

This photograph was taken as part of the third group project. Many photos were taken attempting to show the various phenomena that can be visualized by carbon dioxide gas produced from dry ice by placing it in various liquids. The final image shows fluid flow patterns produced by laminar gas flow over a bluff body. The team experimented with placing the dry ice in different liquids including oil and dyed water of various temperatures, but the desired flow in the final image was achieved using only hot water with the dense flow pictured falling around the perimeter of the vase used to contain the solution.

To create this image, approximately 3/4 of a liter of hot tap water was poured over 85 g of dry ice in a red vase. The vase, which is 10 cm wide at its widest point, was placed on a backdrop of yellow velvet to reduce glare and provide a uniform background that still had some texture. The basic flow seen is gas flow over a bluff body. The solution was allowed to settle for 1 minute so the sublimed carbon dioxide gas would be laminar as it exited the opening of the vase. All of the vapor cascaded directly down the sides of the vase as it exited because its density is  $1.98 \text{ kg/m}^3$ , or about 1.5 times that of air. It flowed at approximately 1 m/s, resulting in a Reynold's number that was sufficiently low to allow laminar flow. No significant time resolution is required; in fact the idea of the image is to capture the smoothness of the gas as it appears to the eye.

Dry ice and hot water were all that were necessary to produce the fluid visualized in the image. The dry ice sublimates in the hot water, producing a gas that appears as a thick fog due to its water vapor content. A yellow velvet sheet was used underneath and behind the vase. The lighting used was two 60W light bulbs that lit the object from above as well as the camera's flash.

This photo was taken with a Canon EOS Digital Rebel XT. The field of view seen is approximately 20 cm wide by 15 cm tall. The lens is 20 cm from the edge of the vase. The lens has a focal length of 31 mm, an aperture of 5.6, a shutter speed of 1/40 sec, and the camera's ISO was 400. The final image is 2496 x 1664 pixels. Photoshop was used to invert the photo for more desirable colors as well as to see increased detail in the gas flow, and to increase contrast.

The image is effective at displaying what was intended, which is the flow of gas around a bluff body. The flow is so laminar and smooth that it makes the foreground of the image look out of focus, or that the gas is actually a fabric draped over the vase. The high color contrast between the vase and the backdrop, as well as the backdrop's texture, add some depth to the image. I would like to know what causes the folds in the smooth flow, and would also like to experiment with colored gases, which are difficult to achieve.