Today:
- Admin
- Choices in imaging: Categories of Flow Vis

Admin:
- Talk to your neighbor about what you will do for GW
- Schedule
- Office hrs are Monday at 2, ECME 220

Last time:

Make CHOICES:
1. Flow phenomenon: Water boiling? Faucet dripping?
   - Why does it look like that: Consider FORCES:
     - Body forces: gravity, magnetism
     - Surface forces: Pressure (normal, perpendicular), and shear (parallel to surface)
2. Visualization technique: Add dye? See light distorted by air/water surface?
3. Lighting (source of worst image problems)
4. Image acquisition: Still? Video? Stereo? Time lapse? High speed?
5. Post processing, final output. Edit, at least crop the image, consider contrast.

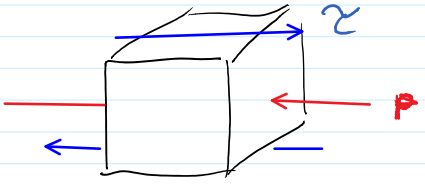
All *forces* can be categorized like this: 2 types of forces

Body

Acts directly on every molecule equally
a) Gravity
b) Electromagnetics

Surface

Acts on the surface of a volume of fluid



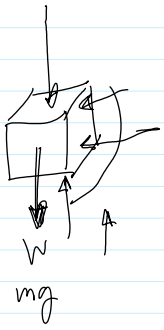
P Pressure: always perpendicular to surface

τ Shear: always parallel to surface

Any surface force can be decomposed into a shear plus pressure

Note: these are actually STRESSES = Force acting on an area.

Surface tension
Drag
Body force
Normal force
Shear force
Friction
Pressure
Gravity
Buoyancy
Atomic forces
Oscillating pressure forces
Kaye effect
http://fuckyeahfluiddynamics.tumblr.com/search/Kaye



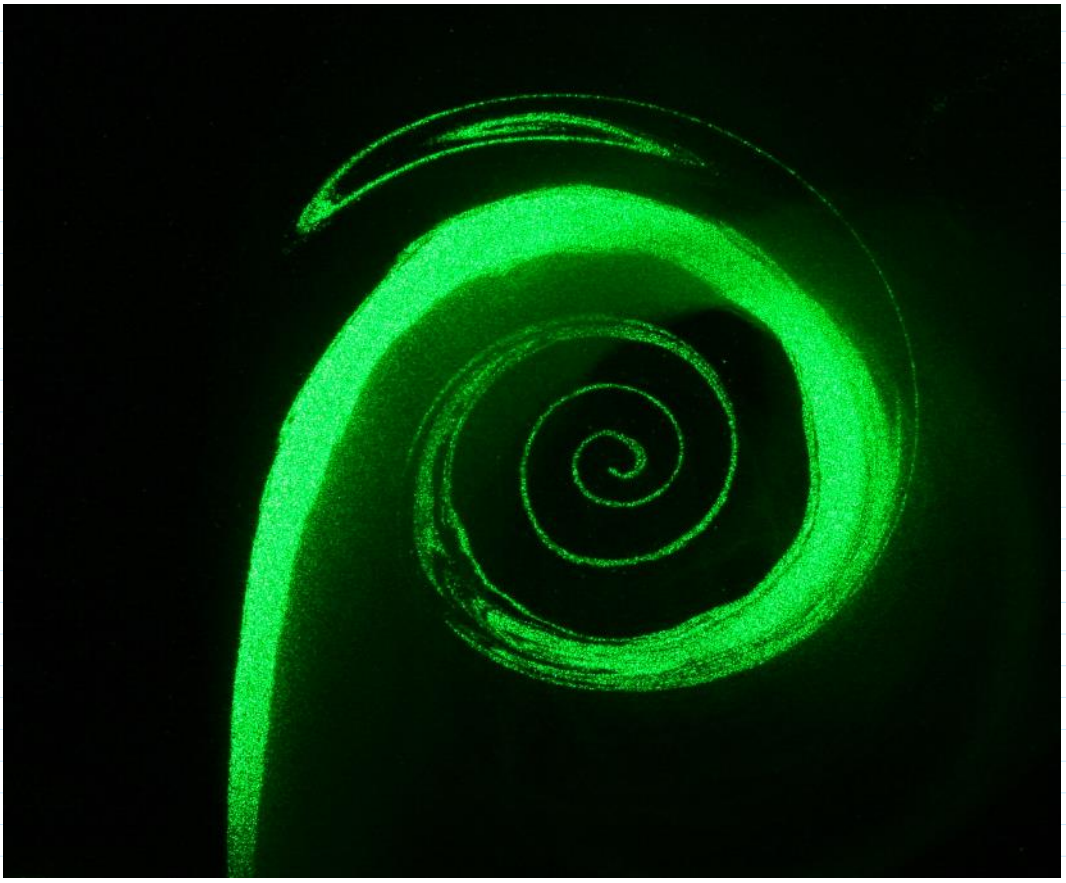
Inertial forces
Mass flow
Thermal/heat
Viscosity/intermolecular forces
Centripetal force
Electromagnetic
Coriolis
Sound
Chemical force/reaction
Electrostatic
Vanderwaals

