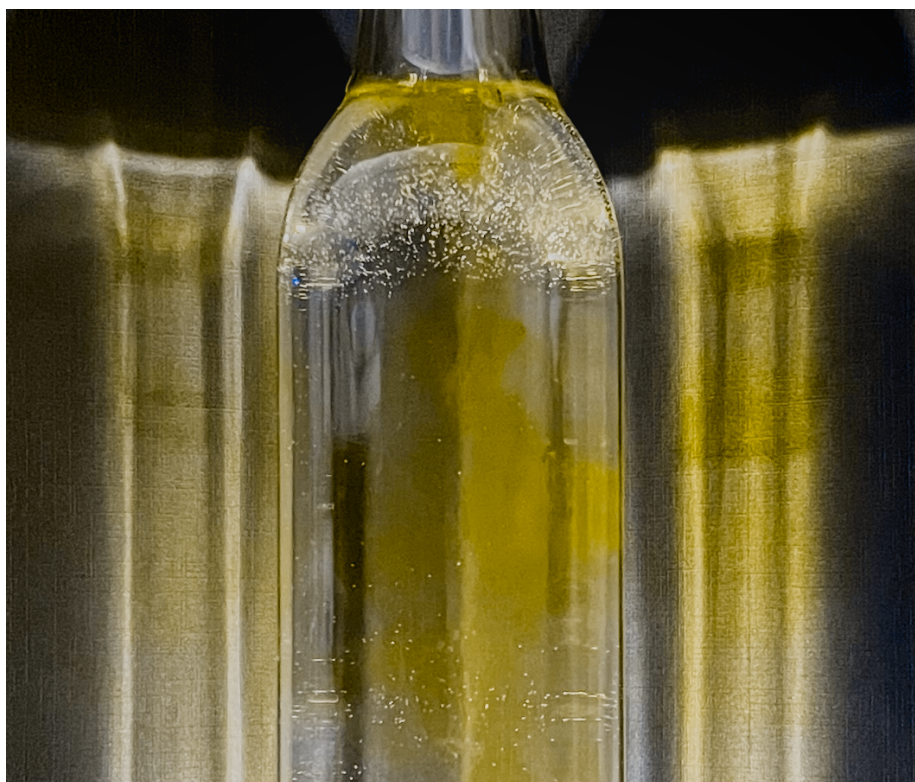


Get Wet 2026

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1 Introduction

For this individual, get wet assignment, I decided to photograph cloth dye as it was dropped into a bottle of water. I was hoping to capture the effects gravity had on dye and how it created turbulence in the water leading to a dispersion of color throughout the bottle.

2 Flow Set Up

When setting up the flow I knew I needed a container and a dye but that was the extent of it. I had purchased three items initially: a rectangular container with a depth of 2 inches, a bottle of yellow clothe dye, and a dropper. During initial experimentation I found that the shallowness of the container meant that it was essentially impossible to view the dye swirling into the water. Figure 1 displays the initial setup looked like. Note that the dye has very little room to travel before reaching the bottom.

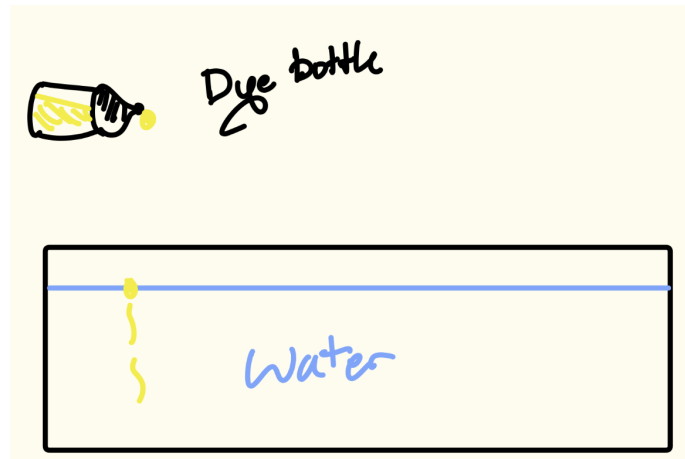


Figure 1: Sketch of initial setup with a shallow base

With that, I opted to use what is seen in the image, a taller bottle which is typically used for olive oil or balsamic vinegar. Figure 2 displays a sketch of what I ended up using for the final image.



