Dry-Ice Flow

Our intentions for the final team project were to play with dry ice and to try to observe the types of flow properties that can be created by manipulating the CO2. We first started playing with the dry ice by dropping pieces in a cup of water. We eventually found that there was a big difference in the amount of CO2 created by changing the temperature of the water, amount of dry ice, surface area of the dry ice, and volume of water. After playing with different containers and different ways of visualizing the CO2, the picture I decided to use was created by pouring the CO2 down a cardboard tube.

The flow apparatus used for this photograph can be seen in Appendix 1. A 24 oz cup was filled ¼ of the way with hot water. Crushed dry ice was then dropped into the cup. Finally, the CO2 that was created was poured down a 2in diameter cardboard tube. This created the flow seen in the photo. It is very easy to see the vortices created from the CO2 falling out of the tube. The transition from laminar to turbulent flow is also very apparent in the photo. The CO2 coming out of the tube is laminar, and as it falls it speeds up and breaks up into a turbulent flow toward the bottom of the photo.

The visualization technique used in this photograph is smoke in the form of CO2. The cup was filled ¼ of the way up with water at 95˚F, and about 5 pieces of crushed dry ice. The dry ice was crushed because this created more surface area for the ice to contact the water. This creates much more CO2, much more quickly than if we used one solid block of dry ice. The lighting apparatus can be seen in appendix A. We used two strobe lights in a darkened room. One had an umbrella to soften the light, and another had a soft box. The flash on the camera was also used.

The field of view in the final photograph is 12in x 12in. The distance from the flow to the lens was about 3ft. The lens focal length is recorded as 60mm. The camera I used was a Nikon D80. The pixel size in the original photograph was 3888 x 2592, with an image resolution of 72 dpi. The exposure time was 1/200 sec, with an ISO speed of 1600. There quite a little bit of Photoshop work done with this photograph. The image was cropped, and then converted to grayscale. Finally, the layers were then adjusted to get the blacks darker and the white's whiter

This image reveals a lot about what we were trying to visualize. There were hundreds of photos taken, but this one is the only one that shows the laminar to turbulent transition so well, while still having such well formed vortices. I like how the flow starts in the top left then moves into the bottom right of the frame. This moves your eyes across the picture very well. I also like how it starts strong in the top left, and then even though you can follow it diagonally to the bottom right, it almost disappears. To me, this almost tells a story. We completely fulfilled our intent to visualize CO2 from dry ice. The physics shown are exactly what we were trying to see. If we were going to do this again, I think it would be fun to try different ways of pouring, dropping, or manipulating the CO2 clouds. There seems to be endless possibilities when it comes to playing with dry ice.

