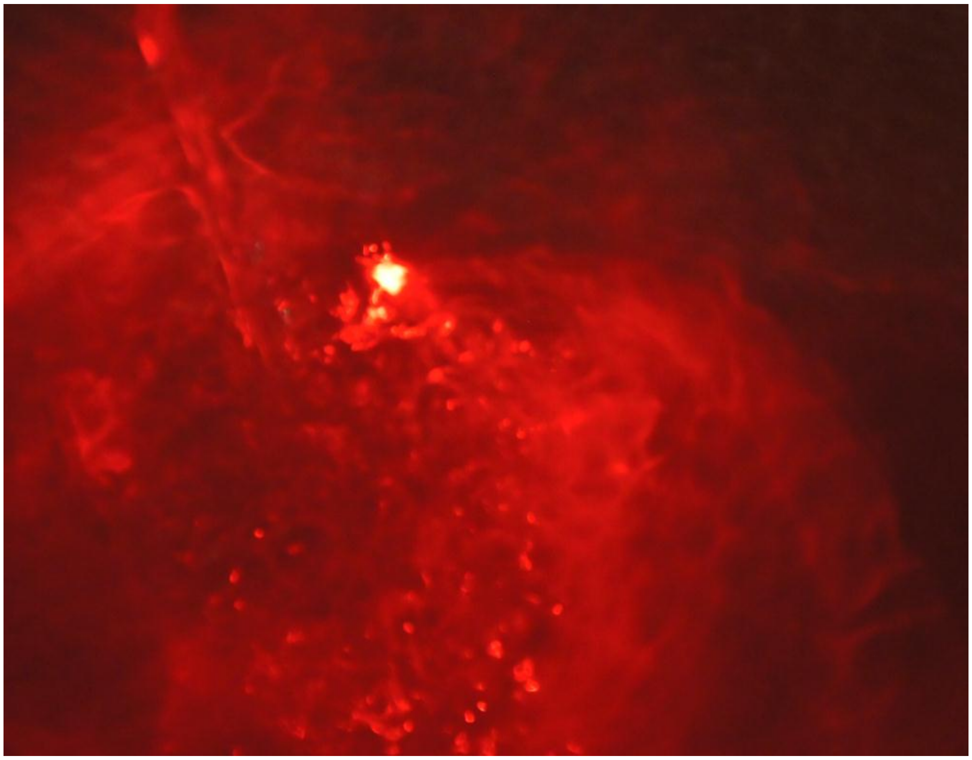
Flow Visualization: Team Image #1 Report



The image seen to the right is a submission for the spring semester of Flow Visualization's first team based image assignment. In this particular case, the image and setup was created independent of a group. Originally, the picture was intended to capture the concept of total internal reflection of a red laser pointer. However, due to issues and difficulties during setup, totally internal reflection was not captured accurately. What is shown in the image is what resulted from the attempt.

At first, the setup involved a large plastic two liter bottle punctured near the bottom. This allowed for water to leak out of the bottle. The sketch below illustrates the attempted setup.

Figure 1 - Bottle & Water Setup. Orig Image source - http://www.physicslessons.com/demos.html

On the opposing bottle wall from the puncture where water was to exit the bottle, a red laser pointer was held and directed through the bottle towards the hole. Here, total internal reflection should be clear. The image should appear like the image below.

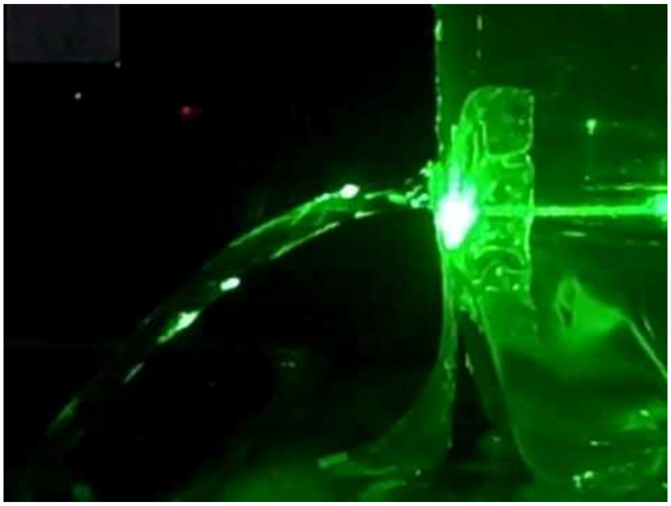


Figure 2 - Example of Total Internal Reflection. Image Source - http://wn.com/Total_internal_reflection

As shown in the above image, the internal reflection of the laser pointer along the water stream is clear. Unfortunately, the setup for the image concept continued to fail and the bottle hole degraded steadily over time. The image submitted is the eventual setup of sink water flowing downwards into a flat plate. The red laser pointer was aimed downwards alongside the sink water fluid stream. The setup concept can be seen in the image below.

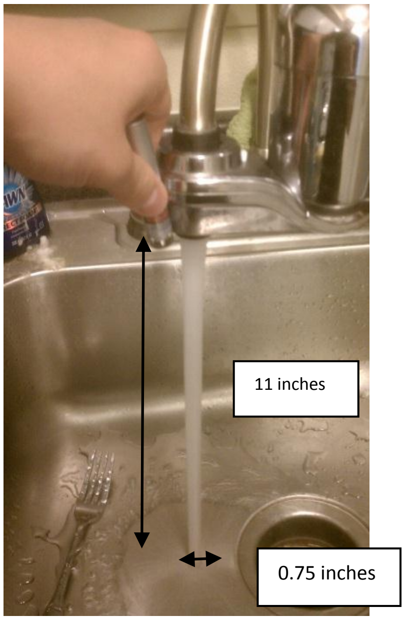


Figure 3 - Setup for submitted image

The sink water exits the faucet at a relatively quick velocity. This speed is approximated by measuring the time it took the water to travel the gap between the faucet head and the bottom of the sink. To perform a brief analysis of the flow, the Reynolds number can be estimated. Reynolds number, Re, is length x speed divided by the kinematic viscosity. In the case of the image, the water (at ~70 degrees Fahrenheit) has an approximate kinematic viscosity of 1.052E-5 (ft^2/s) [1].