Figure 2: Sketch of final setup with a deeper base

3 Fluid Behavior

Before delving into the forces and specifics of the flow, it's important to discuss what specific fluids were being used. I used Rit All Purpose Golden Dye as the marked boundary which was dropped into room temperature tap water. I encountered difficulty determining the exact chemical composition of the dye, so for the sake of simplicity we will assume that the dye has the same density of water. This is a fairly safe assumption to make as we watch the dye disperse into the water fairly evenly with no large amount of dye moving to the top or bottom of the bottle.

As we discuss why the fluid takes on this specific flow, we will begin by acknowledging the major forces acting upon it. The main force that acts upon the dye in this case is gravity and shear forces of the water interfacing with it. As the dye makes its initial impact with the surface of the water, the initial collision disrupts the surface tension of both the dye and the meniscus layer of water leading to an initial plume dye near the top. As the dye is carried by inertia further into the water, it disperses more evenly as shear forces between the water and the dye cause it to slowly strip away from the droplet it once was and becomes a more homogeneous mixture with the water.

Of course, purely mentioning what forces were acting upon it isn't enough without having metrics aside it. In particular, we can use the Reynolds number to further discuss whether or not the flow appears turbulent or laminar. We can

use the equation

$$Re = \frac{\rho v L}{\mu}$$

where ρ is our fluid's density, v is the velocity of the fluid, L is the distance it travels, and μ is the dynamic viscosity of the fluid.

Making the initial assumption that our dye shares characteristics with water we can arrive at the conclusion that

$$\rho = 0.99802 \frac{\text{grams}}{\text{cm}^3} \quad \mu = 0.0009737 \text{Pas}$$

These numbers are courtesy of Water Science School [4] and Engineering Toolbox[2]. It's important to note that these values do vary slightly depending on temperature. I used the values for these numbers provided the water and dye are at room temp. The other values will be a bit more difficult to determine.

Velocity will have to be derived using the equation

$$v = \sqrt{2gh}$$

where g is the acceleration of gravity and h is the height of release. These are fairly easy things to determine. With a ruler I measured that the distance I dropped the droplet from was 3.5in or 8.89cm. Further, the constant of gravitational acceleration is a constant of $9.81 \frac{\text{m}}{\text{s}^2}$

Plugging in these values we find that

$$v = \sqrt{2 * 9.81 * 0.089} = 1.32 \frac{\text{m}}{\text{s}}$$

Note that the value of the height was converted to meters.

With this, we can now determine the value of the Reynolds number. The characteristic length of our bottle can be assumed to be 14cm which is roughly as far as the fluid traveled.

$$Re = \frac{0.99802 \frac{\text{grams}}{\text{cm}^3} 1.32 \frac{\text{m}}{\text{s}} 0.14 \text{m}}{0.0009737 \text{Pas}}$$

$$Re = 189415$$

This indicates the flow is turbulent by the time the image was taken. This makes sense given what we are seeing as the yellow dye in the bulk of the photo is largely cloudy without clear streak lines.

Another factor that plays into this is diffusion, "Diffusion is the process by which particles of one substance spread out through the particles of another substance" [1]. Diffusion occurs because the dye is very hydrophilic, meaning that it loves liquids. When it comes into contact, it is attracted the water and begins to spread out rapidly into the rest of the liquid, filling the container.

More specifically, "most dyes also contain groups known as auxochromes (colour helpers), examples of which are carboxylic acid, sulfonic acid, amino, and hydroxyl groups. While these are not responsible for colour, their presence can shift the colour of a colourant and they are most often used to influence dye solubility" [3]. They operate by adding more polar or ionizable groups that are favorable in the conditions of water. This leads to the dye spreading out rapidly once it enters the water as the charge in the molecules of the dye attract to the molecules in the water.

4 Visualization Technique

For the visualization technique I opted to go for the marked boundary approach as well as light contortion. My initial plan was to use diffused light to simply illuminate the marked boundary provided by the dye; however, the light ended up being used as a way to locate the concentration of dye in a two dimensional plane.