Appendix A

Top View

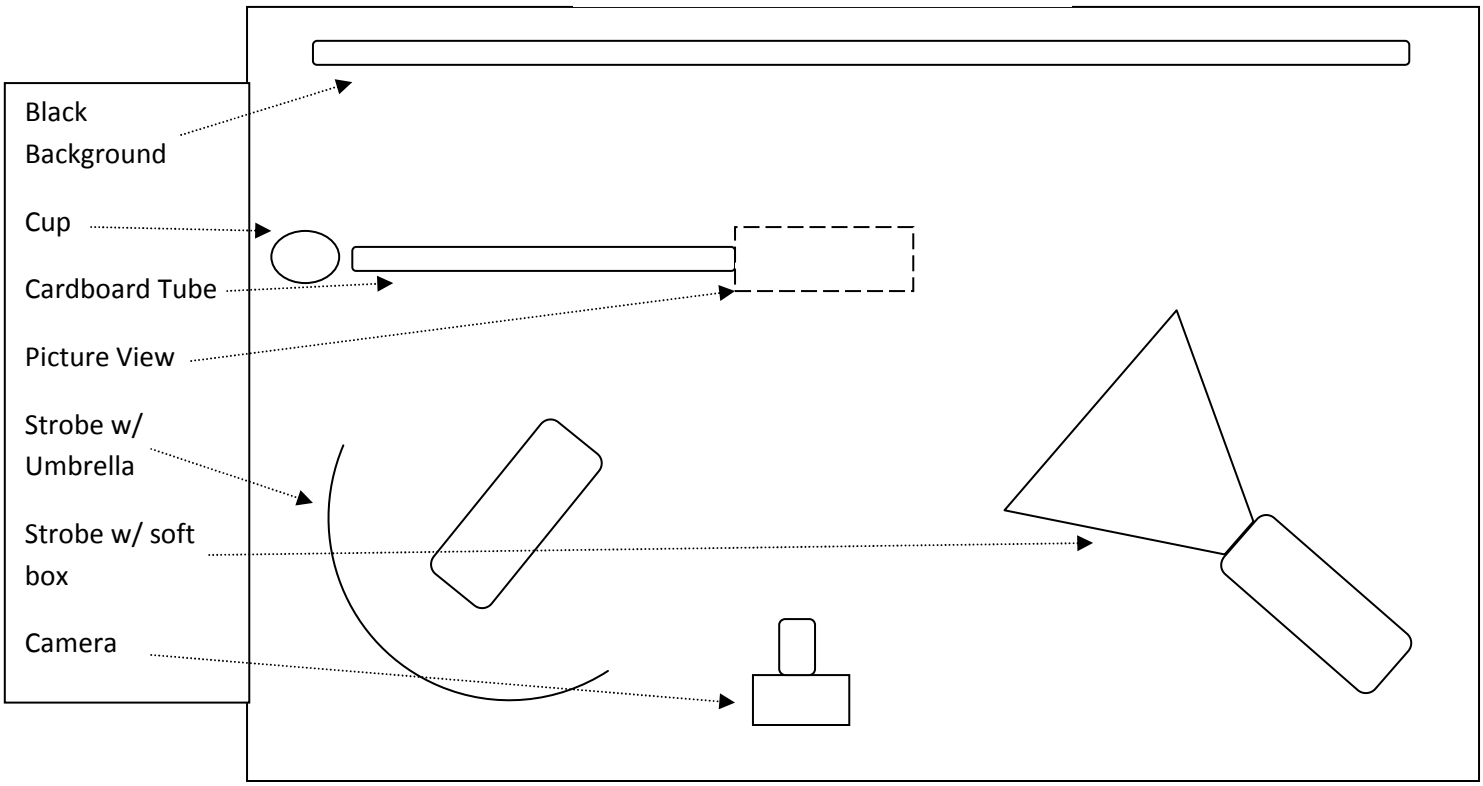

Image Assessment Form
Flow Visualization
Fall 2007

Scale: +, ! = excellent Ö = meets expectations; good. ~ = Ok, could be better. X = needs work. NA = not applicable

Art	Your assessment	Instructor assessment
Intent was realized	+	
Effective	+	
Impact	+	
Interesting	+	
Beautiful	+	
Dramatic	+	
Feel/texture	+	
No distracting elements	+	
Framing/cropping enhances image	+	
Flow	Your assessment	Instructor assessment
Clearly illustrates phenomena	+	
Flow is understandable	+	
Physics revealed	+	
Details visible	+	
Flow is reproducible	+	
Flow is controlled	+	
Creative flow or technique	+	
Publishable quality	+	
Photographic technique	Your assessment	Instructor assessment
Exposure: highlights detailed	+	
Exposure: shadows detailed	+	
Full contrast range	+	
Focus	+	
Depth of field	+	
Time resolved	+	
Spatially resolved	+	
Clean, no spots	+	
OK, simple print	+	
Mat	N/A	
Mounting	N/A	

Report		Your assessment	Instructor assessment
Describes intent	Artistic	+	
	Scientific	+	
Describes fluid phenomena		+	
Estimates appropriate scales	Reynolds number etc.	+	

Calculation of time resolution etc.	How far did flow move during exposure?	+	
References:	Web level	+	
	Refereed journal level	+	
Clearly written		+	
Information is organized		+	
Good spelling and grammar		+	
Professional language (publishable)		+	
Provides information needed for reproducing flow	Fluid data, flow rates	+	
	geometry	+	
	timing	+	
Provides information needed for reproducing vis technique	Method	+	
	dilution	+	
	injection speed	+	
	settings	+	
lighting type	(strobe/tungsten, watts, number)	+	
	light position, distance	+	
Provides information for reproducing image	Camera type and model	+	
	Camera-subject distance	+	
	Field of view	+	
	Focal length	+	
	aperture	+	
	shutter speed	+	
	film type and speed or ISO setting	+	
	# pixels (width X ht)	+	
	Photoshop techniques	+	
	Print details	+	
	"before" Photoshop image	+	