Get Wet Image Assignment

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Flow Visualization
Professor Jean Hertzberg
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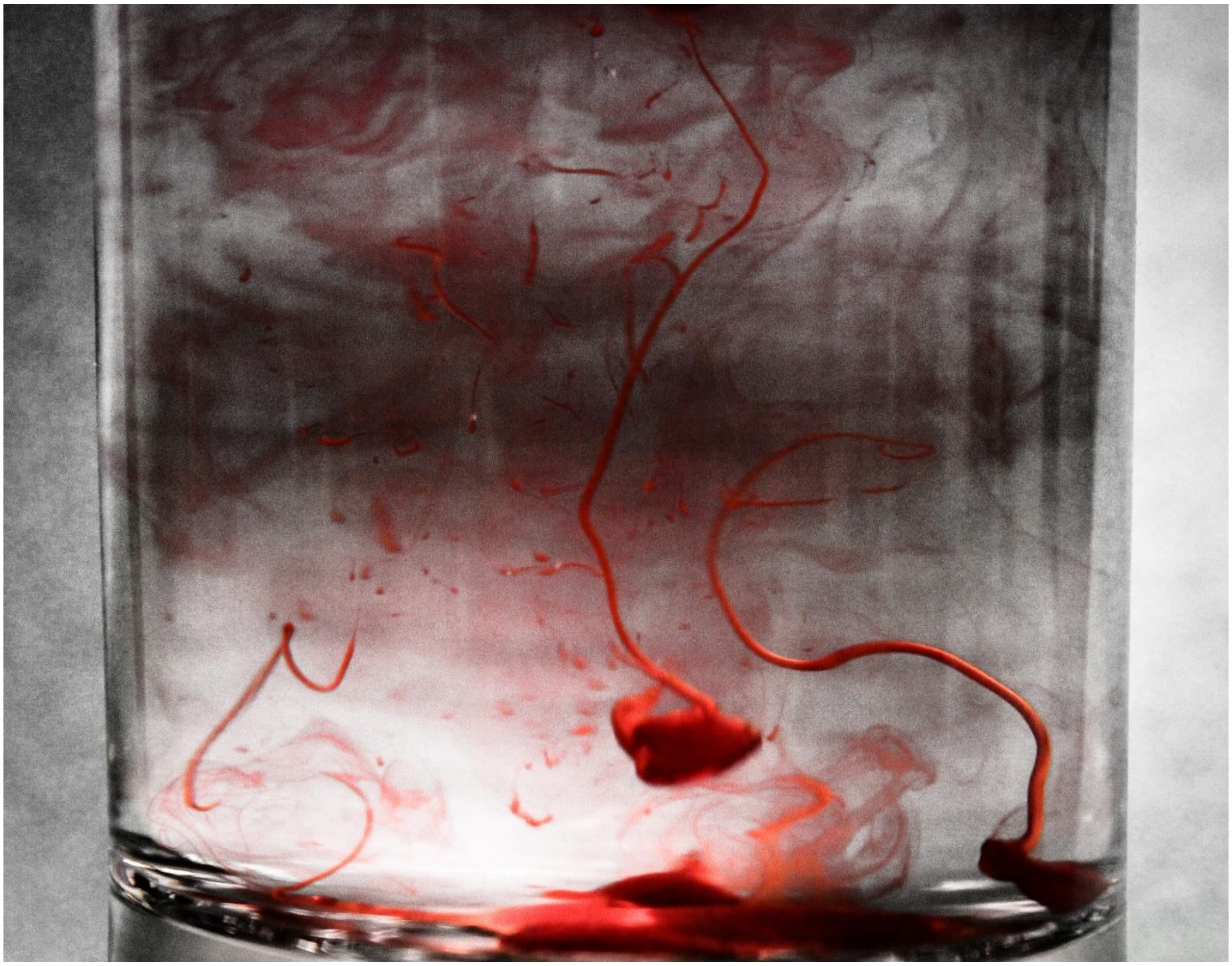
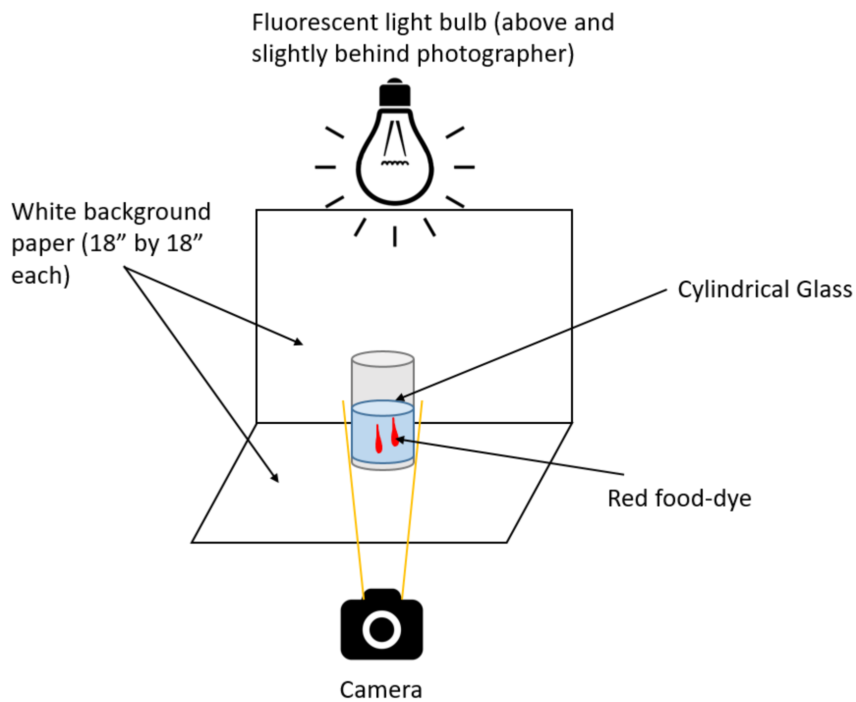


