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Get Wet Assignment
Due Date: 2/8/2010

Objective

In every day life, we always see fluid stream flowing in and out of certain fluid containers such as pipes and faucets, however, it is might be invisible to human eyes what are the mechanisms that are causing the fluid flow phenomena to occur. The primary purpose of this Get Wet project is to examine the effects of gravitational and pressure on a stream of Sunkist soda flowing into a glass.

Flow Apparatus

The image below displays the flow apparatus for the Get Wet experiment. The following materials are needed to set up the experiments: a glass, soda can with Sunkist in it, black apron to use as a background, a pouring person, and camera person. Basically, a glass is used to hold the stream of the Sunkist soda. The camera person would take the image as the pouring person pours Sunkist into the glass. The distance from the camera len to the fluid is approximately 3 inches.

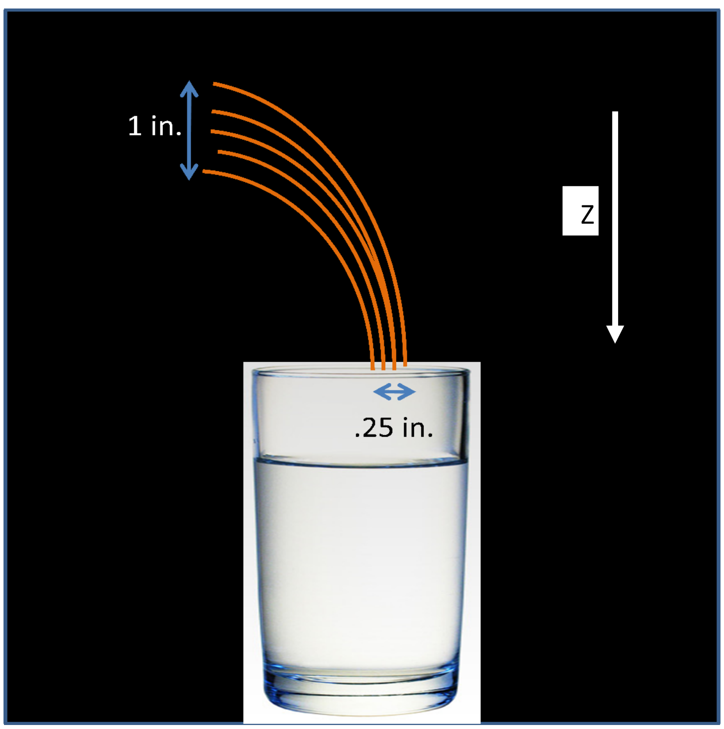

Figure 1: Flow Apparatus Set Up

Discussions

The primary force that makes the fluid leaves the soda can is the force of my hand. After leaving the soda can, there are two main forces that are acting on the Sunkist stream in order to make the fluid flow from top of the glass into the bottom of the glass. These two forces are known as pressure and gravitational force.

Pressure is a normal force and will act on all the surfaces of the fluid. Gravitational force occurs due to gravitational effect and it is the same everywhere in the z-direction. Figure 2 shows a volume element of Sunkist and how pressure and gravitational force act on the volume element.

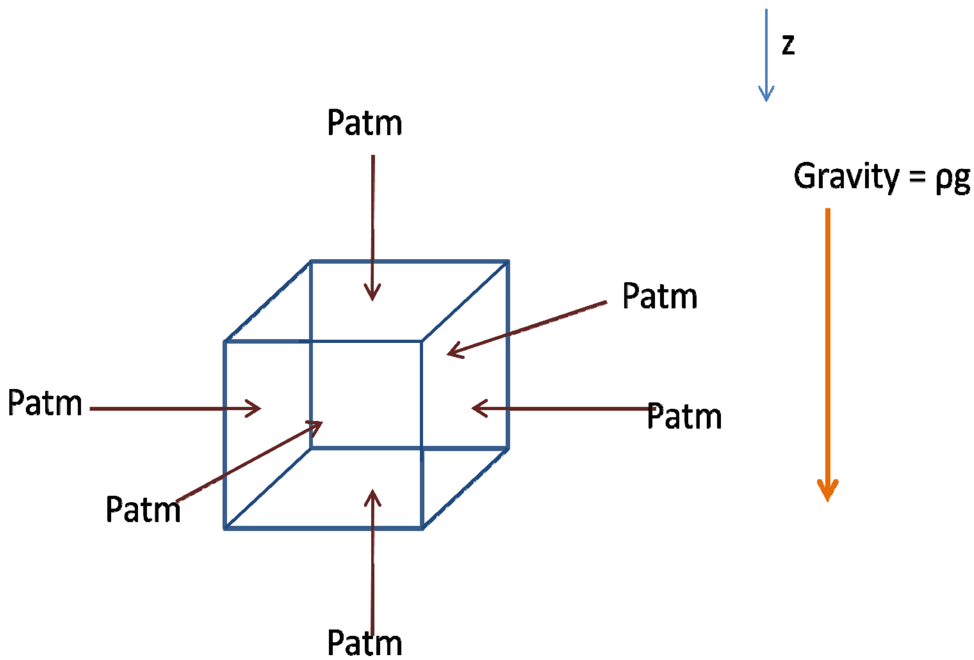

Figure 2: Body Force Diagram

Based on the figure above, the net force of the system is just the gravity force because the net pressure force is zero. Since the gravitational force is constant, the acceleration must be constant as well, therefore, it is possible to calculate the velocity of the system. Equation 1 is used to analyze the velocity.

