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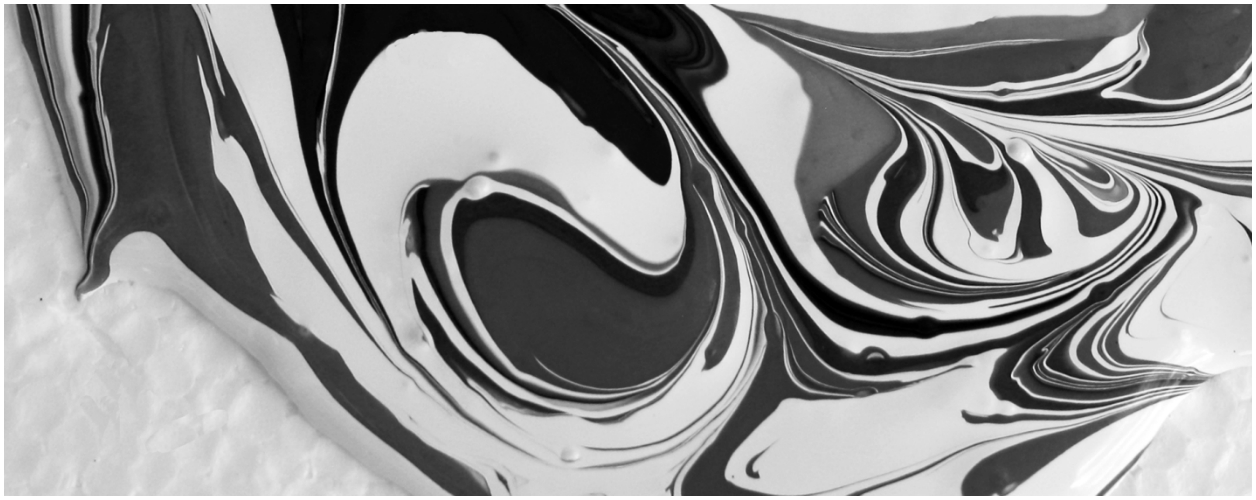
Group Assignment #3

Group Members: Joshua Smith and Benjamin Pacheco



Context & Purpose

This image was inspired by the online video involving "paint-pour art." For those not familiar with the concept, paint-pour art is created simply by pouring paint layer upon paint layer onto an obstruction. Most pour-paint art uses some kind of cylinder or circular obstruction that guarantees a symmetric, beautiful product. However, we decided to experiment with a more "imperfect" image, which used a triangular piece of Styrofoam for the sculpture base. As we poured more paint onto the Styrofoam, we realized that the paint, for the most part, remained in separate layers corresponding to different paint colors. We were fascinated by the "un-mixing" properties of paint, in that we could run a stick through the different colors and the layers would remain disparate. Although we did not get to view the beautiful symmetry of a circular paint sculpture, we did get to learn a lot about the mixing behavior (or lack thereof) of paint.

The Physics of Paint "Un-mixing"

Why does it require so much effort to make paint mix? This is a surprisingly complex question. In this case, we used two types of paints: water-based Crayola paint, and latex-based white paint. House paints labeled as "latex" generally do not contain the latex we think of (derived from rubber trees). Latex paint is actually water based also. Therefore, both the Crayola paint and the latex paint have similar bases – water. So why don't they mix? First, it is notable to examine the properties of paint. Paint is a non-Newtonian fluid, which means that it doesn't follow the rules that we generally apply to fluids. Specifically, it is a thixotropic viscoelastic fluid, in which the apparent viscosity decreases with duration of stress [1]. Perhaps you may have noticed that when stirring paints, the fluid seems thicker initially than when fluid is being stirred steadily a few seconds later. It turns out that paint actually does mix, it just takes some outside force. For starters, let's calculate the Reynold's number:

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

Where: ρ = density, v = velocity, L = length scale, μ = viscosity. To calculate, we need to find out about the parameters of paint, and estimate the velocity and length-scale of the experimental set up. First, the paint was moving quite slow, thus we estimate the velocity to be about 0.01 m/s. The length-scale of the paint plumes were about the size of the obstruction: approximately 0.1 m. The density of paint is about 1200 kg/m^3 [2]. The viscosity of paint is estimated to be approximately that of maple syrup, or 150 cP, or 0.15 Pa-s [3]. Thus, the Reynold's number can be characterized:

$$Re = \frac{(1200)(0.01)(0.1)}{0.15} = 12$$

The turbulent regime begins at about $Re = 4000$. We have just determined that our flow is, indeed, laminar. This was expected because of the way the layers "slid" past each other and remained distinct. In fact, the properties that make paint "impermeable" to mass flow is why we use paint in the first place – to coat objects and provide a physical barrier [4].

