

Project 3: A Cup of Tea

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Flow Visualization

CU Boulder

Spring 2014

The purpose of this short film was to observe the fluid dynamics of an everyday activity, pouring milk into tea. The short was made for a course titled Flow Visualization at the University of Colorado at Boulder. The course aims to explore the physics and art of fluid flow.

The flow in the film was made with a fairly simple experiment. First, I brewed a cup of tea in an average sized coffee mug. Then poured 2% milk from a height of about 6" into the center of the mug. This milk jet entering the tea created a sloshing effect. In the video, notice that the milk initially sinks to the bottom but momentum carries it back to the surface. Then momentum carries the slosh of milk back to the bottom. Over time, the two fluids, milk and tea, become a more homogenous mixture. One might think the higher milk density drives the milk to the bottom but the density of milk¹ is about 1.033 kg/L whereas water is 1.000 kg/L. This is a very small density, leading to the conclusion that the primary driver of sloshing is momentum.

Sloshing is a common fluid dynamics problem with applications in spacecraft fuel, trucker tanks, and spilling coffee. In order to achieve sloshing effect "the liquid must have a free surface"². In this case, the free surface is the top of the mug. A noteworthy study³, found that the natural frequency of coffee in common mug is very close to the frequency produced from the biomechanics of walking. This creates a sloshing effect and makes spilling coffee quite common.

The lighting in the video was created from a fluorescent lamp above the cup. The video camera was set on tripod with the distance between the cup and lens being about 12". The following camera specs were used:

Type of camera: JVC GC-PX100

Original Frame Rate: 59 fps

Edited Frame Rate: 29 fps

Original Frame Dimensions: 640 x 360

Edited Frame Dimensions: 854 x 480

The video was post processed using windows movie maker. A soundtrack from the Free Music Archive was used titled "Ninna Nanna" by Pink Martini. The video was slowed during the milk droplet portion to match the piano in the music. Then the end of the video was sped up to make a more interesting credit sequence. If I were to do this again, I would use natural sunlight. The fluorescent lighting provided a distasteful flickering. I would also experiment with coffee. A dark brew of coffee could make a stark contrast with white milk. This contrast could make for clearer flow visualization.

Works cited:

1. "Density of Milk." *Density of Milk*. N.p., n.d. Web. 27 Apr. 2014. <<http://hypertextbook.com/facts/2002/AliciaNoelleJones.shtml>>.

2. "Slosh Dynamics." *Wikipedia*. Wikimedia Foundation, 18 Apr. 2014. Web. 27 Apr. 2014. <http://en.wikipedia.org/wiki/Slosh_dynamics>.
3. Mayer, H. C., and R. Krechetnikov. "Walking with Coffee: Why Does It Spill?" *Physical Review E* 85.4 (2012)