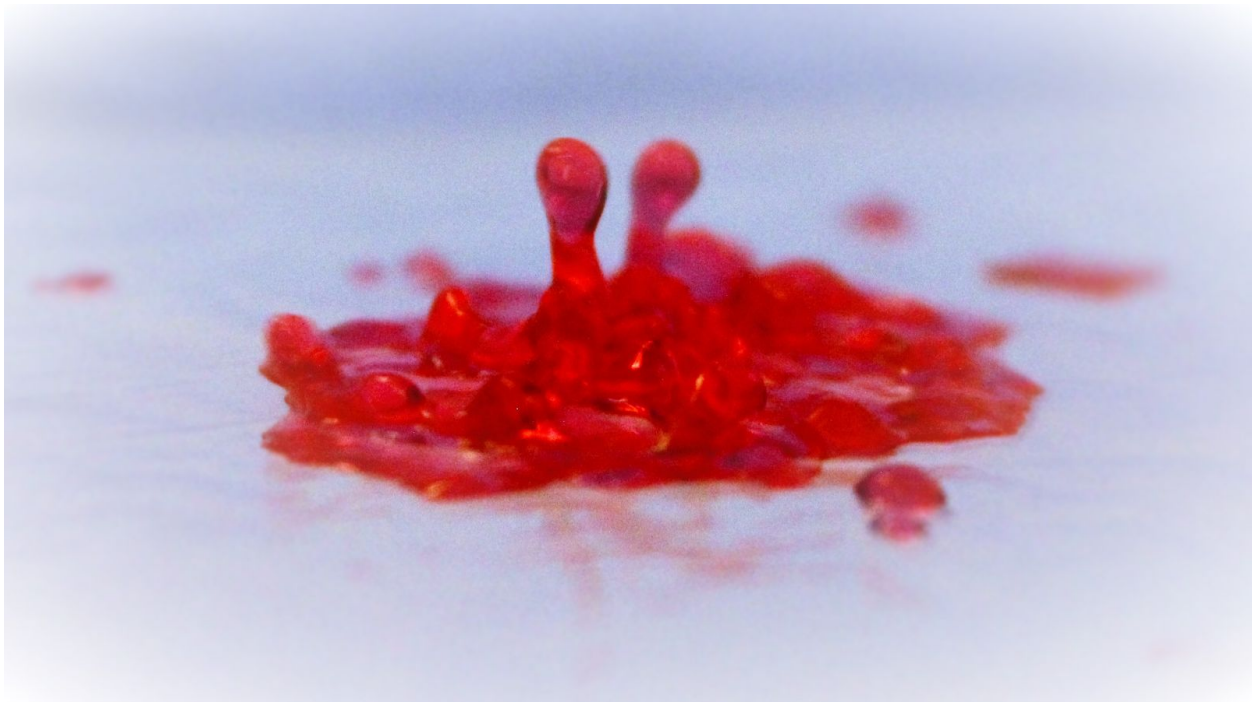
Team First 2016

MCEN 4151: Flow Visualization

University of Colorado Boulder



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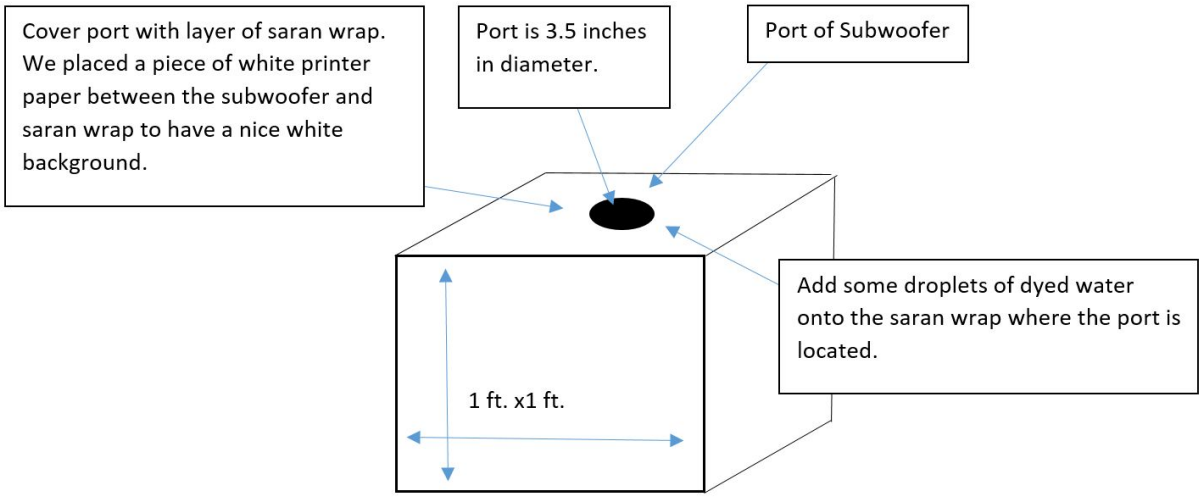
10/26/16

For our first team project we wanted to see how a fluid reacts to vibrations produced by a speaker. In the third paragraph you can read how we setup the apparatus in order to capture the flow. We had a few false starts when trying to produce the right fluid flow we were looking for. For our first attempt we put the saran wrap over the port of the subwoofer and played different frequencies. We found if we used to high of a frequency the saran gets sucked into the port of the subwoofer. So trial and error was necessary in order to find the correct frequency to use. Sean Harrison and Hunter Miller helped with setting up the apparatus and capturing photos.

To get the vibrating fluid flow shown in the image above we placed a subwoofer on its back with the port in the vertical direction. We covered the port with a sheet of white printer paper and a layer of saran wrap on top. This allowed the dyed water to bounce off the saran wrap layer when different frequencies were produced by the subwoofer. The following diagram shows the setup for the experiment.



Frequencies ranging from 20 - 200 Hz for the type of subwoofer we used. When the image was captured the frequency was closer to 70 Hz. Notice how the fluid has spikes in that are located in the center of the fluid. The governing equation we can use to calculate the pressure coming out of the port of the subwoofer is shown below.

$$P = \rho c A w$$

