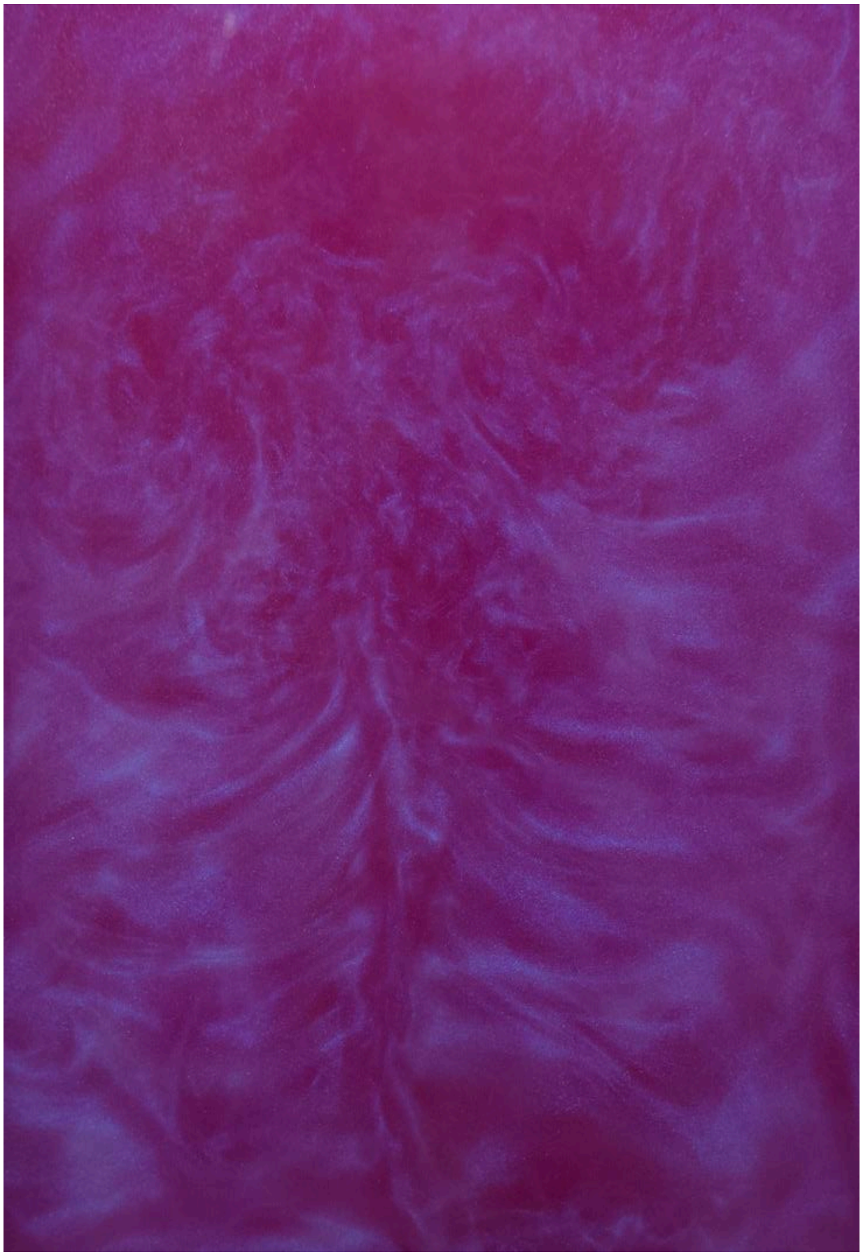
Team Second: Mica Mixture



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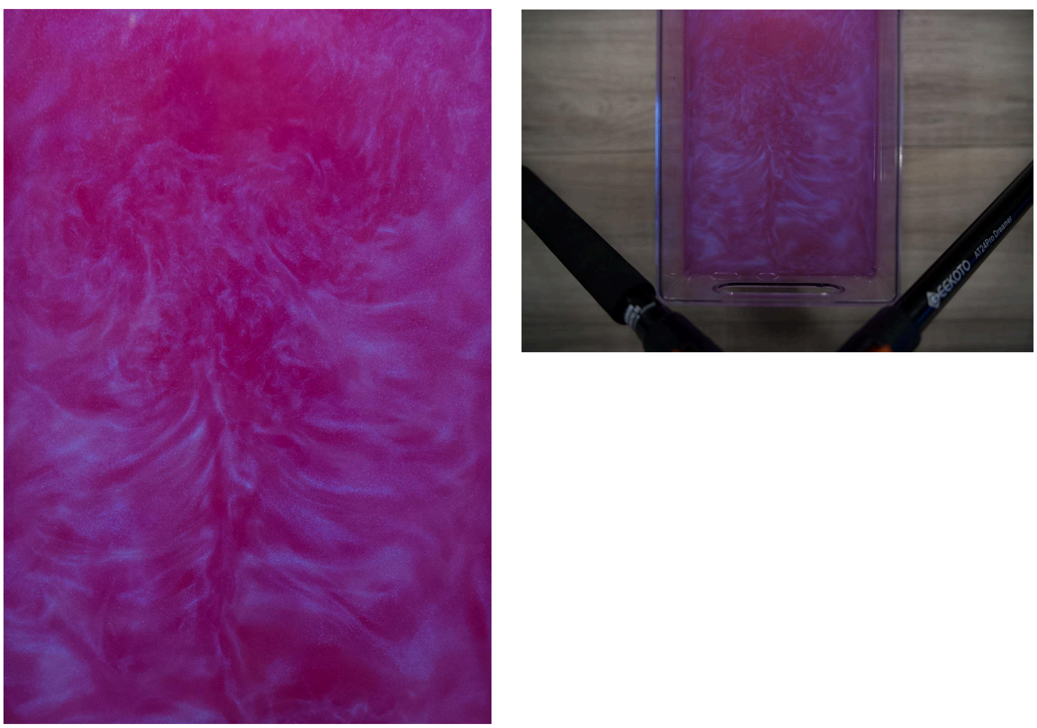
For the Team Second Assignment, I decided to photograph the effects of motion on a mixture of mica powder and water. I was inspired to run this experiment after viewing previous photographs taken by students who conducted similar experiments. In my particular study, I wanted to examine how different objects interacted with the mixture. Specifically, I wanted to see how various mixing tools and motions affected the flow within the mixture. I tested several objects while also experimenting with different motions, such as mixing in circles, side to side, up and down, and crossing patterns. To begin the experiment, I initially took images from a perpendicular angle to the side of the tank, hoping to capture interesting flows against the walls of the container. However, after trying this method for some time, I struggled to create consistent or visually appealing images. Additionally, it was challenging to properly light the setting, as I mainly relied on overhead lighting and flashlights. This resulted in dark images that lacked detail and had distracting glare from the flashlights. I later changed my approach and took photos directly above the tank, focusing on the surface of the liquid. In the end, my favorite image was captured by pulling a spatula from right to left across the surface of the mixture. This particular image stood out to me because it resembled a mushroom cloud.

Figure 1: Edited vs Original Image



The flow captured in the image shows a thin wake leading to a cloud-like area of turbulence. Overall, the image resembles a cross-section of a mushroom cloud. Two prominent features that illustrate the underlying physics are the tendrils in the lower region and the turbulent, cloud-like boundary at the top. These aspects highlight the