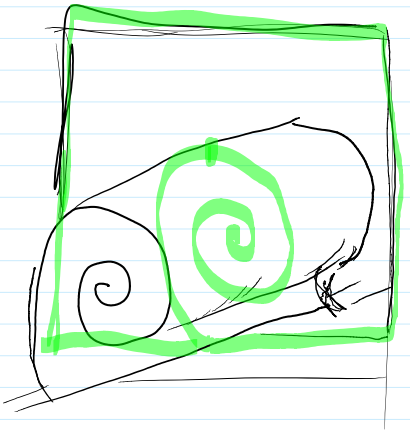
2. Visualization Techniques

a. Seeded Boundary techniques
b. Index of refraction (light bending)
c. Particle tracking

a. Seeded Boundary techniques:

One fluid is seeded with dye or particles which scatter or absorb light. The other fluid is transparent, not scattering or absorbing light. The boundary can be seen.

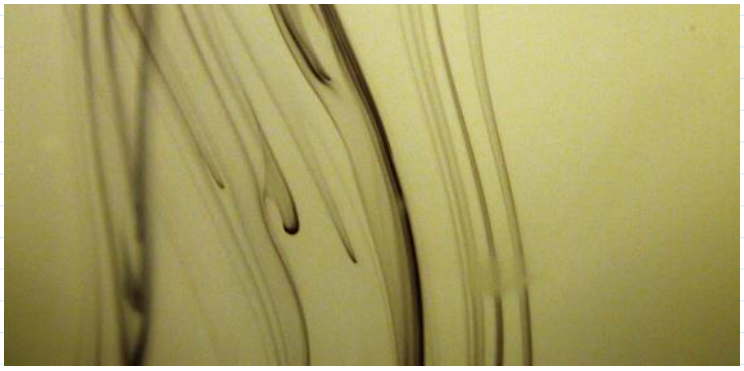




Stage fog illuminated by a sheet of laser light forms a suddenly started laminar planar jet at Re = 330. Tanner Ladtkow, Geneva Wilkesanders, Tim Read, Andrea Fabri. Team Project 3, 2006

India ink falling through water shows the Rayleigh-Taylor instability. Gordon Browning. Get Wet Fall 07.

Back-lit. Dark ink absorbs light.



Team-1/FV_popup1-21.htm>

http://www.colorado.edu/MCEN/flowvis/galleries/2009/Team-1/FV_popup1-21.htm

Lucy Dean, Joseph Duggan, Tim Jarrell, Melissa Lucht

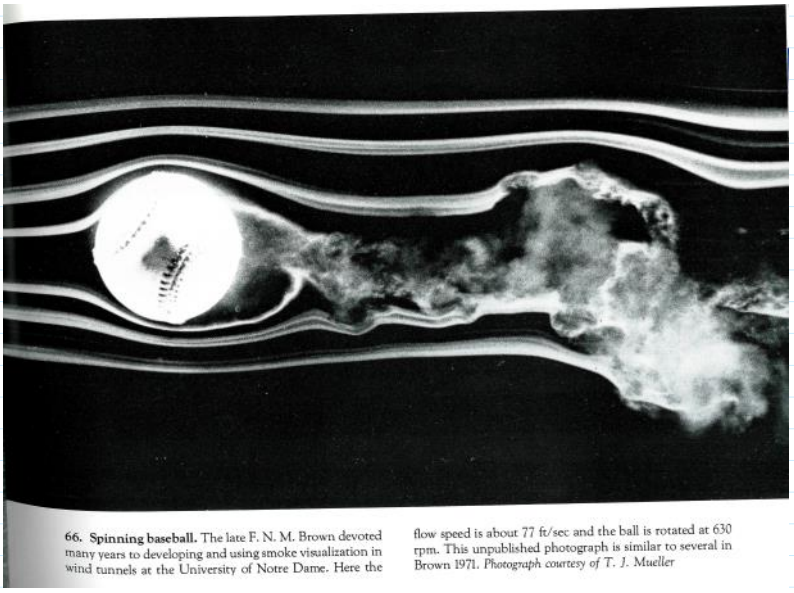
White gas (naptha) pool flame.
Team 1 Spring 2009

Light emission shows hot soot region
Red to yellow to white

Blue = specific emission from C_2 or CH radicals

Seeded boundary technique is characterized by dense seeding, can't see individual particles:

- Dye = food coloring
- Hydrogen bubbles (in water)
- Smoke
- Water droplets (clouds, fog)



66. **Spinning baseball.** The late F. N. M. Brown devoted many years to developing and using smoke visualization in wind tunnels at the University of Notre Dame. Here the flow speed is about 77 ft/sec and the ball is rotated at 630 rpm. This unpublished photograph is similar to several in Brown 1971. *Photograph courtesy of T. J. Mueller*

