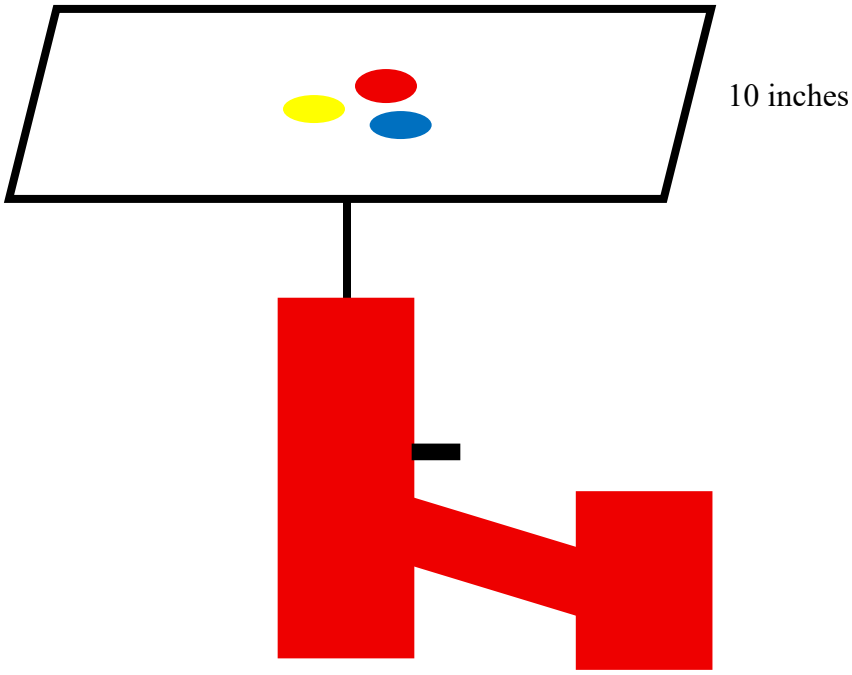
Visualizing Centrifugal Force on Acrylic Paint

MCEN 5151

Cody Popelka and Avery Calloway

For the Team Second project in Flow Visualization, I worked with Avery Calloway to capture, with high speed video, acrylic paint spreading radially outward on a spinning canvas. The paint needed to be diluted with water; during the first run, the paint barely spread out at all. The paint was diluted approximately 4:1 paint to water.

The flow apparatus consisted of a 10 inch canvas attached to a cordless drill. The canvas was held at a slight angle (<10 degrees from horizontal) so that the light from the sun would shine on the canvas more directly.



The canvas took 61 frames to make one revolution. The frame rate was 960 frames per second.

$$\omega = \frac{1\,rotation}{61\,frames} * \frac{960\,frames}{1\,second} = 15.7\,rotations/second$$

The Taylor number is a nondimensional number that compares centrifugal forces to viscous forces:

$$Ta = \frac{4 * \omega^2 * R^4}{\upsilon^2}$$

Where R is the characteristic length, in this case 5 inches (0.127 m). Yuningsih (2019), found that for a similar dilution of acrylic paint to solvent of 80:20 gave a viscosity of 2.7 poise. This first needs to be converted to a kinematic viscosity using a density of approximately 1 g/cm^3.

$$\upsilon = 2.7\frac{g}{cm * sec} * \frac{cm^3}{1g} = 2.7\frac{cm^2}{sec}$$

$$Ta = \frac{4 * (15.7\ rot/sec)^2 * (0.127\ m)^4}{\left(2.7\frac{cm^2}{sec} * \frac{1\ m^2}{100^2 cm^2}\right)^2} = 9.5 * 10^{-6}$$

The fact that the Taylor number is small implies that viscous forces play a significant effect on the behavior of the paint as it spreads. This makes sense as there are the fingers in the blue paint. If the Taylor number were larger, the paint would most likely spread very easily and become a sheet of paint that covers the canvas quickly.

The flow was captured on a Sony HXR-NX80 in 1080p at 960 fps with an ISO of 1000. The camera was mounted in a tree overlooking the canvas by about 2 meters. Sunlight was the only light source. The camera was set to constantly record with the trigger causing the previous several seconds to be written to longer term storage. Avery triggered this when the paint appeared to cover the whole canvas.

Bibliography

Yuningsih, I., Rahayu, I. S., Lumongga, D., & Darmawan, W. (2019). Wettability and adherence of acrylic paints on long and short rotation teaks. *Wood Material Science & Engineering*, *15*(4), 229–236. https://doi.org/10.1080/17480272.2019.1575903