Faucet – Sink time ~ 0.5 seconds; velocity = 11inches/0.5seconds = 22 in/s = 1.83 feet/s

Re = (0.0625 ft)*(1.83 ft/s)/(1.052E-5 ft^2/s) = **10872.15**

The high Reynolds number associates with turbulent flow for the falling sink water stream. The red laser is partially reflecting inside the stream as it travels downwards and then undergoing much more additional reflection once it hits the plate. The image itself captures the laser reflecting within the water as it ripples outwards.

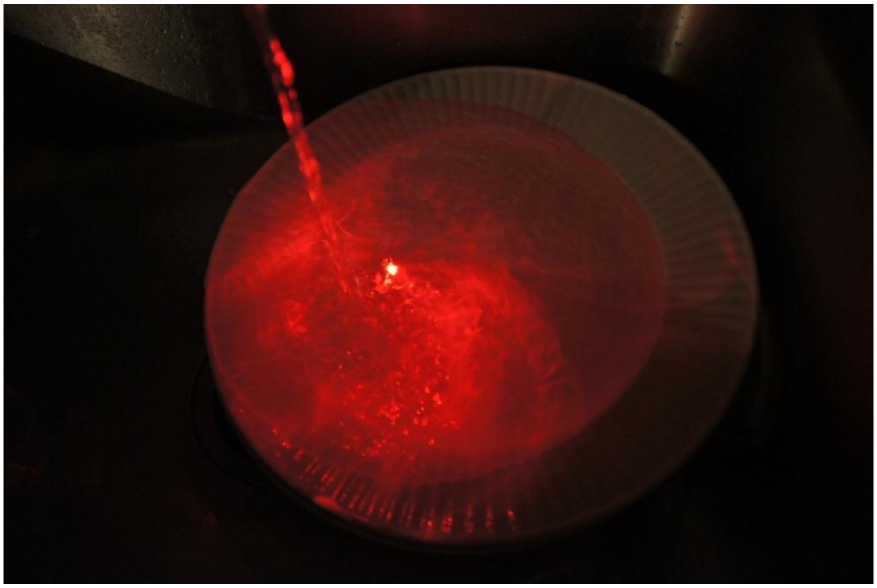
For future recreation of the submitted image, the same setup can be used. However, in order to capture the original concept, changes must be made to the apparatus. Firstly, the puncture hole on the sides of the bottle should be made using a hole punch in order to create a smooth circular exit for the water. Secondly, a mount for the laser should be constructed in order to hold it in a steady position, accurately pointing at the hole in the bottle. Lighting conditions for the image should be dark with minimal lighting to best capture the light of the laser.

Total internal reflection, the concept failed to be captured in the image, is an observable event in which light fails to pass through a medium and refract. Instead, the light is all reflected. This reflection instead of refraction is due to the refractive index being lower past the medium and the incident angle being greater than the critical angle. In the case of the laser in water, the light of the laser continuously undergoes total internal reflection. Regardless of the water stream's direction, the laser will continue to reflect inside the stream. What results is the laser following the direction of the stream, typically appearing to "curve".

The original image spanned approximately one and foot and a half high by two foot wide, and in addition to not using the camera flash capability, a combination of default and custom camera settings were used. The camera, a Sony SLT-A55V DSLR, was located approximately 24 inches from the plate. A focal length of 18 mm was selected in order to best focus the light on the plate. Alongside the focal length, an F-number of 3.5, an exposure time of 1/15, and an ISO of 1600 were selected for the best combination of clarity and lighting. In regards to post production, Adobe Photoshop was used to slightly increase the brightness and crop down the image. The original, unedited image can be seen below. Its resolution is 4912 x 3264.

---

[1] http://www.engineeringtoolbox.com/water-dynamic-kinematic-viscosity-d_596.html



In the end, the original intended concept of total internal reflection was not portrayed, but a new interesting image setup was also discovered. For future image capture, a few improvements can be made to the unintended setup. These include further aligning the laser pointer with the sink water stream, trying different color and material plates, and also utilizing better camera settings to avoid some of the small amounts of blur on the outer edges of the water. In addition, improvements can be made in order to capture the original intended concept of total internal reflection. Most of these involve the apparatus, however, camera settings should be similar to the submitted image. Although the fluid flow of the sink water stream isn’t clear in the image due to the resizing, the rippling outwards of the water in the plate as well as the light reflecting throughout the water is in fact clear. With better focus, the clarity of the interesting patterns due to the ripples and light would be more visible and add to the effectiveness of the image.

Works Cited.

"Water - Absolute and Kinematic Viscosity." *Engineering ToolBox*. Web. 29 Mar. 2012. <http://www.engineeringtoolbox.com/water-dynamic-kinematic-viscosity-d_596.html>.

"Total Internal Reflection." *Wn.com*. Web. 29 Mar. 2012. <http://wn.com/Total_internal_reflection>.

"Demos." *PhysicsLessons.com*. Web. 29 Mar. 2012. <http://www.physicslessons.com/demos.html>.

"Total Internal Reflection." *Wikipedia.org.* Web. 6 May. 2012. <http://en.wikipedia.org/wiki/Total_internal_reflection> .