15.DyeTech

Monday, March 15, 2010
4:17 PM

Today
Finish Resolution
Start specific FV techniques. Dyes
Admin: no office hours Tuesday this week. Yes office hours today and Wednesday.

Resolution

Need a tripod for macros, or shutters > 1/30 sec
Full size start at $25. Highly recommended.
Several available for checkout.

Estimate motion blur *in pixels* to guide choice of shutter speed.

Example:
Field of view = 10 cm
Fluid moving at 0.5 m/s
10 Mpx sensor

Minute paper, groups: what shutter speed will 'freeze' this flow?

Can tolerate maybe 5 px blur?
10 Mpx ~ 3750 X 2750
0.1 m / 3750 = 2.6 e-5 = 0.000026 m/px = 26μm/px
5 px = 1.3 e-4 m = 0.00013 = 0.13 mm estimated acceptable object displacement *x*
time *t = x/velocity*
1.3e-4 m / (0.5 m/s) = 2.6e-4 seconds
2.6e-4 sec = .00026 sec = 260 μsec= 1/3750 Very short. Can your camera do this?
5/3750 = 0.0013 = 0.13% of image width

Do this analysis for each image. Motion blur is surprisingly common and annoying.

If unacceptable, increase time resolution= shorter exposure time

Increase shutter speed
    Max is 1/10,000? 0.1 msec, 100 μsec? At best.
    High speed camera 30,000 fps ~ 3 x 10-5 sec = 30 μsec

Freeze the flow with short light source (won't work for light emitting fluids, i.e. flames)
    Strobe, camera flash ~ 10-5 or -6 sec = 1-10 μsec
    Pulsed laser 3x10-9 sec = 3 nsec or less
Good resource for high speed photography: http://www.hiviz.com/index.html

SPECIFIC FV techniques
Boundary techniques. Boundary between 'seeded' and unseeded fluid.
Choice depends on physics desired
I DYES Today. Mostly in water.
2 Aerosols Particles. Mostly in air for boundary effect.

In this class, often visualization technique determines physics examined, but usually physics are determined by system under study, and FV technique applied should not disturb the flow/physics

I Dye Considerations:

1)Want dye to NOT disturb flow
2)Want dye to show up - HIGH VISIBILITY
3) Special techniques

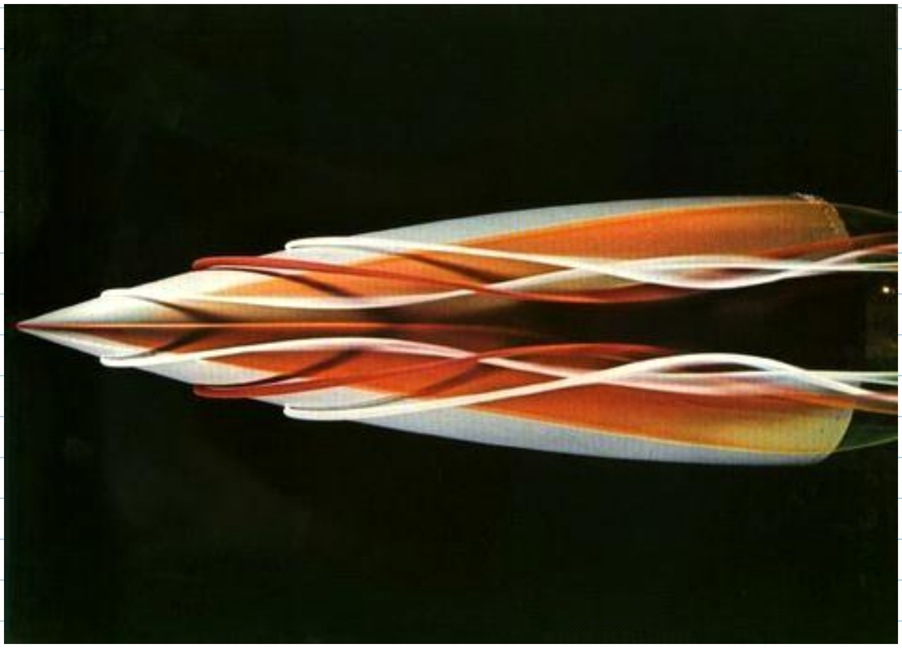
1) Not Disturb flow "How?"

