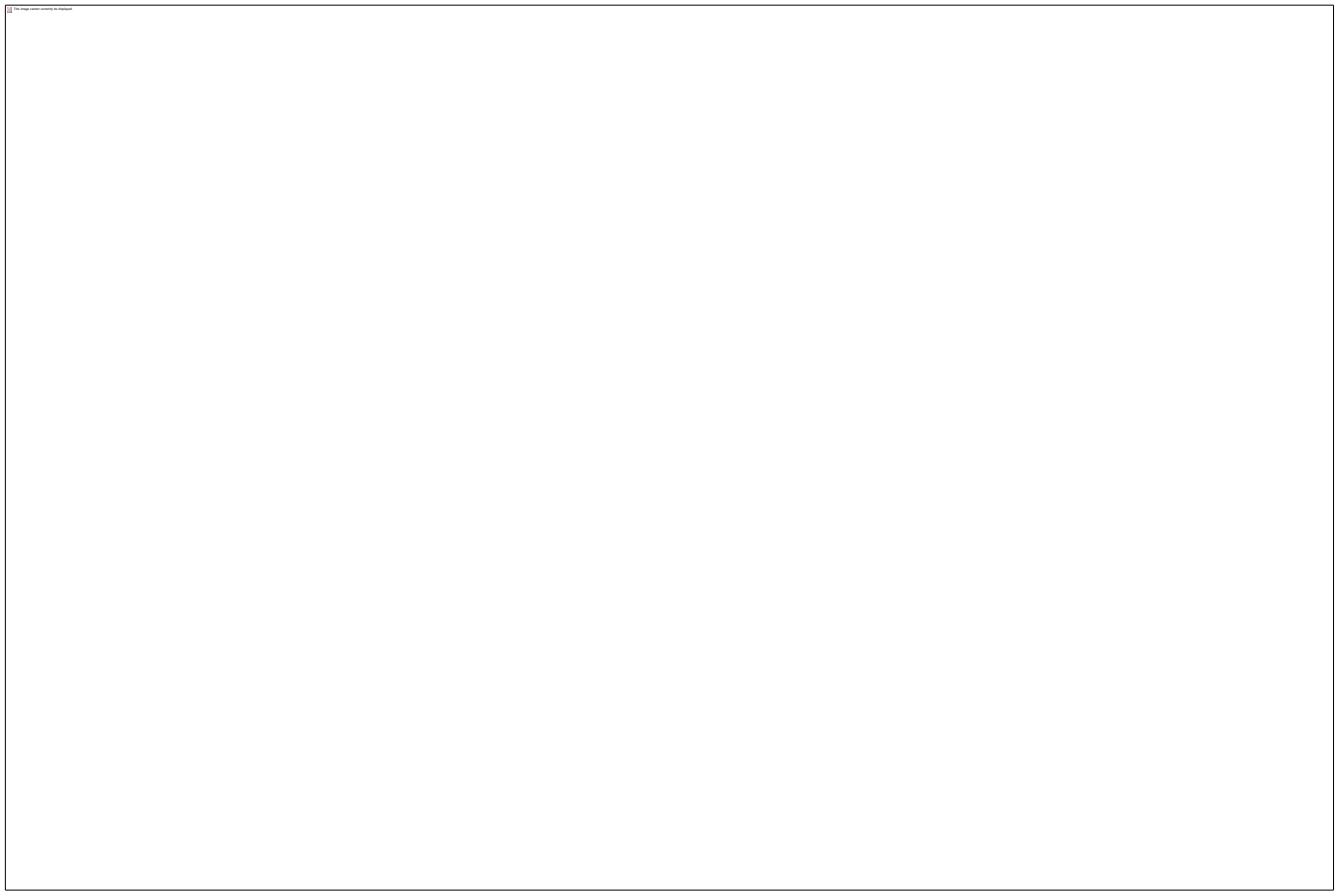
MCEN 4151
Flow Visualization

Instructor:
Jean Hertzberg

Andrew Locke

Assignment #3: Team Image

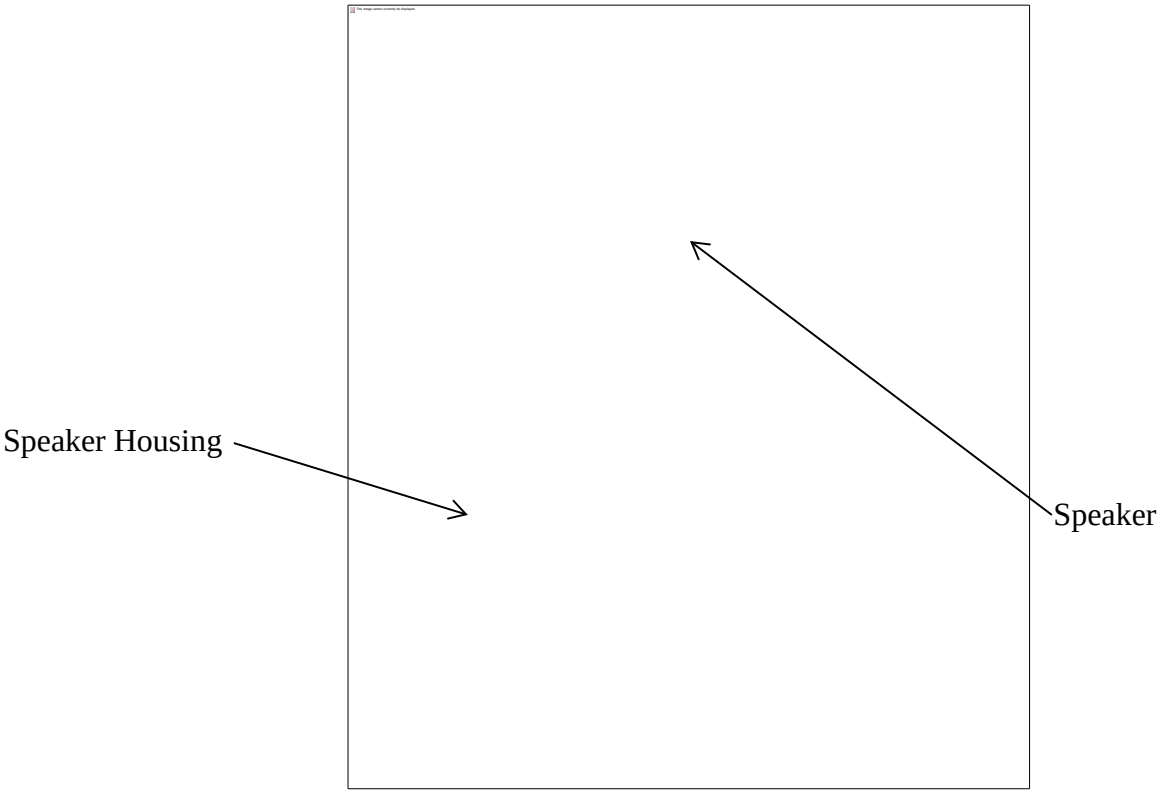


Introduction

The image above shows how non-Newtonian fluids behave under applied vibrational stresses. Additional credit is awarded to Zachary Wehner, for aid in the setup and lighting. The intent of the image was to show atypical fluid behavior. The fluid used is a mixture of corn starch and tap water, more commonly known as Oobleck. A non-Newtonian fluid is characterized most often by its non-constant viscosity. In most cases, the viscosity is dependent on applied shear. This effect is visualized by using a speaker to generate non-uniform applied shear. A plastic covering is stretched over the speaker to protect it. The corn starch and water mixture (approximately one quarter teaspoon corn starch per ounce water) is poured over the plastic covering, and a tone is played first through an amplifier, then through the speaker. In this experiment, a song was played, which caused changing fluid viscosity during different sections of the musical number.

Setup

The image below depicts the setup used. I stood approximately two feet away from the 8" diameter speaker when the image was taken. The speaker housing is approximately 24"x30"x28"



Viscosity is defined as the measure of a fluid's resistance to deformation under shear stress. In Newtonian fluids, this value depends only on temperature, and is constant at a constant temperature. However, in many non-Newtonian fluids, including Oobleck, the viscosity