

Get Wet

Nail Polish on Water

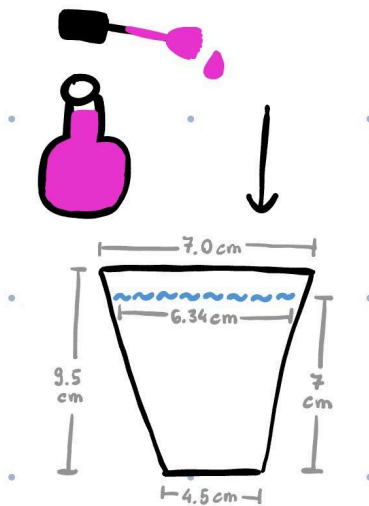
Maria Cristina Sarno

MCEN 4151 - 001

9/17/2026

For my Get Wet assignment, I wanted to visualize how nail polish behaves when dropped in water. The goal was to observe how the nail polish spread on the surface of water and the circular pattern it created as I was alternating between blue and pink polish. I was really interested to see the concentric rings as I added more drops. During the experiment, I accidentally dropped more than one drop of pink polish for the second ring starting from the outside, which is why that ring is less even than the others and why the later rings spread less evenly. After that, I added one drop at a time, which produced more circular and defined rings.

SIDE VIEW



TOP VIEW



The experiment was completed using a plastic cup with an inner diameter of 7.0 cm at the top and 4.5 cm at the bottom, with a total height of 9.5 cm. The water depth was 7.0 cm. Because the cup was tapered, the diameter of the water surface was smaller than the 7.0 cm diameter at the top of the cup. Assuming that the sides of the cup taper linearly, the diameter at the water level was estimated using the top diameter, bottom diameter, total cup height, and water depth:

$$D_{water} = D_{bottom} + (D_{top} - D_{bottom}) \frac{h_{water}}{h_{cup}}$$

$$D_{water} = 4.5 \text{ cm} + (7.0 \text{ cm} - 4.5 \text{ cm}) \left(\frac{7.0 \text{ cm}}{9.5 \text{ cm}} \right)$$

$$D_{water} = 6.34 \text{ cm}$$

The nail polish was dropped from approximately 5 cm above the water surface, alternating between blue and pink polish. A sketch of the experiment is shown in the figure above. Each drop landed near the center of the water surface and spread outward, creating an approximately circular flow pattern. The outer pattern spread across nearly the entire water surface, which had an estimated diameter of approximately 6.3 cm.

The spreading of the nail polish appears to be influenced by surface tension effects at the interface between water and air. The water-air interface is the boundary where the surface of the water meets the surrounding air. Surface tension is caused by the attraction between molecules at the surface of a liquid and makes the surface resist being stretched or disturbed[5]. When the nail polish comes into contact with the water, it changes the surface conditions in that region, which can create differences in surface tension across the interface. These differences, also called surface-tension gradients, can cause fluid to move along the surface[1]. This surface motion caused by differences in surface tension is known as the Marangoni effect[1]. In this experiment, the Marangoni effect likely contributed to the nail polish spreading outward from the point where each drop landed. Because the drops were placed near the center, the spreading occurred approximately in all directions from the center, producing the circular rings visible in the image. To characterize the flow quantitatively, I estimated the Reynolds number and Weber number. The Reynolds number compares inertial effects with viscous effects[2], while the Weber number compares inertial effects with surface-tension effects[3]. The Weber number is especially relevant to this experiment because the observed flow occurs at a liquid surface where surface-tension effects are important.

Because the nail polish spread radially from approximately the center of the water surface, the characteristic length L was selected to be the radius of the water surface:

$$L = \frac{D_{\text{water}}}{2}$$

$$L = \frac{6.34 \text{ cm}}{2} = 3.17 \text{ cm} = 0.0317 \text{ m}$$

The nail polish took approximately 2-3 seconds to spread from the center towards the outer edge of the water surface. Because this time was estimated, the characteristic velocity U was calculated as a range:

$$U = \frac{L}{t}$$

$$U_{\text{max}} = \frac{0.0317 \text{ m}}{2 \text{ s}} = 0.0159 \text{ m/s}$$

$$U_{\text{min}} = \frac{0.0317 \text{ m}}{3 \text{ s}} = 0.0106 \text{ m/s}$$

The Reynolds number is defined as $Re = \frac{\rho UL}{\mu}$ [2]. For water at approximately 20 °C, I used a density of 998.2 kg/m^3 [4] and a dynamic viscosity of $1 \times 10^{-3} \text{ Pa} \cdot \text{s}$ [4]:

$$Re_{\text{min}} = \frac{(998.2 \text{ kg/m}^3)(0.0106 \text{ m/s})(0.0317 \text{ m})}{1.0 \times 10^{-3} \text{ Pa} \cdot \text{s}} = 335$$

$$Re_{\text{max}} = \frac{(998.2 \text{ kg/m}^3)(0.0159 \text{ m/s})(0.0317 \text{ m})}{1.0 \times 10^{-3} \text{ Pa} \cdot \text{s}} = 502$$

This Reynolds number range indicates that inertial effects are larger than viscous effects at the characteristic scales used in this estimate.