Minute paper -Groups

Answers:

- Match flow speed when injecting
- Use small ports, minimize volume injected,
- Consider location of injection; reveals different physics

http://media.efluids.com/galleries/laminar?medium=113



by Henri Werlé, at ONERA = NASA of France Master of colored dye streams

Avoid injection altogether: Coat object with alcohol-dye mixture, let dry, then tow in tank. Shows vorticity layer, wake, boundary layer

Or coat short strings on a rake. OK for low speed, short run times

- Match fluid properties between dye and medium
  - Density
  - Temperature
  - Viscosity
  - Surface tension (match intermolecular forces)
  - Minimize chemical reactions (unless needed)
  - Diffusion coefficient

N.J. Mueschke et al., "Measurements of molecular mixing in a high-Schmidt-number Rayleigh-Taylor mixing layer," *Journal of Fluid Mechanics* 632, J. Fluid Mech. (UK) (2009): 17-48.

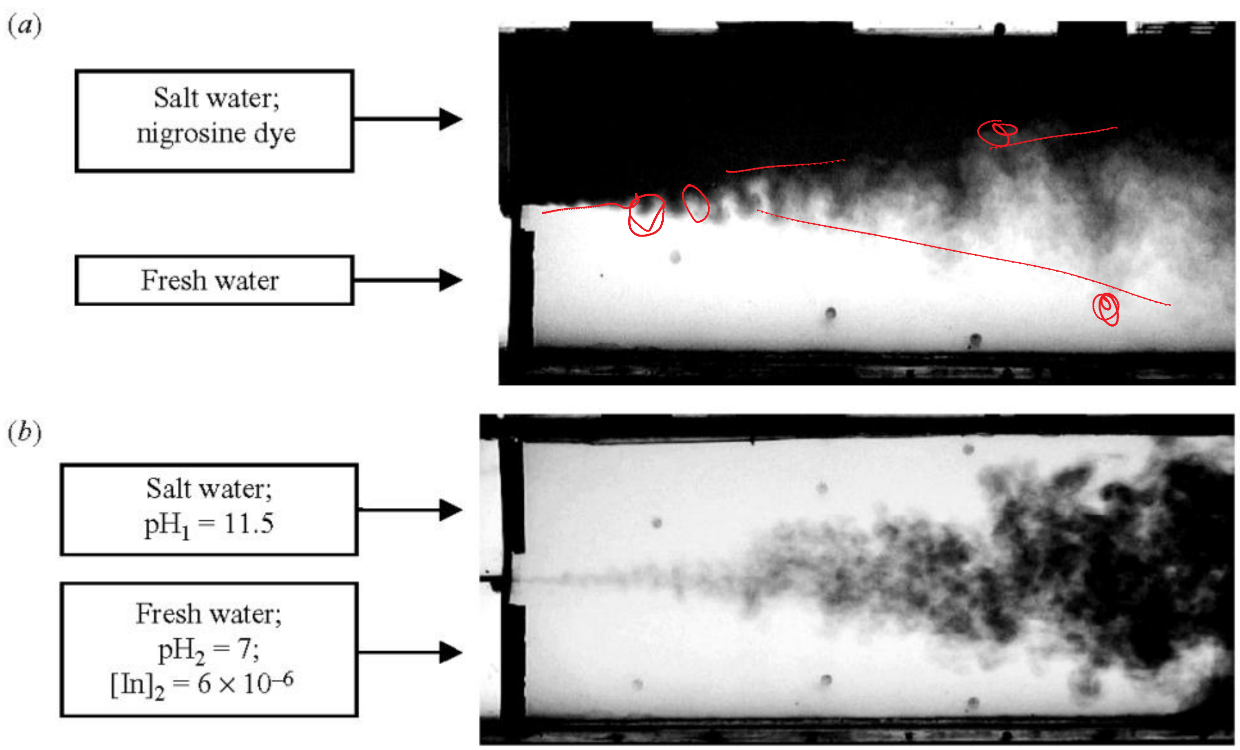


FIGURE 4. Photographs (contrast enhanced for visualization) of the buoyancy-generated mixing layer in a typical water channel experiment. (*a*) Nigrosine dye was added to the top stream. (*b*) Phenolphthalein was added to the bottom stream, which changes to its pink form as the two streams molecularly mix (here, "pink" is shown as dark regions within the mixing layer).

Ph indicator, shows where mixing got to molecular level.

Tough to match all these properties- Dye properties are different from ambient fluid.
To match density, try a premix.

For food dye in water, premix dye (dense, sinks in water) and isopropyl alcohol (floats) to get neutral buoyancy in water

The concentration gradient between dyed and undyed fluid may cause dye to diffuse too rapidly, misleading when studying mixing. Turbulence also causes fast diffusion, making visualization of the overall flow structure difficult. Try some milk or latex paint to slow diffusion.
Famous example:

Cloud tank was invented by Douglas Trumball to make realistic clouds in 'Close encounters of the third kind' (1980's sci fi). Used many times since:
http://www.youtube.com/watch?v=2Ps0iXwS60E

More info in Special Effects article
http://www.americanheritage.com/articles/magazine/it/2007/1/2007_1_10.shtml