Marked boundary techniques are fairly straight forward. They only require a contrasting medium in the flow which provides a "marked boundary" of the flow to better visualize what is going on. For this, I used Rit All Purpose Golden Dye. I did not dilute the dye at all aiming to have the most vivid color when added to the water itself. While not critical, the water and dye were, again, both room temperatures. This implies that they had a lower viscosity than if they were warmer which can affect the flow of the fluid.

As for the lighting, I used a flashlight and headlight with some tissue paper over it to diffuse it. I had hoped that the tissues would diffuse the light enough to the point where it would provide an even lighting, and the black background could absorb any incident light refracted onto it. This was not entirely the case, which ended up working in my favor I believe. The light being a bit more abrasive than I had hoped lent itself to creating this "streak lines" along the paper background where you can see the concentration of dye throughout the water.

This in particular happened because I set the lights at 90 degrees to each other as seen below in the diagram below. Figure 3 displays the configuration.

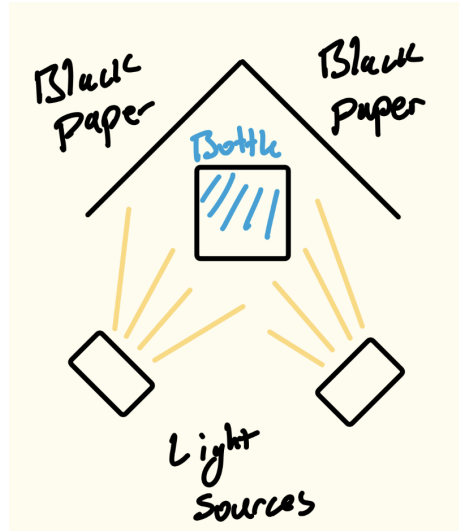


Figure 3: A sketch depicting the orientation of lighting and backdrop

5 Photographic Technique

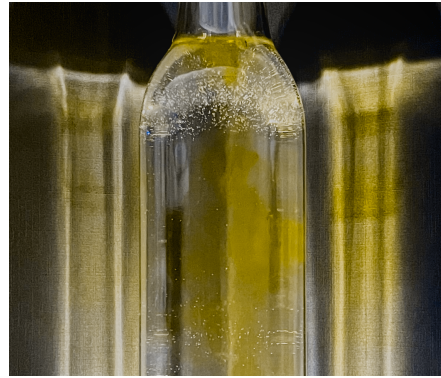
For this image, I used the main camera on an iPhone 13. This camera has a 12MP resolution and an $f/1.6$ aperture. Since I was using the built-in Apple Camera app, there is no real way to determine what the exact shutter speed is as it is automatically adjusting constantly. The same applies for ISO settings.

I took this image roughly a 2 feet away from the fluid. I didn't want to go any further back than this as it would lead to the flow being hardly, if at all, visible or clear. I had the physical barrier of the table in the way in order to get much closer. I was also a little nervous to put my phone close to something that could tip over and spill water over it.

I did a good amount of editing in DarkTable. Below, Figure 4, is a side by side of the initial and final image. Notably, I cropped the image a good amount. to put focus on the flow itself. I also increased the contrast quite a bit to make the yellow color pop out a bit more. This also meant I adjusted the tint so that the only real color become the yellow, everything else became a grey scale. Lastly, I repaired some of the glare near the neck of the bottle by copying the bubbles over so that there wasn't anything overly distracting from the dye itself.



(a) Initial image



(b) Final image

Figure 4: Initial and final image of flow

6 Image Assessment

The image is able to reveal how the dye disperses into a container of water. The combination of the marked boundary and the light is able to provide a visual of how the dye expands into the water, and where it remains concentrated. I like that the light shows those concentrations and that the bottle is clearly the focus. I would've liked a different color of dye that pops a bit more vibrantly and didn't require as much editing. I believe part of this could have been adjusted had I configured my lighting better. If I were to go further, Dr. Elle Stark provided a good idea which was to use iridescent dye which will interact with the light really well to make it pop. I am on the fence about the choice of container. While it lent itself to some interesting visual properties, it was difficult to actually experiment in.

References

- [1] BBC. *What Is the Process of Diffusion?* BBC Bitesize, 2025. URL: <https://www.bbc.co.uk/bitesize/articles/znqbcj6%5C#zq6896f> (visited on 09/18/2026).
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