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Overview:

This image was created for the third team visualization assignment of the Flow Visualization course. The intent of the image was to observe flows created by vibrating a paint-water mixture vertically on a shake table and how different frequencies change the capillary wave pattern in the fluid. Initially, the plan was to use a high-speed camera provided by the CU Boulder ITLL, but it was determined that the slo-mo setting on a phone camera provided better resolution and overall better results, despite the loss of control over most settings.

Fluid Dynamics:

The waves shown in this video are capillary waves, which are waves whose restoring force is the surface tension of the fluid. Capillary waves are characterized by a rounded crest and a v-shaped trough[1]. In the video clip of the green fluid, the shake table was shaking at 15 Hz, while in the clip of the red fluid, the frequency was 17.5 Hz. This frequency difference translates to a larger amplitude and a smaller number of crests at the higher frequency. The green fluid exhibits a six-sided shape with seven points, while the red fluid transitions from one to three points. At 17.5 Hz, the red fluid also breaks surface tension and releases a droplet, which then falls back into the fluid and disrupts the wave. Interestingly, the lighter paint seemed to settle into the throughs of the waves while the darker paint stayed mostly at the crests. This might be due to a density difference in the pigments but is still unexpected, since mixing should result in a more homogenous mixture over time.



Figure 1: Color separation between crests and troughs

Visualization Method:

The pigment used in this visualization was a mixture of about 1 part water to 1 part Tulip Soft Matte Fabric Paint. A base color was added to the container, and several drops of a contrast color with a similar viscosity were added before shaking began. Figure 2, shows the shake table setup. The lights used were ceiling fluorescents about 5ft directly above the table.



Figure 2: Photographic setup

Photographic Method:

The camera used for this image was from an iPhone SE with the settings listed in table 1.

Table 1: Camera settings	
Focal Length	28 mm
f-stop	f/1.8
ISO	100
Frame rate	240 fps

The camera was as close as it could be to the side of the container without touching the glass. The field of view of the camera was around 5×3 inches. The original image size is 1920×1080 pixels, and the cropped image was about 1440×810 pixels. In post-processing, the shadows and highlights were slightly increased and the saturation was increased. This was most of the editing capabilities available in iMovie. Figure 3 shows the unedited image for comparison.



Figure 3: Unedited image

Final Thoughts:

I'm happy with the flows I was able to get for this visualization. The mixing of the dark and light paint turned out to be really interesting in a way I didn't expect. It would have been nice to have time to set up the slo-mo camera very carefully, but I am also impressed with the iPhone camera results. In the future, it would be interesting to try different color combinations to test whether the color separation trend continues.

References:

[1] The Editors of Encyclopaedia Britannica, "capillary waves", Britannica, (2011). https://www.britannica.com/science/capillary-wave.