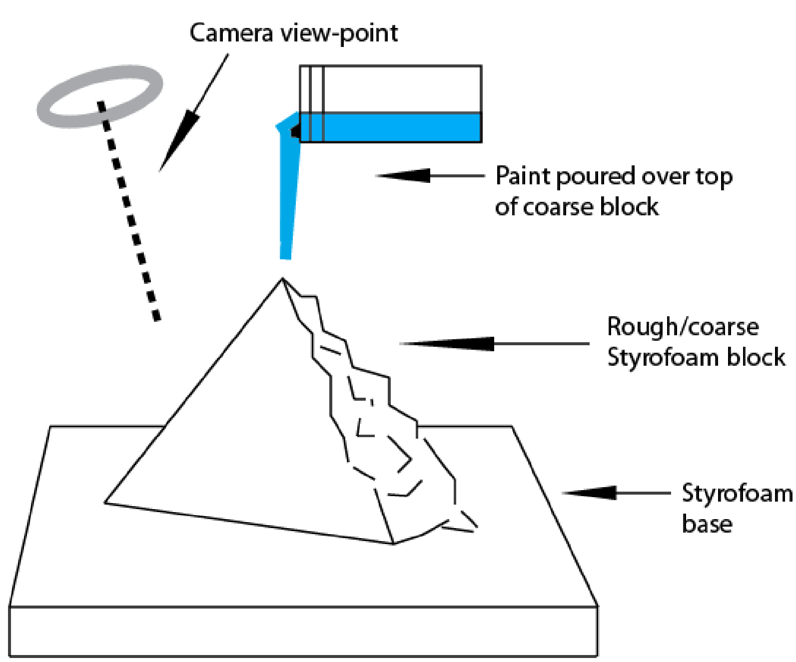


Figure 1: The setup used to capture the image.

Visualization Technique

As mentioned, we modeled this experiment around the “paint sculptures” in which layers of colorful paint are poured onto a barrier in succession. We constructed our barrier out of Styrofoam and used approximately 8 colors of paint. The two types of paint were Crayola water-based paint and a latex-based wall paint. To begin, we assembled the barrier and put down tarp to ensure the paint would not leak onto the grass where the image was being taken. The various colors of paint were poured straight downward onto the pyramidal shaped Styrofoam sculpture constructed. The photographer, Joshua, Benjamin, and myself, would then take pictures as the other group members poured paint from above. The camera was located approximately 10-100 cm from the sculpture at various angles. The lighting was overhead from the sun. See **Figure 1** for the side-view of the setup.

Photographic Technique

This image was captured using a Nikon D40 DSLR. The approximate size of the field of view is 5 cm by 2 cm. The distance from the lens to the object was about 10 cm. The final pixel size is 1890 x 744. The shutter speed was 1/60 sec, and the F-Stop value was f/5.6. The ISO was at 560, and the focal length was 55 mm. The original image is seen in Figure 2 below. Manipulation of the image was conducted in Photoshop. The image of the background detracted from the overall image, so the photo was highly cropped. Additionally, the contrast was increased to bring out the

colored paint against the white background and to further contrast colors. At the last minute, I decided to submit a black and white image, which I found quite dramatic. Indeed, classmates commented on the "dramatic" nature of the image.

Impact of Image

Overall, I think this image captures the strange physics of paint. This phenomenon is very common – everyone has seen the behavior exhibited by non-Newtonian fluids in toothpaste, yogurt, and Oobleck. However, I think the black and white image greatly captures an appropriate degree of "drama" in the image. For instance, the viewer is maybe uncertain about what exactly they are looking at, which I think is an overall effective technique. If I could retake this photo, I would use a symmetric "obstacle" to flow, so that a nice symmetry could be observed. However, I do like the random flow exhibited here. Overall, I enjoyed taking this image and my interest in non-Newtonian fluids has been piqued – and I realized that they are very fun to play with.

References:

1. Zhu, H. et al. "Non-Newtonian Fluids with a Yield Stress." *J. Non-Newtonian Fluid Mech* 129 (2005): 177-181.
2. Joseph, Ron. "Paints and Coatings Resource Center." Updated: September 2006. Accessed: May 2012. < http://www.paintcenter.org/rj/sep06d.cfm>.
3. "Newtonian Fluids." Viscosity Chart. Accessed: May 2012. < http://www.research-equipment.com/viscosity%20chart.html>.
4. Thomas, N.L. "The barrier properties of paint coatings." *Progress in Organic Coatings* 19 (1991): 101-121.