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## Purpose

This video demonstrates the Leidenfrost effect, and was created for the second group project of the fall semester. The Leidenfrost effect inspired our group to create videos to capture the phenomenon, since the experimental setup is so simple, yet creates such a unique visual.

## Background

It turns out that boiling isn't such a simple process. While we may boil water in our daily lives to make tea or cook pasta, boiling water exhibits different characteristics that change with temperature. Typically, when we think of the signs of water beginning to boil, we know that bubbles of steam will form in the water and begin to rise to the surface. These are called isolated vapor bubbles, and boiling water exhibits this behavior when at, or a few degrees above the boiling point[1]. If the temperature is increased beyond that of the boiling point, *nucleate boiling* begins to occur. Nucleate boiling is caused by a higher rate of heat transfer into the water due to the higher temperature. This increased energy creates columns of steam bubbles that act more violently and burst at the surface. After a certain temperature above where nucleate boiling occurs, the rate of energy transferred into the water begins to decrease. The temperature is so high, that a vapor layer begins to form at the bottom surface. This vapor layer of steam has a much lower thermal conductivity than water in its liquid form, which slows the rate at which heat enters the water. This is called transition boiling, and the temperature at which this change occurs is known as the Leidenfrost point. Using EES software, I was able to calculate the different thermal conductivities of water and steam at atmospheric pressure to provide some better understanding of this.

$$k_{water} = 0.6032 \frac{W}{m-K} \quad (1)$$

$$k_{steam} = 0.02457 \frac{W}{m-K} \quad (2)$$

This effect can be observed on a small scale with water droplets on a very hot surface that do not immediately evaporate, but instead maintain their droplet shape for much longer than expected as shown in the figure below.

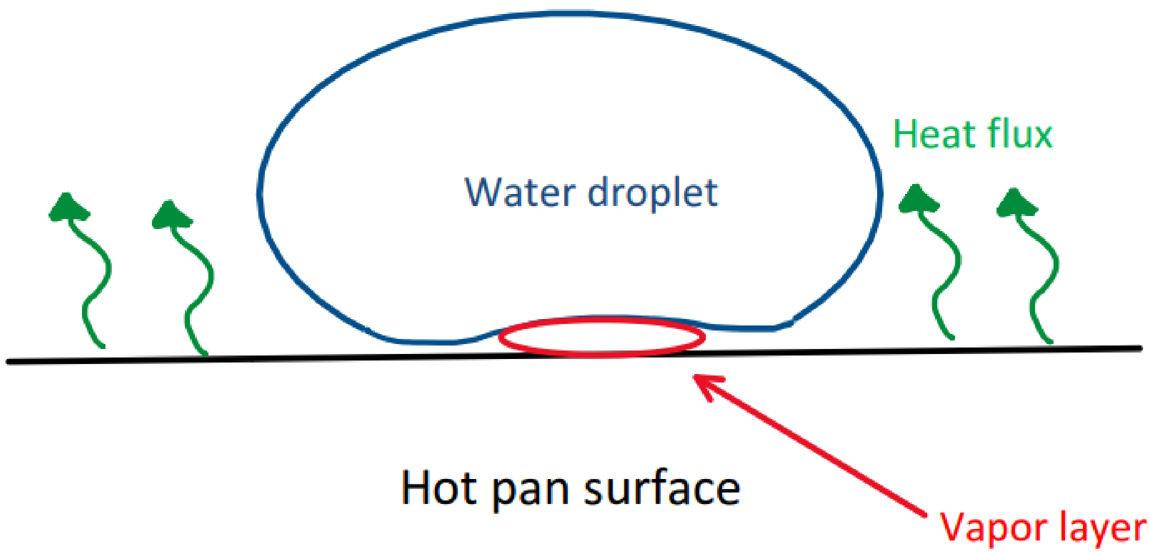


**Figure 1.** Diagram showing the formation of a vapor layer at the Leidenfrost point

## Visualization

To demonstrate the Leidenfrost effect, a teflon pan was heated to temperatures above the boiling point of water using a kitchen stove. The pan was measured to be ~343° F (172.8° C) using a meat thermometer. According to an article published by Emory University[2], the Leidenfrost point stabilizes at 240° C, and collapses at 140° C. This puts our experiment somewhere in the middle of this range, but the pan material and other factors have been shown to affect the Leidenfrost point. Two syringes were filled with yellow dyed water, and blue dyed water. Tristan distributed small volumes of each on opposite sides of the heated pan. One of my team members, Abdullah, then swirled the pan back and forth twice to allow the two pools of different colored water to collide and mix. This allowed the two pools to merge into a new pool that dispersed and formed a nice uniform green color. A floor lamp was placed near the edge of the stove, and the stove light was also turned on for the lighting of this video.