This photograph embodies an amazing fluid flow produced by merely dropping red food dye into a glass of cold water. For a first project, I chose to display a beautiful flow that can be easily dissected into the physics that creates it. The intent of the image was to display an extremely interesting flow pattern that is difficult to describe yet simple enough to reconstruct for observation. The objective was to reveal fluid patterns and instabilities and consider the potential causes of such an occurrence. I would like to thank my teammate, Preston Marcoux, with his generous help in creating this image.

In regard to the flow apparatus, I used an indoor lighting scene with a single fluorescent light about 3 feet above and slightly behind the camera/photographer. I used two sheets of white paper (18" by 18" each) as the background and rested the camera on the table about .2 meters away from the cylindrical glass. The diagram below shows all of this in a visual form.



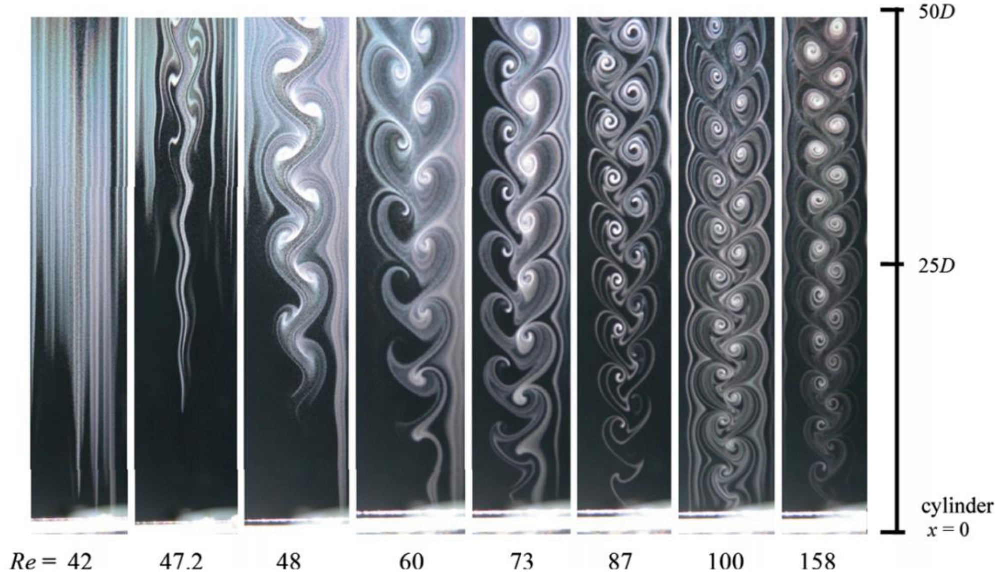
The flow that I captured in this image involves red food-dye dropped into cold tap water. Due to the food-dye having a greater density than the water, buoyancy forces occur causing the food-dye to sink into the water. Because the water is so cold (about 10 °C or 50 °F), the dye takes longer to diffuse than if it were in warmer water. In cold water, molecules move more slowly, in turn causing the dye and water to mix slowly. At the time the photo was taken, a few seconds had passed between droplets so the dye that had already sunk to the bottom had begun to diffuse. In the case of this photo, the cold water causes the dye droplets to largely remain intact as they fall to the bottom of the glass. Yet interestingly enough, tails spiraled off the back of the droplets. An important aspect in characterizing this flow is the Reynold's Number. The Reynold's Number determines fluid flow patterns and, when calculated, expresses whether the flow is laminar (smooth), turbulent, or transitional. In order to calculate this number, we measured the velocity of the dye as it sank in the water using a timer as well as using frame-rate analysis. The velocity scale was chosen to most precisely represent the fluid flow using what we had available for the testing.

