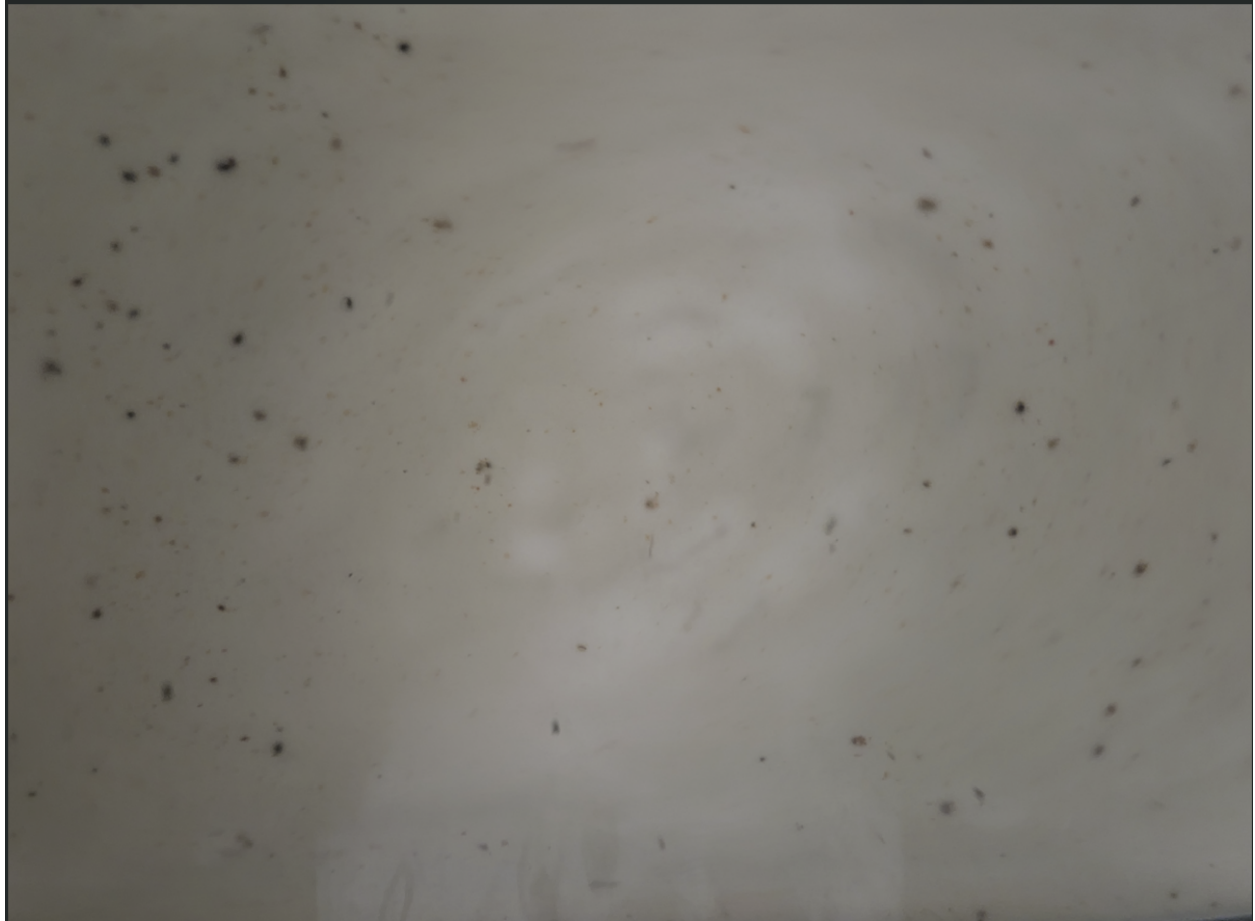
Due to the circular flow a modified version of the Reynold's number formula was used. Diameter of the circle (measured as the width of the narrowest part of the pan) * velocity (extrapolated from frequency of a complete loop) divided by the viscosity of vegetable oil (roughly 110 mm²/s around 20 C) to produce the number in the figure above. Which is firmly in the range for laminar flow. Which considering the minimal strength of the simulated wind acting on it and the collisions with the side of the pan to simulate stronger currents the circular shape begins to make sense.

Visualization

There were no dyes added to the milk or oil, the pepper over top not dissolving into either and serving more as a good indicator of how fast the mixture was swirling. The largest of the visualization came from the camera, where the long exposure captured the swirling and altering the white balance made the distinction between the fluids clearer when viewed at a still.

Photography

The taken picture was 4080 by 3072 pixels on a pixel 9 pro with f/17 and an iso of 876. The shot was taken from underneath the dish shooting into the light through the table where spacers put the bottom of the dish 2 inches above the table.



This was the original image, which through changing the hues and increasing the contrast of the image became the image shown in the main post.

Final thoughts

The image was intended to show the mixing/ flow patters of immiscible fluids when under outside stimulus in a fixed environment, and to that extent it did okay. It does show the hidden flow patterns over a period of time, however there is no distinct fluid phenomenon that is shown. I can appreciate how much was pulled from a simple concept, however there isn't much of interest, and there isn't an evoked feeling the image creates. It feels like staring at a sheet of rock, which may be fascinating, is less intense than I would have liked. If I were to develop this idea further I may try it with more distinct substances and a more accurate setup with dyes and micah powder. However I am not particularly enthused about such a plan. I would be curious to see how this changes with a deeper tank and temperature changes of the ocean, and how this may change with the inclusion of obstacles within the path or with miscible fluids. Overall the image is one that I am not dissatisfied with nor satisfied with.