Van Dyke book: An Album of Fluid Motion

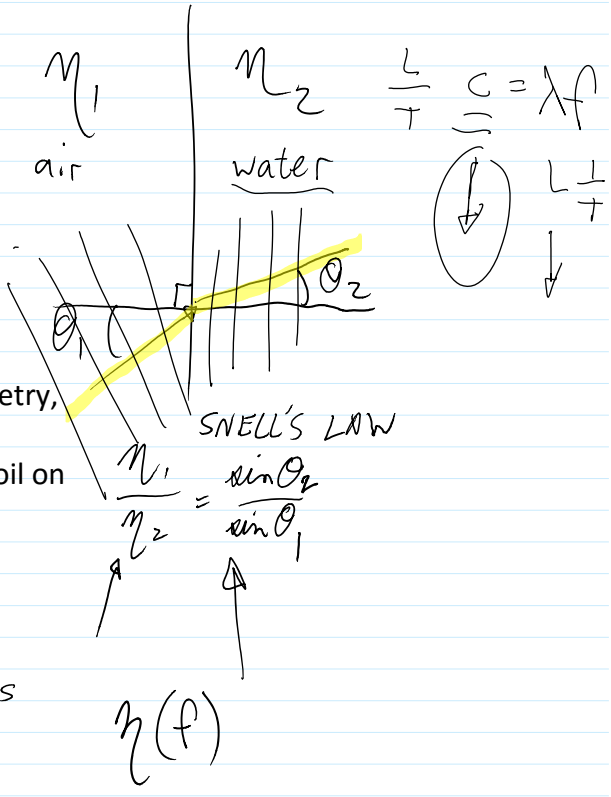
This is a relatively easy technique.
Remember, choose environmentally benign fluids: foods, personal care products. No chemicals down the drain here.

b. Index of refraction techniques

Minute paper, in groups: What is the index of refraction?

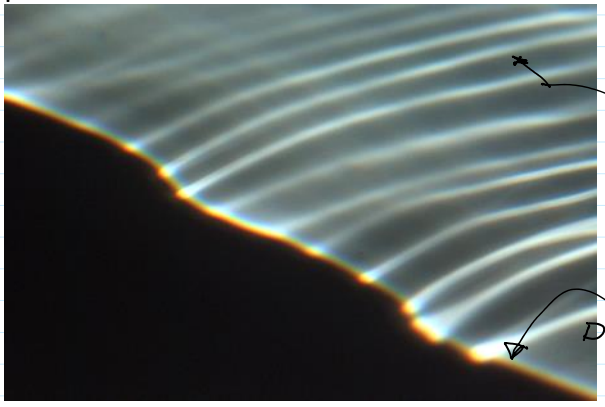
$$\eta = \frac{c}{v} = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in medium}}$$

eetah



= 1.5 for glass
= 1.3 for water, plexiglas, approximately
=1.00029 in air

Specific techniques: schlieren, shadowgraphy, interferometry, holography,
Free liquid/gas surfaces, thin film effects (soap bubbles), oil on puddles



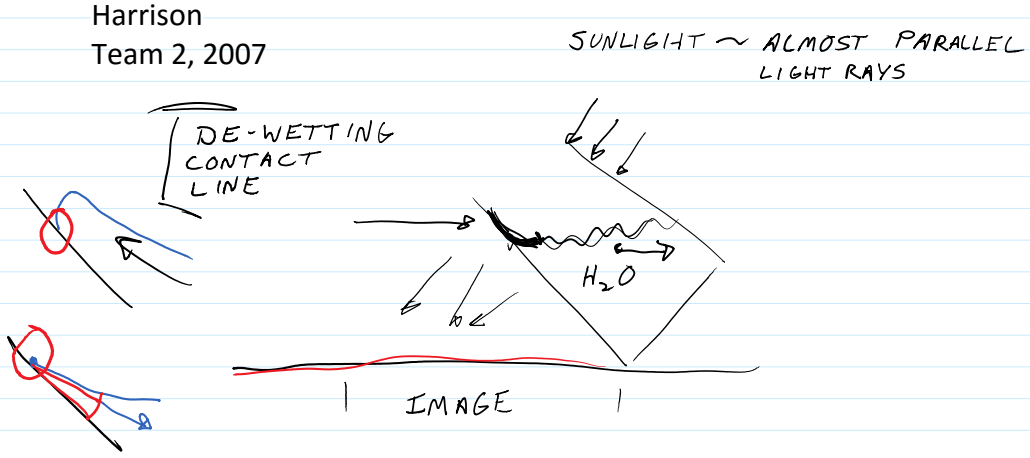
Pasted from <http://www.colorado.edu/MCEN/flowvis/galleries/2007/assignment4/Hnath.jpg>

A rectangular tank, partially filled with water, was tipped on edge. Sunlight projected through the waters' edge to the ground, resulting in Moire interference patterns : CAUSTICS.

Owen Hnath, Gordon Browning, Tracy Eliasson, Travis Gaskill, Trisha Harrison
Team 2, 2007

SUNLIGHT ~ ALMOST PARALLEL LIGHT RAYS

Owen Hnath, Gordon Browning, Tracy Eliasson, Travis Gaskill, Trisha Harrison
Team 2, 2007



Contact line: solid, fluid and gas meet together. Mathematically makes a singularity; very interesting to applied math folks.