Distance traveled by dye = .09m
Time to drop .09m = 1.2s
Velocity = .075m/s = μ

Temp. of water = 50 °F
Temp. of food-dye = 70 °F
v = 52 cST = .000052 m^2/s – (Engineering Toolbox - Propylene glycol (main ingredient in food-dye) @ 70 °F)

Re = $\mu D/v$ = (.075m/s)(.09m)/ (.000052 m^2/s) = 129.81 (Laminar Re < 2000)

The calculated Reynold's number of 129.81 theorizes a laminar flow which means there is a smooth motion to the dye as it sinks in the water. We can also presume from this low Re that the tail of the droplet may be a Kármán vortex street caused by vortex shedding. Vortex shedding occurs when water flows past a blunt body creating vortices at the back of the body that may occasionally detach[4]. This phenomenon is displayed below with a steady flow over a simple cylinder.

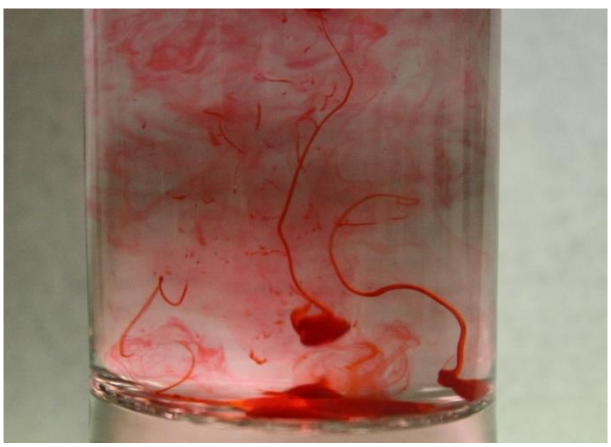


(Image credit: Z. Trávníček et. al)

The visualization technique displayed in this image is dye-dropping. It is simple food-dye bought from Safeway. The glass used to hold the water and dye came from my house and the water was just from the tap. The lighting used is merely a fluorescent light bulb that was above and behind the camera.

With respect to the photographic technique, I shot the object at 1/125s to be able to get the quickly moving object without motion blur. The image was taken at about .2m away from the lens in order to be close enough to see the droplets flow yet still be able to get a good focus on them. Since I was trying to take a shot of such small droplets, my depth of field was of little worry and so the aperture was set to f/4.5. The field of view was set from a 35mm lens and the ISO was 3200 due to me only using a single light that was not super bright. The original image was 5184 x 3456 pixels and the edited version came out to 4210 x 3294 pixels. The image was captured using a Canon EOS REBEL T5 curtesy of Preston Marcoux. Lastly, the clarity and contrast edits as well as shadow and exposure changes were done through Adobe Photoshop Express.

The image reveals the magnificent and quite mysterious flow of red dye in cold water. The beautiful tails of the droplets which may be Kármán vortex streets are interesting and give the droplets a vein/blood-like look which I was excited to be able to capture. My intent of capturing food-dye diffusion was fulfilled but in a slightly different way than I had imagined. The shadows on the droplets due to the lighting are perfect, but I wish I had been able to get the droplet in the middle more in focus. Although the darkness gives the image a little mystery, I wish I had a brighter image and had a bit whiter of a background to give it more contrast. I would like to know if the tails are truly due to vortex shedding or some other phenomenon. I would like to take this idea further by trying multiple colors at once to see if can them with their tails before any diffusion occurs.



Original

Edited

Cited Sources

1. Hill, Kyle. "Food Coloring, Fluid Dynamics, and an Awesome Lab Demo." Science Based Life. N.p., 17 Oct. 2012. Web. 8 Oct. 2016.

2. "Liquids - Kinematic Viscosities." Liquids - Kinematic Viscosities. The Engineering Toolbox. N.p., n.d. Web. 11 Oct. 2016.

3. Wikipedia contributors. "Kármán vortex street." *Wikipedia, The Free Encyclopedia*. Wikipedia, The Free Encyclopedia, 17 Sep. 2016. Web. 17 Sep. 2016.