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MCEN 4151 Flow Visualization
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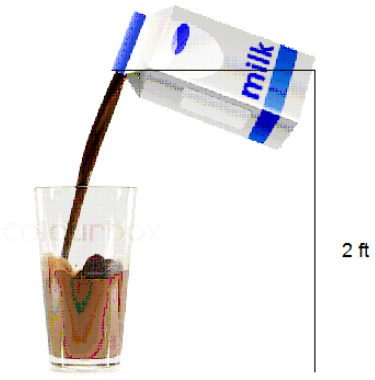
Team Two Image: Pouring Chocolate Milk

The purpose of this image was to capture the behavior of chocolate milk being poured into a cup from a relatively high position. This image was really fun to take because of the varying behaviors of the chocolate milk flowing into (and sometimes, out of) the cup while it was being photographed. The big challenges of this image were to actually get the fluid in focus in the shot, making sure the stream actually hit the glass, and trying to keep the camera dry. This image was really fun to take, and I wanted to convey that sense of fun through the subject of chocolate milk. After an hour of playing, I was finally able to get a satisfactory image.

In order to set up my image, I place a clear glass on my counter and measured two feet above the ground with a ruler. I then started to pour the chocolate milk in a thin stream to aim it at the glass. When I was sure that I had the stream lined up, I would tip the chocolate milk container so that it was nearly inverted. This simplified some of my calculations in assuming that the chocolate milk was in pure free fall. The diagram below should better the visual of this.



The density of the chocolate milk used was 1056.6882 kg/m^3, and based on the instantaneous velocity of a free falling object: $v_i = \sqrt{2gd}$, I was able to estimate the chocolate milk traveling at approximately 3.46 m/s. With a little searching I was able to find a study done with chocolate milk with measured viscosities ranging from 5 to 20 mPa s (I will choose to use a value of 11). Then plugging these values in, I was able to find the approximate Reynolds number for my chocolate milk flow. Re=ρVL/μ = 1056.6882(3.46)(0.6096)/(11MPa)= 2.03E4. This image shows the path of the chocolate milk as it flows down and back up the glass it was poured into. The cohesion between the glass and the chocolate milk helps the milk “grab” on to the sides of the glass and really create interesting and chaotic flow patterns. As the liquid reaches the top of its trajectory

in the glass, it starts to fall back down and interfere with the rest of the flow which is what really gives this image its uniqueness.

This picture was simply taken while the chocolate milk was poured into the glass. The container was set two feet off the surface and then poured into the glass. The camera was positioned between two feet and eight inches away from the glass in order to try to get the best shots. Ambient lighting from the ceiling fluorescent lights was all that was used to illuminate the image not even a flash. The chocolate milk was brought straight out of the fridge when the shooting began and only a clear glass was used in order to best see the effects of the drink moving in the glass.

In this image I wanted to focus on the effects of the milk in the glass, but I didn't want to leave out the little trail of milk coming into the glass. I used the kitchen as my background so it seemed more natural than just a normal photo shoot with a backdrop. I didn't really do much ion photoshop because the image was already pretty clean. I just cropped it so the glass was framed in a more natural way.

This photo was shot with the following specifications;

CAMERA	Nikon D40X
SHUTTER SPEED	1/100 sec
F-STOP	f/6
APERATURE VALUE	f/6
ISO	1600
FOCAL LENGTH	120.0mm
LENS	28.0-43000 mm f/3.5-6.3
PIXEL DIMENSIONS	3872 by 2592

I really think that this image reveals the unpredictability of fluid flows in general. I think that this image displays the physics of how the milk interacted with the glass, but we are still mathematically inept at predicting what will happen each time I pour more milk into the glass in terms of fluid behavior near the boundary wall and due to the interference of the back flow of the falling milk. I think I fulfilled my intent, but my only regret was not having more time to play with the phenomena.

Sources

"Milk, chocolate, fluid, commercial, reduced fat, with added calcium." *Aqua Calc*. N.p., 2012. Web. <http://www.aqua-calc.com/page/density-table/substance/Milk-coma-and-blank-chocolate-coma-and-blank-fluid-coma-and-blank-commercial-coma-and-blank-reduced-blank-fat-coma-and-blank-with-blank-added-blank-calcium>.

Mario Yanes, Luis Durán, Elvira CostellCorresponding author contact information, . "Rheological and optical properties of commercial chocolate milk beverages." *Science Direct*. Journal of Food Engineering, n.d. Web. <http://www.sciencedirect.com/science/article/pii/S0260877401000619>.