The area can be calculated using the dimensions of the circular port of the subwoofer with r = 1.75 inches (0.044 m), A = 6.08 x 10^-3 m^2. C is the wave speed which is equal to 42 m/s and the density of air is 1.225 kg/m^3. Lastly, w = 70Hz is the frequency of the wave. We can calculate the pressure to be 21.90 mPa. Now, we can calculate the force the pressure applies to the saran wrap to make the fluid jump.

$$F = PA$$

Using the above equation we get a force of 1.3315E-4 N. This is a small force but considering it only has to move a small amount of water it seems reasonable.

For our project we used Klipsech 200w speaker/subwoofer to generate fluid flow on the port of the subwoofer. The type of fluid we used was water with red food coloring dye mixed in. We tipped the subwoofer on its back so that the port was in the vertical direction. We first covered the speaker with white printer paper to have a nice white background since the speakers were black. Then we laid down a layer of saran wrap so the fluid would not absorb into the white printer paper. We also had a white printer paper as a background to grab images from multiple angles. We tried to use a small

spotlight that was placed about a foot above the subwoofer but in some images the saran wrap emitted rainbow colored reflections that were distracting. So in order to prevent that we had to play around with different sources and angles of lighting. Here trial and error was the easiest way to figure out what lighting worked best.

To capture the image I used a Canon EOS Rebel T5 with a 18-55mm lens. The ISO was set to 2500 and a depth of field of 39mm. The f stop was set to f/5 with a timing of 1/500 seconds in order to capture the quick jump of the fluid. The dimensions of the original image was 5184 x 3456 pixels and the edited was 2844 x 1595 pixels. The original image is shown below in Figure 1.

