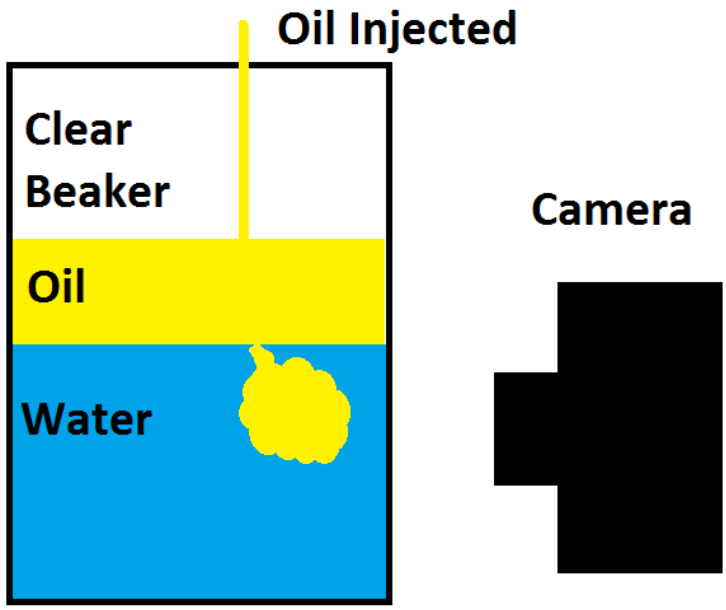
Phil Nystrom
MCEN 5151-001
5/4/2018

Team 3rd Report, Alien Planet

Phil Nystorm, Luke Collier, Eric Robinson, Zach Marshall, Yousef Shashtari

For our third project, team Epsilon 5 sought to demonstrate the interaction of fluids with varying densities and surface tensions, giving interesting patterns and flows when forced together. The fluids chosen were water and canola oil. Water was chosen as a polar liquid because it's readily available, and canola oil was chosen as the non-polar liquid because it is environmentally friendly. This combination gave a strong interaction, and a very interesting picture overall.

The flow apparatus was contained in a clear beaker of roughly one gallon. The beaker was filled with about 4 inches of tap water, then about one inch of canola oil. Note that while pouring the canola oil into the system the surface interface was distorted, so the fluids were left to sit undisturbed to reach a steady state. [1] Once the water-oil interface was completely flat, more canola oil was shot directly through the interface with a cooking squirt bottle. This method pushed the moving liquid directly through the oil and into the water, making for an interesting flow. The flow apparatus can be seen in the figure below.



Note that the density of canola oil is only 92% that of water, giving it an inherent buoyancy when shot into water. Further, it has some momentum from the fall, which makes a force balance between momentum and buoyancy. This force balance is calculated below. [2]