The Weber number ($We = \frac{\rho U^2 L}{\sigma}$)[3] was also calculated to compare the inertial effects with surface tension effects. For water at approximately 20 °C, the surface tension σ is approximately 0.07275 N/m[4].

$$We_{min} = \frac{(998.2 \text{ kg/m}^3)(0.0106 \text{ m/s})^2(0.0317 \text{ m})}{0.07275 \text{ N/m}} = 0.049$$

$$We_{max} = \frac{(998.2 \text{ kg/m}^3)(0.0159 \text{ m/s})^2(0.0317 \text{ m})}{0.07275 \text{ N/m}} = 0.109$$

Because the Weber number is less than 1, the surface tension effects are important relative to inertial effects[3]. This is consistent with the spreading of nail polish across the surface of water. These calculations use the properties of pure water as an approximation because the actual surface properties after the nail polish was added were not measured.

The spatial resolution of the final image was also estimated from the 9 cm field of view and the final image width of 2782 pixels:

$$\text{Spatial resolution} = \frac{90 \text{ mm}}{2782 \text{ pixels}} = 0.0324 \text{ mm/pixel}$$

To find the time resolution needed to follow the spreading motion, I calculated how long the flow would take to move approximately one pixel:

$$\Delta t = \frac{\Delta x}{U}$$

$$\Delta t_{faster} = \frac{3.24 \times 10^{-5} \text{ m}}{0.0159 \text{ m/s}} = 0.0020 \text{ s}$$

$$\Delta t_{slower} = \frac{3.24 \times 10^{-5} \text{ m}}{0.0106 \text{ m/s}} = 0.0031 \text{ s}$$

Therefore, resolving movement on the scale of approximately one pixel would require a time resolution on the order of 2–3 milliseconds. The final photograph is a still image, so it shows the resulting flow pattern rather than the complete motion as each ring spreads.

The visualization technique used in this experiment was colored nail polish placed onto the surface of water. I used Kokie nail polish in the colors Royalty Blue and A Fuchsia Feeling. The experiment was performed indoors in my kitchen using a plastic cup filled with tap water at approximately room temperature. To reduce reflections on the water surface, I turned off the kitchen light and only left the living room light on. I did not use the camera flash because it created reflections on the surface of the water. The camera was positioned directly above the cup to get a top view of the concentric rings and make their shape easier to see.

The photograph was taken using an Apple iPhone 17 Pro with the ultra-wide camera positioned directly above the cup to capture the concentric rings from a top view. The digital camera was approximately 7 cm above the cup, and the field of view was approximately 9 cm × 9 cm. The lens had a focal length of 13 mm with an aperture of f/2.2. The image was taken at ISO 1600, with an exposure compensation of -0.2 EV and an exposure time of 2.0 seconds in Night Mode. The original image was 3024 × 4032 pixels. I chose the top-down view because it made the circular shape and spacing of the nail polish rings easier to see. For image processing, I slightly cropped the sides of the original image so that the final photograph focused only on the water surface. The final cropped image was 2782 × 2787 pixels.

The final image reveals how the nail polish spread outward across the surface of the water and formed a series of concentric rings. I like how the alternating blue and pink colors make the different rings easy to see and help distinguish the regions created by each drop. The main thing I dislike is that the first pink ring is less even than the others because I accidentally added more than one drop at once, which also affected the shape of the rings that formed afterward. Overall, I think I fulfilled my original intent because I was able to clearly capture the pattern. If I repeated the experiment, I would make sure that exactly one drop was added at a time and that each drop landed as close to the center as possible. I would also record the experiment so I could measure how quickly each ring spreads. One question I still have is whether different types of nail polish would spread at different speeds or create different patterns because of differences in their composition.

References

- [1] Wikipedia contributors. (2026, May 16). *Marangoni effect*. Wikipedia.
https://en.wikipedia.org/wiki/Marangoni_effect
- [2] NASA Glenn Research Center. (2024, July 19). *Similarity Parameters* | Glenn Research Center | NASA. Glenn Research Center | NASA.
<https://www1.grc.nasa.gov/beginners-guide-to-aeronautics/similarity-parameters/>
- [3] Works, H. E. (2025, May 10). What is the Weber number, and what does it represent? *How Engineering Works*.
<https://www.howengineeringworks.com/questions/what-is-the-weber-number-and-what-does-it-represent/>
- [4] *Thermophysical properties of fluid systems*. (n.d.). <https://webbook.nist.gov/chemistry/fluid/>
- [5] Wikipedia contributors. (2026b, September 17). *Surface tension*. Wikipedia.
https://en.wikipedia.org/wiki/Surface_tension