presence of momentum, vortex rings, entrainment, and pressure differentials. When a spatula is dragged across the surface of the water, it creates an effect similar to that of a mushroom cloud. This phenomenon results from surface drag, wake formation, and vortex action. As the spatula moves, it exerts a dragging force that displaces water to either side, forming a wake behind it. This drag creates a low-pressure zone directly behind the spatula, pulling some surrounding water into the wake and forming a trailing "stem." This effect contributes to the elongated shape of the flow, drawing water into a narrow line behind the main disturbance.

As the spatula moves through the water, it displaces water to the sides, causing a lateral expansion that fills the area left behind. This outward flow creates a broad, rounded "cap" characteristic of a mushroom cloud shape, as the water spreads from the centerline of the spatula's path. The result is a wide, smooth front that resembles the top of a mushroom cloud. At the edges of the wake, shear forces arise where the moving water meets the still water, generating small vortices. These rotating sections of water create turbulence at the edges, pulling more fluid into the wake and adding a textured effect to the water's surface. This vortex action reinforces the shape of the cap, contributing to the cloud-like detail that mimics the characteristic outline of a mushroom cloud. As the spatula continues to move forward, the inertia of the trailing water follows the same path. Eventually, the trailing water slows down, and the wake narrows, forming a distinct "stem" that connects back to the broader "cap," resembling the complete structure of a mushroom cloud. The combined effects of drag, vortex formation, and lateral flow all contribute to creating the mushroom cloud effect on the water's surface, with this entire phenomenon occurring horizontally rather than vertically.