depends on the magnitude of the applied shear stress. Oobleck is considered a "shear thickening" fluid, because its viscosity increases with an increased rate of shear. This can be seen in one's kitchen, in that the mixture will flow similarly to syrup when no shear is applied. However, once shear stress is applied, the viscosity increases, and the fluid will stop flowing. The setup above aims to rapidly vary the applied shear from maximal shear to very little shear. In doing so, the viscosity varies wildly, and the effect above can be seen.

Technique

No special techniques were employed. The lighting consisted of two table lamps, placed directly over the fluid

Camera Technique

FOV size: unknown. This will be known in future publications.
Distance from object to lens: 2 feet
Lens Focal Length: 55mm
Digital camera: Canon EOS Rebel XSI DSLR 4272x2848
No post-image processing
F-stop: f/5.6
Exposure time: 1/400s
ISO: 800

Intent and Assessment

This image very clearly shows non-Newtonian shear thickening behavior, and it was quite enjoyable to set up. The most difficult aspect in setting up this experiment was the fact that the air between the plastic covering and speaker is compressible. This means that some of the vibrations from the speaker are dissipated through the air, before being transferred to the fluid. If I were to repeat this experiment, I would use a less valuable speaker and pour the Oobleck directly over the speaker.

References

http://en.wikipedia.org/wiki/Shear_thickening
http://en.wikipedia.org/wiki/Viscosity
http://en.wikipedia.org/wiki/Non-Newtonian_fluid