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### Team Third: Ferrofluid

For our 3rd and final image, my team opted to try working with ferrofluid, as we had seen some interesting results from other groups, and wanted to try and take that in a different direction. We used several sets of disappointingly weak fridge magnets to try and create interesting geometry in the fluid. This proved a more difficult task than anticipated due to the shape (and construction) of the magnets. Another subject we photographed was a few different bolt/washer combinations placed atop a more powerful bar magnet. We also made an attempt at using electromagnets for active control over the ferrofluid, but that was never completed.



Figure 1: Final Image

In this image, a thin layer of ferrofluid was placed in a plastic petri dish. Magnets were stacked 3-5 tall, and placed beneath the dish. It's worth noting that the magnets were assembled from individual strips of ferromagnetic domains, which caused the distinct lines in the image. Some care was taken to align the magnets, but it was not until after the majority of shooting that we noticed the interference pattern in many of the images, which can be seen in the left magnet here. For comparison, the magnets on the right were all aligned.

The magnets measured 1" on each, and were square, triangular and circular. Here, only square ones were used. Without knowing the thickness of the ferrofluid, and some other difficult to measure parameters, the magnetic field strength cannot be determined. However, I would wager that these magnets are somewhere in the range of  $10^{-3-4}$  T.



Figure 2: Original Image

The image was taken near a large window, with lighting from the sun shining through, as well as overhead fluorescent lights, and an iPhone LED for good measure. It was shot using a Nikon D7000, at ISO 200 and 1/125 s shutter speed at f/5.6. While the subject was dark, the ferrofluid reflects quite a bit of light due to the suspended metallic particles, and thus a low ISO was the best choice for the amount of reflected light. In post-processing, I cropped to remove the petri dish and associated mess of ferrofluid, and instead focused on the domain lines. I then took it to grey-scale to try and mimic an SEM image, as I think was successful. The final product certainly evokes other images of tiny transistors and the likes. I also opted not to remove some of the bubbles and blemishes, as I wanted some information pointing to the fact that this is not, in fact, on the micrometer-scale.

While shooting, I was very disappointed with the magnets, and the weak effects we were seeing. I was also unable to get any sort of coloring to take to the dye, even though other teams had done so with great success. However, after looking at the photos and editing a few, I found that there were actually some really interesting phenomena taking place with these magnets around the boundaries, and on a smaller scale due to the magnet strength. I'm quite happy with what came of it, though I certainly wish the effects were more pronounced. The electromagnets would have also been great, but that is a larger project, perhaps for the future.



Figure 3: Disappointing Magnets