Reynolds Number Calculation: $Re = \frac{\rho \cdot \nu \cdot L}{\mu}$

Density of water (ρ)	1000 kg/m^3
Fluid velocity (ν)	Est 0.3048m/s
Spatula width (L)	3in (0.0762m)
Dynamic viscosity of water (μ)	0.001 Pas
Reynolds Number (Re)	23,200

In this experiment, the Reynolds number serves as a measure of the flow regime within the water, indicating whether the flow is primarily laminar (smooth) or turbulent (chaotic). With a calculated Reynolds number of 23,200, the flow is well within the turbulent range, as values above 4,000 typically suggest turbulence in water flows. This level of turbulence is expected due to the motion and speed of the spatula as it is dragged through the water, creating chaotic mixing patterns. The high Reynolds number corresponds with the observed mushroom cloud effect, where turbulent eddies and wake formations are clearly visible. This finding supports the effectiveness of using a relatively fast, directed motion in combination with a large object to induce dynamic flow patterns in the mixture. Furthermore, this Reynolds number indicates that adjustments to the spatula's speed or size could result in noticeable changes in turbulence intensity, potentially allowing for the capture of even more distinct or complex flow structures.

To set up the experiment, I filled a rectangular clear container with water and mixed in purple and blue duo-colored mica powder. The container has a volume of 1,352 cubic inches and was filled with 1,076.04 cubic inches of water. I then added three grams of mica powder to the water and mixed it until it was evenly dispersed. To capture the image, I placed the tank on a level floor and set up a camera attached to a tripod directly above the container, aimed at the surface of the liquid. The camera lens was positioned approximately 18 inches above the surface of the mixture. The tank and tripod were placed equidistant between two overhead lights to evenly illuminate the scene, and I also used a flashlight focused on the center of the liquid. Various instruments were then used to create flows on the surface, with breaks in between to allow the surface to settle. To achieve the result shown in the image, I dragged a spatula with dimensions of 3 inches by 4.75 inches across the surface at a depth of approximately 2 inches, maintaining a consistent pace, and lifted it straight up and out at the end of the motion.

To take the photo, I used a mirrorless Sony A7R III with a Tamron 35-150mm lens. After setting up the camera on its tripod and aiming it at the surface of the liquid, I opened the aperture as wide as possible to capture the maximum amount of light. Since my subject was only the surface of the liquid, which is a flat plane, I didn't need to worry about depth of field. I set the camera to manual focus to ensure I could select the sharpest setting. Additionally, because there was going to be substantial motion in the image, I adjusted the shutter speed to 1/320 second to freeze the movement. Lastly, I set the ISO as low as possible while still keeping the image bright enough to avoid introducing too much grain.

Camera Type	Mirrorless
Camera Model	Sony A7R3
Original Dimensions	7952 x 5304
Cropped Dimensions	2695 x 3929
Distance from Subject	18 Inches
Aperture	f2.8

Shutter Speed	1/320s
ISO	1000
Focal Length	35mm
Lens Specs	Tamron 35-150mm f2-2.8
FOV	• Hor: 1’ 6.5” • Vert 1’ 0.3” • Diag 1’ 10.25”
Post Processing	• Increase exposure • Increase contrast • Increase hue and saturation • Decreased luminance • Increased sharpness

In terms of fluid physics, the image effectively illustrates concepts such as drag, wake formation, and entrainment. The lateral spread of water across the surface, along with the distinct turbulent region at the top, clearly conveys the fluid dynamics involved. Moving forward, my question is how variations in the speed or pressure of the spatula's movement might affect the shape and size of the cloud-like structure. Although I achieved my goal of capturing a flow that resembles a mushroom cloud, I see potential for further exploration—particularly regarding the effects of using other fluid mixtures with different properties to see the different results.

Works Cited

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