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Group Image #1
3/14/13

Flow Visualization Spring 2013

Glycerin on CD

For this first group image assignment I choose to capture how light bends around a glycerin drop while it sits on the back of a CD. For this image I worked with Grant Boerhave, we worked together to get the lighting right and capture the images that we each wanted. I wanted to show how the white light interacts with the glycerin, dispersing the light and bending it around the boundary of the drop. I started out using my regular lens which is an 18-55mm lens, but this was not getting me close enough to really see the detail of the light for my image. This being the purpose of my image, we moved to using a macro lens which allowed us to focus in on small portions of the CD and isolate sections of glycerin drops.

Below is a diagram of how we set up the shot with the light source, position of CD and the direction of where I was taking the picture from. My picture was taken from a really high angle, almost from directly above. The glycerin drops were on the upper right quadrant of the CD when it orientated like in the picture below. In total there were about 20 - ¼ in. diameter drops spread out in a grid like pattern, though they were not all exactly the same size or spacing between them.

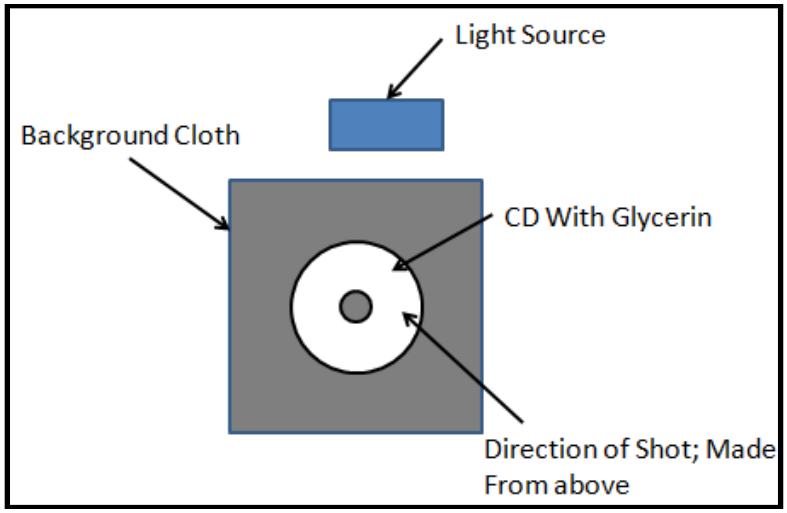
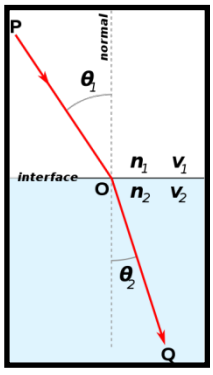


Photo Setup Diagram



Though the fluid (glycerin) is not actually flowing in my image, the light that is being bent and diffracted around the drop is a phenomenon itself, and the one that I was trying to capture in my photo. As light moves through a boundary of two mediums, the incidence angle that the light refracts at follows Snell's Law: $\frac{Sin\theta_1}{Sin\theta_2} = \frac{v_1}{v_2} = \frac{n_1}{n_2}$, θ = the angle measure from the normal of the Boundary, v = speed of light through corresponding angle, n = refraction index of medium. I estimate that the light was coming down and hitting the glycerin at an angle of 25 degrees. If we then take the constant refraction indexes for air and glycerin, we can then find the angle that the light is bending when it enter the glycerin.

$$n_1 = 1.000308, n_2 = 1.4722$$

Solving for θ_2

$$\theta_2 = Sin^{-1}(\frac{n_2 Sin\theta_1}{n_1})$$

$$\theta_2 = 16.687$$

If you then take this to be the angle that the light is hit the boundary when it leaves the glycerin, you can find the angle that the light is off of the normal to the boundary when the light goes back into the air.

