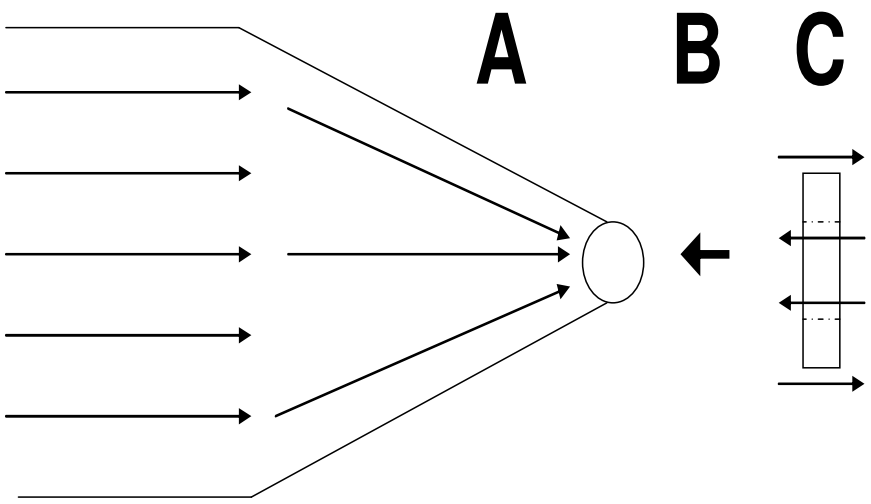
FLORESCENT RING

Context:
The goal in capturing these images was to picture the flow of florescent fluids in a controlled environment. The controlled elements of the environment were velocity, pressure, quantities & concentrations of fluids, and temperature. Most attempts to capture a significant and almost beautiful flow were unsuccessful. Major limitations included shooting equipment, lighting sources and experience in photography.

Laundry detergent and highlighter ink were the chosen florescent materials. The two materials have similar densities but differ substantially in viscosity and florescent color. There for they will react differently and be easily distinguished from one another. The exact materials in each fluid are however unattainable.

Apparatus & Flow:
The apparatus consisted of a pipette and beaker with a screw on assembly. . Highlighter ink suspended in the pipette is submerged into the beaker of laundry detergent. The circumference of the tip of the pipette is reduced by a factor greater than 10. The flow is induced by a relatively instantaneous change in pressure. At this point flow is forced through the reduce cross-section at the tip. Surface tension between the glass and ink cause the ink to emerge in a spherical shape (section A below). The stationary detergent applies a reaction force to the outer most section of the ink sphere (section B below). This causes a rotational flow from the inside of the sphere to the outside and back again (section C below). The ink has then created the vortex ring seen in the image 'florescent ring.'



Estimation of Reynolds number is hard with out known material properties or the exit velocity. However, since there are no significant signs of turbulent flow it is assumed that Re<1600 [1]. At Re=1600 there should be significant signs of each type of flow.

The equation for Reynolds number is Re = (Exit velocity * Exit diameter) / (kinematic velocity).

Visualization technique:
Florescent fluids were used for there illuminating characteristics. With the illuminating fluids as a light source glare was reduce and clarity enriched. To illuminate the florescent fluids to 60W black light bulbs were place on each side of the beaker attempting to create a uniform light distribution.

Photographic technique:

Field of view:	width~4in Hieght~3in
Distance from object to lens:	~.28m
Lens focal length:	55mm
Camera:	Digital 8.1 Mega Pixels Canon EOS
Exposure Specs:	1/6 sec. shutter speed, 6.3 Aperture value, 200 ISO
Image Processing:	Cropped the photo to better isolate the flow

Conclusions:
This image reveals the laminar flow of a vortex ring moving within a viscous tension reducing fluid of similar density. I would have liked to have used a longer beaker with the same length pipette so that I could had time to take the shot as the ring was suspended in the detergent. The image is a good representation of the shape and displacement of the ring, though it doesn't visualize the rotational flow around the inner and outer circumferences. A turbulent ring would give a better representation of this because it would have more visible action within the ring. In the future I would like to show a series of images with varying velocities and thus varying laminar and turbulent flow patterns.

References:

Takashi Naitoh, Naohiko Fukuda, Toshiyuki Gotoh, Hideo Yamada, and Kei Nakajima. "Experimental study of axial flow in a vortex ring." Physics Fluids Vol. 14, No. 1, 10 Sept 2001