Team Second: Ferrofluid

MCEN 4151-001

https://youtu.be/nTv48iXGinE

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Help from Max Armstrong

For our Team Second project we decided to work with ferrofluid. After playing with ferrofluid and a couple magnets, I discovered the unique behavior that I decided to film. I wanted to show how the density and height of the spikes change as the distance from the magnet changes. I also wanted to show the arcing path the ferrofluid takes when moving from one magnet to another. To capture these phenomena, I controlled the fluid flow with the magnets while Max Armstrong held the camera still.

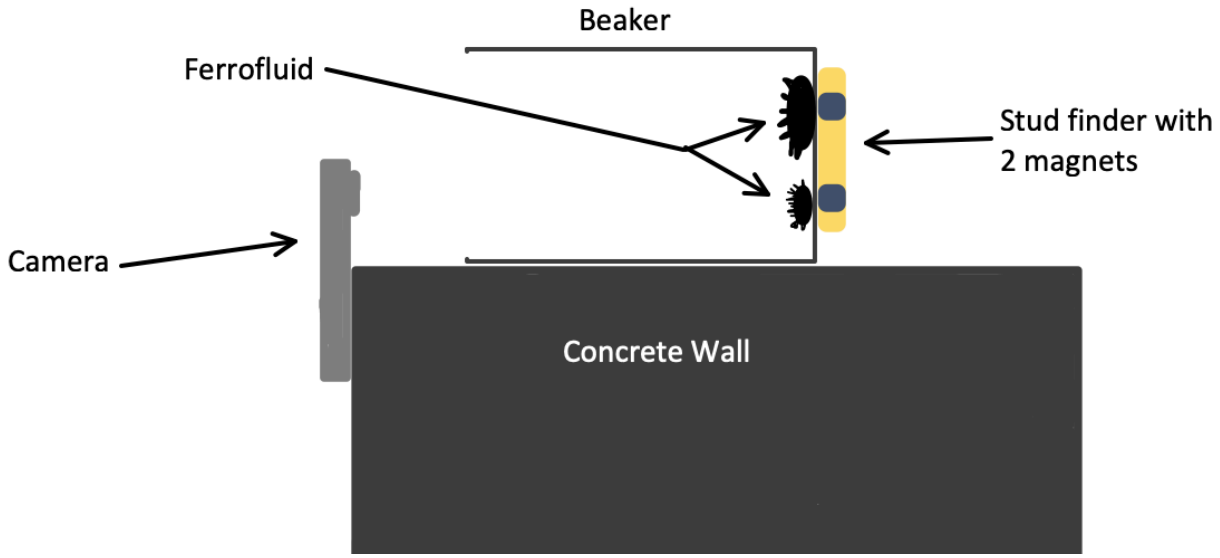

Figure 1: Experimental setup

Figure 1 shows how the experiment was set up to capture the video. Ferrofluid was added to the beaker until the bottom was completely covered. A stud finder with two magnets spaced about three inches apart was placed on the bottom of the beaker. The stud finder was tilted so the majority of the ferrofluid was attracted to only one of the magnets, then the stud finder was placed flat against the beaker again. Next, the beaker was laid on its side near the edge of a concrete wall. The wall provided a nice sturdy surface to hold the camera phone against to prevent shaking. I rotated the stud finder so the larger puddle of ferrofluid was above the other and started filming.

I began by changing the distance of the upper magnet from the beaker to show how this effects the density of the “spikes”. These spikes form when the magnetic surface force outweighs surface tension and the weight of the fluid [1]. The spikes visually show how the magnetic field lines become less dense the farther away you are from the magnet. Next, I slowly removed the upper magnet until the ferrofluid started moving toward the lower magnet. As the upper magnet was removed, gravity and the magnetic attraction from the lower magnet started to outweigh the weakening magnetic force of the upper magnet. Figure 2 [2] helps show why the ferrofluid travels in an arced path toward the lower magnet and not straight down. The ferrofluid follows the magnetic field lines, and since there are no straight field lines between the magnets, the path must be curved. The direction of the arrows in Figure 2 do not affect the path of the ferrofluid since it is not polarized.