$$v = \int_0^t g \, dt \qquad (1)$$

This equation shows that velocity increases with time. This indicates that as the stream flows downward into the glass, the velocity is increasing. Based on the mass balance, mass flow in has to equal mass flow out, so if velocity is increasing then the cross-sectional area must be decreasing. This explains why the cross-sectional area is getting smaller toward the bottom of the glass.

Another transport phenomenon that can be used to examine this free-stream flow system is by measuring the Reynolds number. Reynolds number dictates whether the flow is turbulent or laminar. Volumetric flow rate, diameter of the glass, velocity, and cross sectional area of the glass are measured in order to calculate the Reynolds number. The stream is moving at a volumetric rate of $3.55 \times 10^{-5} m^3/s$. The distance that the stream needs to travel is taken as the distance between the top of stream and the bottom of the class. This distance comes out to be 0.1778 m. Assuming the kinematic viscosity of Sunkist is similar to water, which is 1.0 x 10^{-6} m^2/s. The cross sectional area of the glass with the diameter of 0.068 m is measured to be 3.7 x 10^{-3} m^2. With these parameters, the following equation is used to calculate the Reynolds number of the fluid, where D is the diameter of the glass.

$$Re = \frac{QD}{\nu A} \qquad (2)$$

The above equation yields a Reynolds number of 659, which means the fluid flow is in the laminar flow region according to the Fundamentals of Fluid Mechanics book (1). This is consistent with the fluid flow that I have observed while taking the image.

Flow instability fundamentals can also be used to study the free stream flow. Flow instabilities occur when there is a curved streamline in the direction of fluid flow (2). Since the cross sectional area of the fluid stream is changing with time, this indicates the fluid is experiencing the Plateau-Rayleigh instability. This instability occurs when the surface tension is presence within the fluid system (3). At the top of stream, the surface tension is reduced due to a large cross-sectional area and the surface tension is increased due to a smaller cross-sectional area. Because of this surface tension difference, Plateau-Rayleigh instability is presence in the studied fluid system.

Visualization Technique

In terms of visualization technique, many different types of lighting effects were used to increase image resolution. Flash on the camera was on to reveal the orange color of Sunkist. Household light was also in action to increase the contrast between Sunkist and the background. A black apron was used as background to minimize the reflection and diffraction of light from the surrounding environment.

Photographic Technique

To capture the image, the Canon camera of PowerShot SD 1200 IS was used. The distance from the fluid to the lens was approximately 3 inches. The field of view was 2.7 inches in diameter and 7 inches in height. The image dimension was at 1374 x 1390 pixels. The shutter speed was at 1/60 seconds with F-stop value of f/10. The aperture value was f/10 with the max being f/3.5. The focal length of the camera was set at 9.681 mm. And the ISO speed rating was 80.

Conclusion

Overall, what I like the most about my image is that it clearly shows that surface tension does have an impact on the shape of fluid. Although, light reflection from glass and motion blurs toward the bottom of the glass do distort the image a little. For my next project, I would like to figure out if Photoshop can reduce or get rid of the motion blur effect. I will also maybe try to study the effect of surface tension on static fluid. The reason for this is because I can further use the Young-Laplace equation to examine how the pressure difference changes with radii of curvature of fluid. Nonetheless, the image does fulfill my intent due the changing in fluid shape as the fluid travels downward into a glass.

Works Cited

1. **Munson, Bruce R., Okiishi, Theodore H. and Huebsch, Wade W.** *Fundamentals of Fluid Mechanics.* [ed.] sixth. s.l. : John Wiley & Sons, Inc., 2009.

2. **Pathak, Jai A., Ross, David J. and Migler, Kalman D.** NIST. *Purely Elastic Flow Instability, Curved Streamlines and Mixing in Microfluidic Flows* . [Online] http://www.nist.gov/sigmaxi/Posters04/pathak.html.

3. **Pierre-Gilles de Gennes, Francoise Brochard-Wyart, David Quere,.** *Capillarity and wetting phenomean; drops, bubbles, pearls, waves.* s.l. : Springer+Science Business Media Inc., 2004.