$$\theta_1 = 16.687 \text{ (glycerin is now medium 1)}$$

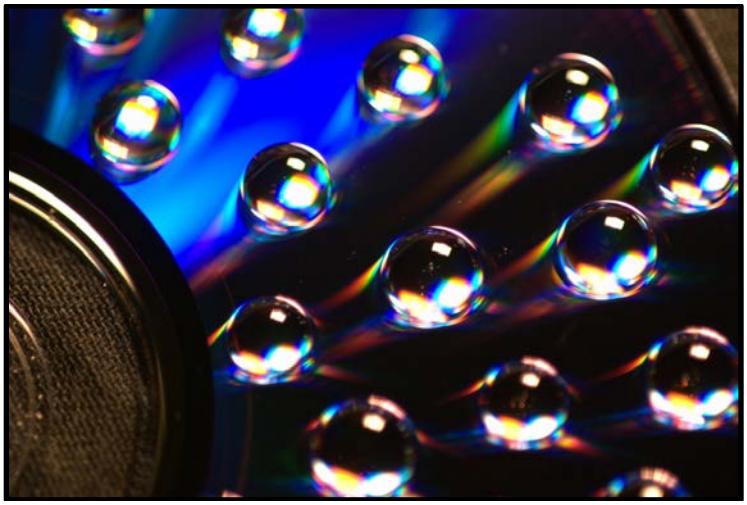
$$n_1 = 1.4722,\ n_2 = 1.000308$$

$$\theta_2 = Sin^{-1}\left(\frac{n_2 Sin\theta_1}{n_1}\right)$$

$$\theta_2 = 25$$

You will notice that the light will exit at the same angle that it originally entered the glycerin at.

For this image we did not have to use any special visualization technique, just light from a halogen work light. The glycerin creates the visualization effect of the light bending and diffracting around the drop. It was very interesting how the light curved after it passed the sides of the drops and how the light diffracts into red, blue green and yellow. This is the important part of my image and the reason that I cut my original image down. From my original to final cut, I cropped my image way down to just focus on two drops and adjusted to color curve a little to bring out the distinct color that he white light diffracted into. Below are my original and final cut images.



Original Image

Final Cut

As discussed before we use a macro lens to capture these images, so I use Grant's camera (Nikon D60) because it was the camera that we had the lens set up on. With lights out in room except for the work lap, we were able direct the light exactly where we wanted it to be, and with a tripod to remove the motion blur from shakes, I was able to shoot with a low ISO and reasonable big aperture. We played around a lot with the shutter speed, so as to get enough light to see the effect of the glycerin but not too much that there was a lot of over exposure. I wish I could have got rid of the over expose on the bottom of the two drops in my final cut, though I could not figure out how to get this done with my limited PhotoShop skills. Below is a summary table of the camera setting used while taking this image.

Camera	Nikon D60
Lens	Micro-Nikkor 105mm 1:2.8
Size of Field (Original)	2.5in. x 3in.
Size of Field (Final Cut)	0.5in. x 1 in.
Focal Length	5 in.
Aperture	f/5.6
Shutter Speed	1/60 sec
ISO	100
Pixel Dimensions (Final Cut)	1924 x 635
Pixel Dimensions (Original Cut)	3900 x 2613

I was really please with the phenomena that I captured in my image, I have always felt that light is one of those things that we think we understand but can surprise us at any time if it wants. The bending of the light and diffraction gives the image a Sci-Fi feeling, almost looking digitally done. Really wish we could have gotten the drops to be more like balls of glycerin, I feel like it would have created an even more interesting diffraction of the light with a complete sphere. I wish I had gotten an image with a sharp focus in the swath of blue that is reflecting on the CD in the original image, there were some really interesting shadow type things from the glycerin drop that showed up in the back of original image, I of course did not notice these until looking at the image later. Another small aspect of my image that I think would be interesting to look further into are the air bubbles that can be seen in my final cut image. I would really like to try to get a bigger ball of glycerin and try to create a bubble in the middle with some kind of smoke and then get an image with the smoke circulating in the glycerin ball. Not sure if I will be able to get a ball big enough to see this though. For my next image maybe, if these challenges can be overcome.

Sources:
http://refractiveindex.info/
http://en.wikipedia.org/wiki/Snell's_law