Get Wet Report

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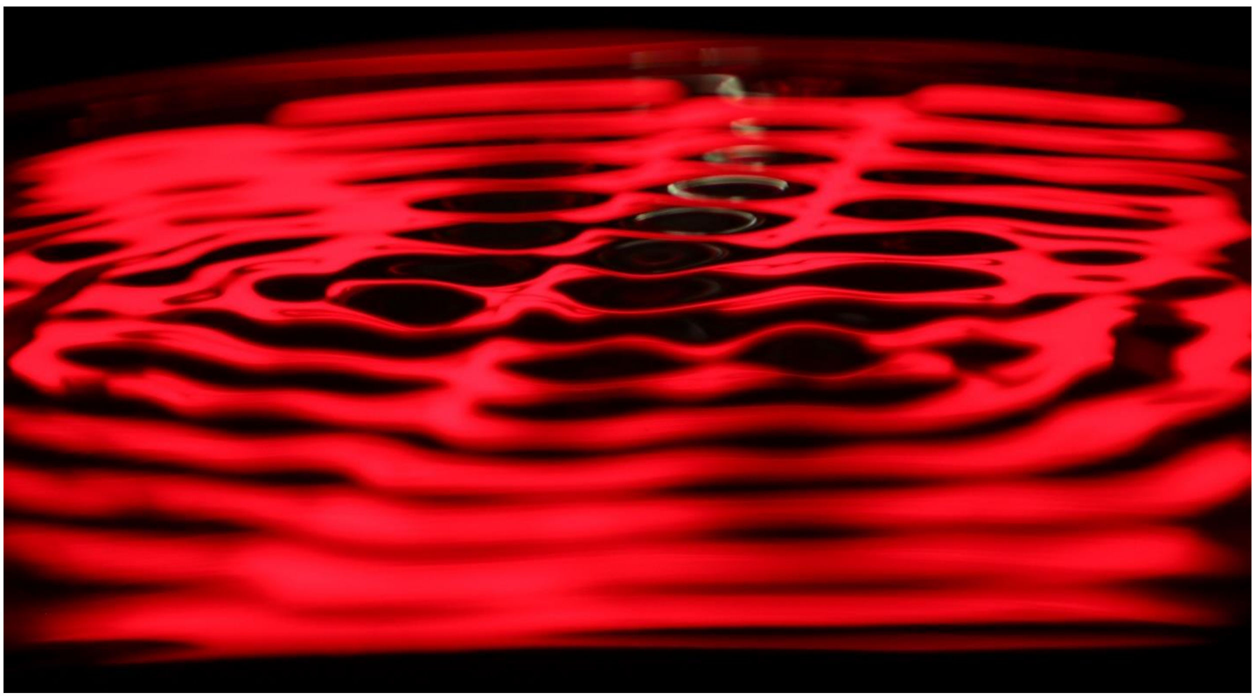

Figure 1. Thumbnail Image used for 'Water Waveforms' video

Background

This video was created for the first visualization assignment of the Flow Visualization course: Get Wet. Titled “Water Waveforms”, the video depicts a spherical vase of water placed upon a subwoofer, where low frequencies propagated up to the water’s surface. Different displacement patterns in the water were observed as frequencies changed from 40 to 60 Hz and volume changed from 60 to 80 decibels. The spherical vase and lighting setup made for mesmerizing patterns as the subwoofer played. A compilation of clips is shown in the video, where stationary water transitions from soft ripples to violent waves.

Fluid Physics

The items used in this experiment’s flow apparatus include: 5-in diameter Pour Over Coffee Vase, SONY SS-WSB101 Subwoofer, Fosi Audio BT20A Amplifier, Ring Light, LED Lamp, and a Canon EOS Rebel T7 camera with a 300mm lens. The items are arranged accordingly as seen below in Figure 2.

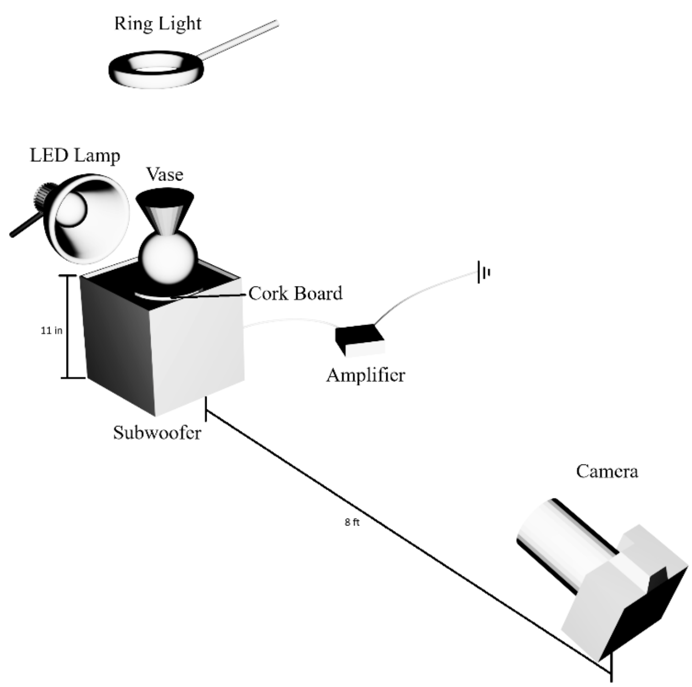

Figure 2. A diagram of the experimental setup used for the Get Wet Project, with approximate dimensions.