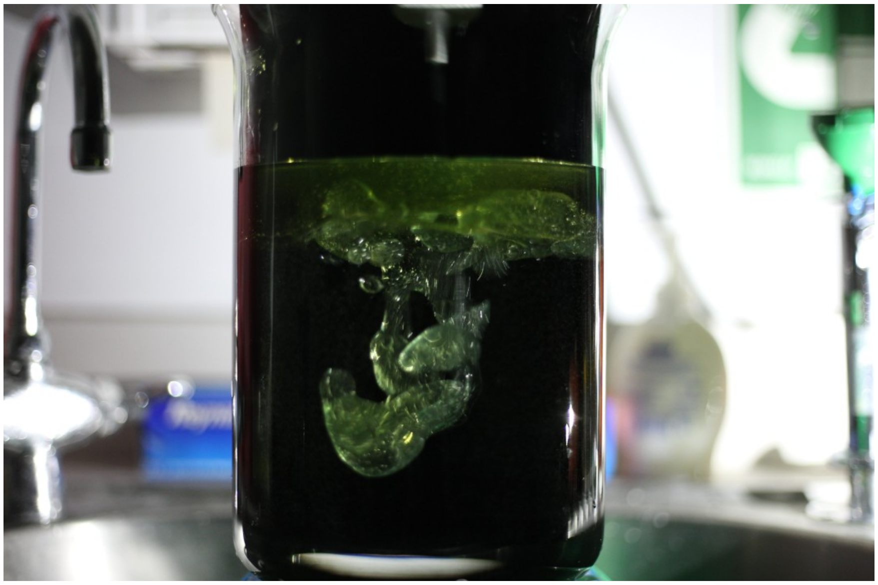
$$F_{Buoyancy} = F_{Momentum}$$

$$F_B = (\rho_{oil} - \rho_{water}) * Volume \qquad F_M = \rho_{oil} * Volume * \frac{Velocity^2}{2 * Distance}$$

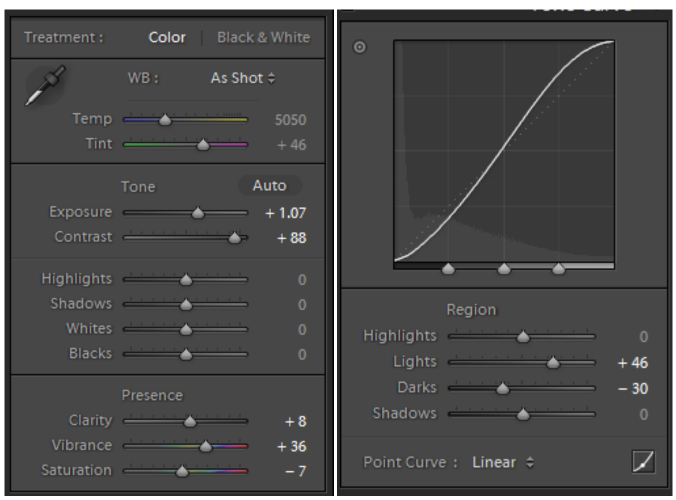
$$Velocity = \sqrt{\left(\frac{\rho_{oil} - \rho_{water}}{\rho_{oil}}\right) * 2 * Distance} = .11\, {}^{m}/_{s}$$

To better visualize the phenomena at hand, food dye was added to only the oil being injected, giving a green hue to the image. This not only emphasized the flow regime, but added an alien look and feel to the image. Note that the room lights helped light up the oil, making it stand out better against the water background. To further mute the water, a black piece of plastic was placed behind the beaker. [3] Overall, this scheme made an image which puts the oil at the forefront and shows the flow regime.

The image was taken with a Canon 6D, DSLR with a fixed 50mm lens. The resolution of the original image is 5472x3648 pixels. It was taken at F/1.8, ISO 2500 and 1/40 sec exposure, to mute the motion of the picture; any slower and the image would be very blurry. When taking the picture the subject was roughly 2 feet away from the camera, giving a field of view of roughly 1 foot. The original image is shown below.



For post processing, the image was first cropped and rotated to better show the flow in the subject. Next, the exposure and contrast were increased to bring out the beauty of the image. The tone curve was also adjusted to match this effect. Lastly, the green hue in the image was increased to make the green dye in the fluid pop more. these effects can be seen below. Note that all edits were made in Adobe Lightroom.



Overall, the image came out very well and shows an interesting flow phenomena. The interacting forces of buoyancy and momentum gave some great physics as well. It resulted in complex shape, which I feel looks like an alien rising out of a molten green lake of goo. To take this concept further, I would like to see more opposite fluids interacting, and maybe some better coloring effects. In sum, the image came out very well and shows a unique and interesting fluid interaction.

References

1) Du, Tao (06/2018). "Experimental study on mixing and stratification of buoyancy-driven flows produced by continuous buoyant source in narrow inclined tank". *International journal of heat and mass transfer* (0017-9310), 121 , p. 453.

2) Britter, R. E. (08/1980). "The motion of the front of a gravity current travelling down an incline". *Journal of fluid mechanics* (0022-1120), 99 (03), p. 531.

3) CAULFIELD, C. P. (04/1998). "Turbulent gravitational convection from a point source in a non-uniformly stratified environment". *Journal of fluid mechanics* (0022-1120), 360 , p. 229.