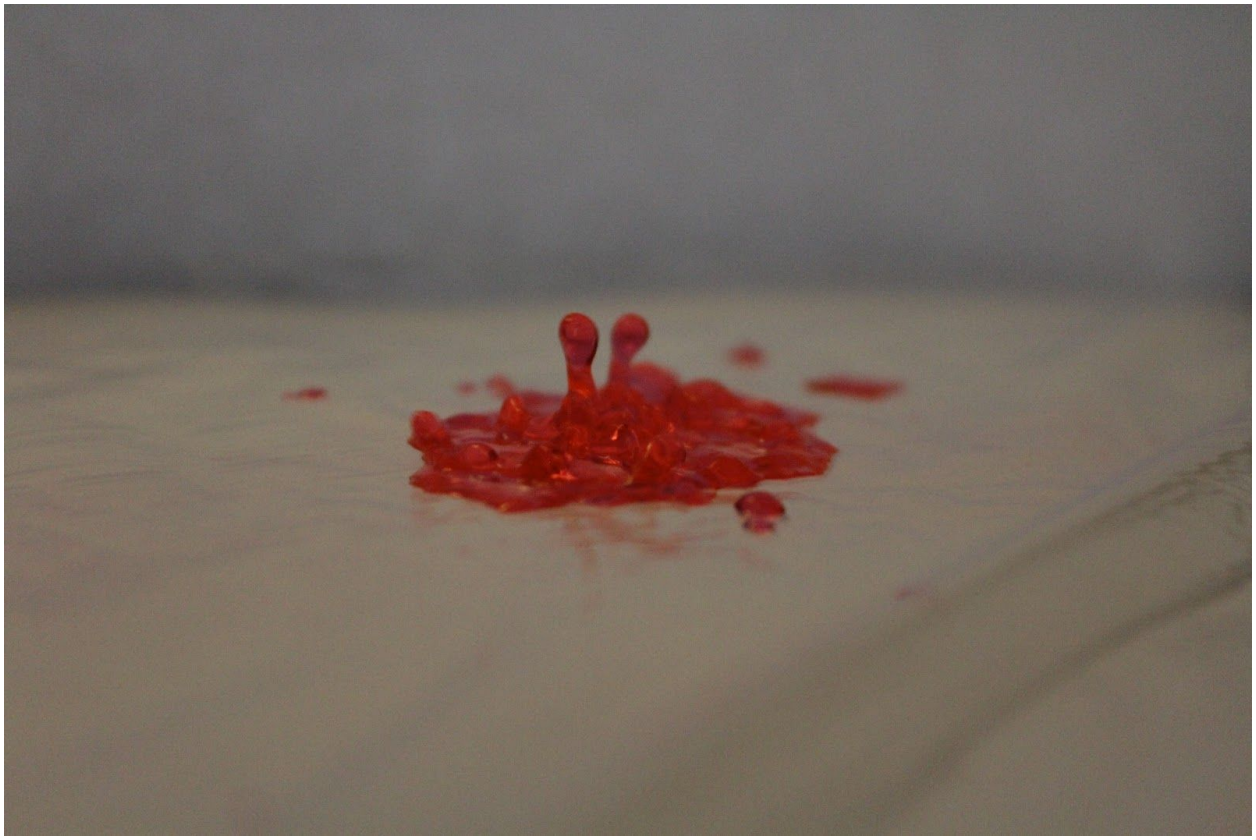


Figure 1: Original Image

After capturing the image I used the software GIMP to add some effects that I thought would enhance the fluid flow. Since the original image was pretty dark I whitened the background to draw more attention to the red fluid in the center. I also cropped the image so there was less distracting elements. Enhancing the contrast helped bring more color to the dyed red water. The last editing I did was to make the shadows more defined in the fluid which helped add more detail to the flow.

One thing I really enjoyed by doing this project is seeing how different the fluid reacts depending on how much fluid you use. In my image I only used a few droplets of water where you can see how dense the fluid is throughout the process. When using more fluid you can notice higher spikes that are further apart from one another. I would have liked to see the images come out clearer. It was very hard to capture the flow at the right time while keeping everything in focus. The most difficult part about capturing the image is the timing when to capture the flow. You have to guess when the flow will be at its peak.