Bass tones could be sent via Bluetooth to the amplifier, which then played over the subwoofer. Initially, the water inside the vase would form radial ripples, but if the subwoofer was allowed to continue playing, these ripples would change into dancing waves in an instant. The subwoofer imparts a time-varying acceleration, or oscillation, to the vase. The vase imparts these oscillations to the water. Then, the water behaves similarly to the subwoofer, where instead of the subwoofer membrane displacing up and down, the water itself displaces up and down. The water takes on a sinusoidal waveform, where the peaks and valleys of the water are highlighted by the red LED lamp. This transformation is due to a phenomenon called **Faraday instability**, which can be framed in terms of the Froude and Weber numbers [1].

$$Fr = \frac{U}{\sqrt{gL}} = \frac{2\pi * 40\ Hz * 0.001\ m}{\sqrt{9.81 * 0.127\ m}} = 0.225 \quad (1)$$

The Froude number represents the ratio of inertial forces to gravity. U is velocity of the fluid, g is the gravitational constant, and L is the container size. For a sample vibration of 40 Hz and 1 mm of vertical displacement, the maximum velocity of an oscillation can be calculated as $2\pi f$A. This yields a Froude number of 0.225, where gravitational forces play a large part in restoring the fluid equilibrium.

$$We = \frac{\rho U^2 L}{\sigma} = \frac{1000 \frac{kg}{m^3} * (2\pi * 40\ Hz * 0.001\ m)^2 * 0.127\ m}{0.072\ N/m} = 111 \quad (2)$$

The Weber number represents the ratio of inertial forces to surface tension, where ρ is fluid density and σ is surface tension. Using the same sample values from the Froude number, this yields a Weber number of 111, where surface tension forces cannot counteract inertial forces and restore fluid equilibrium. In practice, low Froude and Weber numbers characterize a gentle response, with gravity and capillarity providing strong restoring forces that keep the surface organized into circular ripples. As the driving amplitude grows, however, the Froude number rises, indicating that inertial forcing increasingly overwhelms gravity, while a large Weber number signals that surface tension can no longer suppress disturbances. When these inertial vibrations at certain frequencies push the system beyond a critical threshold, the surface undergoes Faraday instability, producing nonlinear standing waves that can lock into quasiperiodic patterns such as fine stripes [2]. With greater forcing and volume of the subwoofer, the oscillations become extreme enough that wave crests destabilize and the system ejects droplets from the surface, a phenomenon called **Rayleigh jetting**. Through the Faraday instability, a clear demonstration of how nondimensional balances govern the transition from ordered rippling to chaotic, nonlinear dynamics.

Visualization Technique

Many different glass containers were initially used in this experiment, but the spherical vase added cool glass refractions to the image. Also, the cork board was essential to vibrating the containers. It would not be wise to place the containers directly onto the speaker and too thick of a surface board would transfer no vibrations into the liquid. The cork board was thin enough (about 0.25”) to transfer vibrations, while also damping out any frequencies violent enough to shake the glass itself.

The video was taken in dark room, where lighting only came from a ring light and a red LED lamp. The red LED was set at a higher level of brightness than the ring light. This helped highlight the crests and troughs of the waveforms, while not overpowering the red LED. When it came to photographic intent, I wanted to make the image as otherworldly as possible. This led to the placement of the red LED directly behind the vase. It framed the video well and made the video more dreamlike with the added glass distortion of the LED. I also tried to capture this mood in writing the ambient, dreamlike music for the video.

Photographic Technique

Besides cuts to video segments, no image or video processing was used. I wanted to have the center of the vase in focus, while the edges be out of focus. This led to a lower F-stop and a large focal length to really zoom in on the fluid. Camera specs are outlined in the table below.

Table 1: Camera Specifications

Camera Make & Model	Canon EOS Rebel T7 1500D
Shutter Speed	1/400
ISO	2500
Focal Length	300 mm
Aperture	f/5.6
Framerate	30 fps
Playback speed	1.00x

Conclusion

The image reveals the striking transition of water on a vibrating surface from gentle radial ripples into nonlinear standing waves characteristic of Faraday instability. I like how clearly the stripe patterns emerge as the vibration amplitude increases, highlighting the competition between gravity, inertia, and surface tension. At the same time, I dislike that the image cannot fully capture the violent, three-dimensional dynamics and eventual droplet ejection that occur at higher Weber numbers. The fluid physics are shown convincingly, but I am left wondering how sensitive the observed patterns are to vibration frequency, container geometry, and water depth. My original intent to capture the beauty of instability in a simple, table-top setup was fulfilled, though the image could be improved with a slightly larger depth of field to resolve finer surface details. Moving forward, I could develop this idea further by experimenting with different liquids and containers to see how they shift the emergent patterns.

References

[1] Faraday, M., "Experimental Researches In Chemistry And Physics," CRC Press, 1990.

[2] Sheldrake, M., and Sheldrake, R., "Determinants of Faraday Wave-Patterns in Water Samples Oscillated Vertically at a Range of Frequencies from 50-200 Hz," *WATER journal*, Vol. 9, 2017.