**Video Specifications**

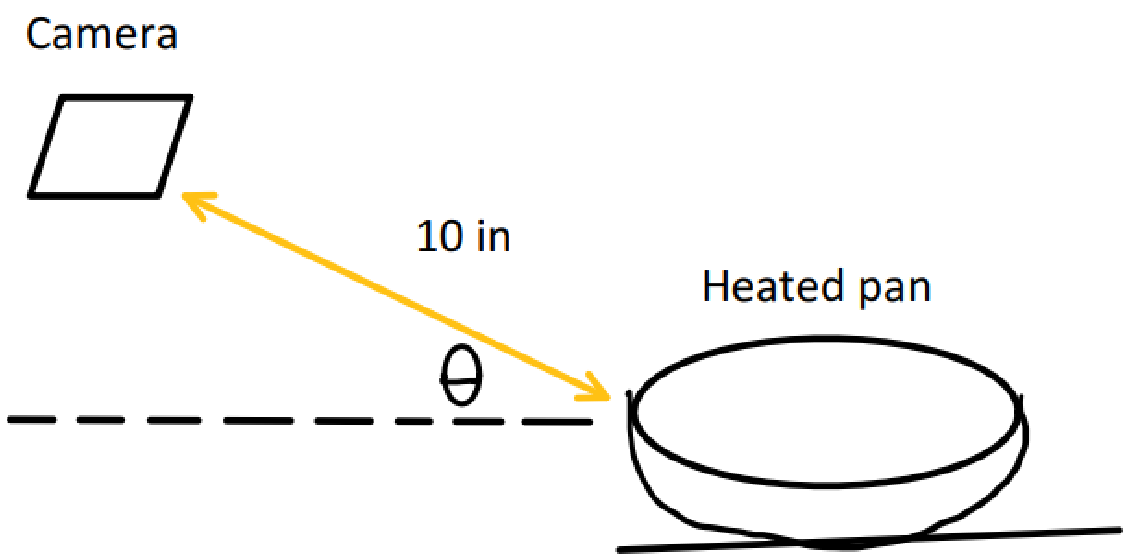


**Figure 2.** Photographic setup

Since the pan size is known to be 12 inches in diameter, with the whole pan in the frame the horizontal field of view can be estimated to be 12 inches. The video was also captured at an angle of ~30 degrees above horizontal. I used my Canon Rebel T5i with a 18-50mm lens, and recorded the video at 60 fps and 720p. The ISO was set to 6400 which may have contributed to the graininess of the final video. The shutter speed was 1/400 and the aperture setting was f4.5. I believe these were not the optimal settings, and in hindsight a lower ISO and longer shutter speed would have been more appropriate for the lighting of the subject.

**Final Editing**

I really enjoyed the editing process for this video project. I zoomed in and slowed down key moments where you can see the formation of a vapor layer, and initially when the two pools collide. I felt that these were the key points of the video, and it successfully highlighted them. I added text to explain the physical processes that were occurring to create a more complete experience for the viewer.

**Conclusion**

This experiment was extremely enjoyable, and beneficial to my understanding of the Leidenfrost effect. With the knowledge I gained from researching this topic for the writing of this report, I believe that I can easily repeat this process and even use a heater in a laboratory to further control the temperature and experimentally determine the Leidenfrost point. However, I am happy with my video as a colorful presentation of some cool fluid physics.

*References*

[1]J. Walker “Boiling and the Leidenfrost Effect” *Cleveland State University* (1994).
[2]J. Burton, D. Harvey “New Method Reveals Minimum Heat for Levitating Drops” *Emory University* (2021)