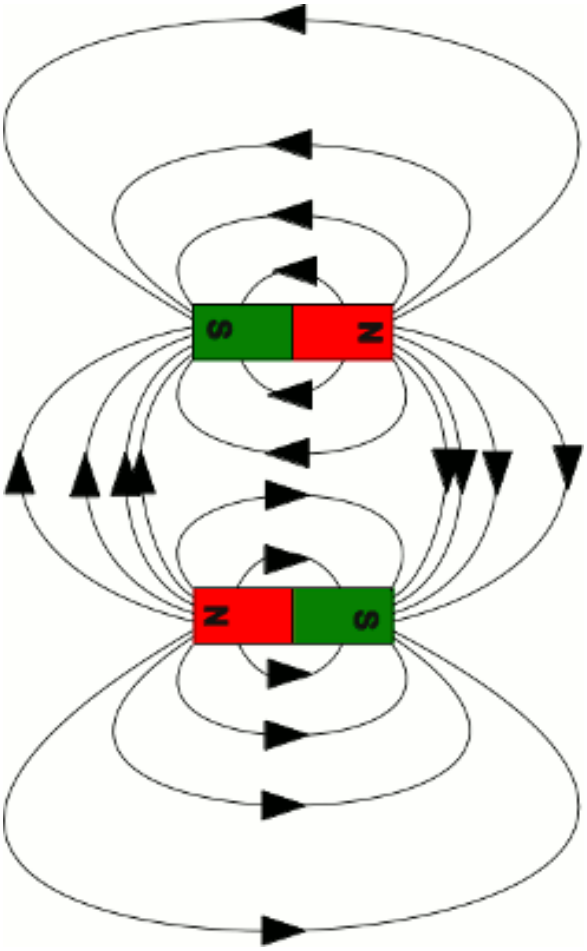

Figure 3: This diagram shows the magnetic field lines between two magnet.

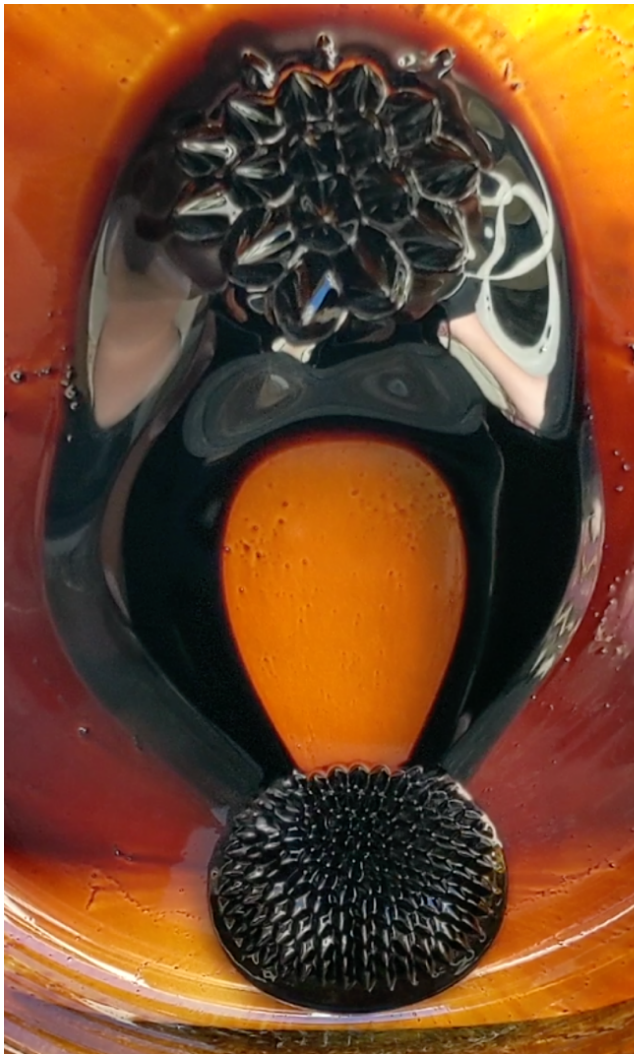

Figure 2: This image from the video shows when the upper magnet is about 1/2" away from the beaker and the lower magnet is up against it. The spikes clearly show how the density of the field lines are affected by distance from the magnet.

We got the ferrofluid from Prof. Hertzberg and borrowed the beaker from the project depot in the ITLL. The stud finder with magnets used belonged to Byron Pullutasig. The video was taken in broad daylight with the sun behind the beaker (in front of the camera). No additional lighting was used.

To capture this video, I used my Google Pixel 3 camera phone because of its ability to focus on objects close to the lens. I placed a couple pieces of white paper between the magnets and the bottom of the beaker so that my hand couldn't be seen through the glass. The field of view is about 4" wide and 6" tall with the bottom of the beaker being 8" from the lens. The video is 1080x1920 pixels. Unfortunately, the aperture and ISO settings are not available in the metadata. I used iMovie to crop, increase contrast, and adjust the brightness. I also slowed the video to 75% of the original speed.

I really enjoy being able to visualize the magnetic fields of the magnets through the behavior of the ferrofluid. I don't like how vertical the video is, but this is inevitable with a camera phone without changing the aspect ratio. If I were to retake this video I would use a DSLR with an extension tube for a more focused close up view.

References

[1] Physicscentral.com. (2019). *Ferrofluid Fun*. [online] Available at: https://www.physicscentral.com/explore/action/ferrofluids.cfm [Accessed 5 Nov. 2019].

[2] Heinz, Norbert. "Magnets inside Magnetic Fields - HomoFaciens." *Homofaciens.De*, 31 Oct. 2009, www.homofaciens.de/technics-electrical-engineering-magnets_en.htm. Accessed 5 Nov. 2019.