Today: Overview 2

Admin
Finish forces
Start Vis Techniques

Admin

Name Table Tents
Put signed Copyright/Use Agreement, Syllabus Agreement, on piles up front.
WP login due tonight: Go to flowvis.org/wp-admin. Put in your firstname.lastname@colorado.edu email, and click 'forgot password'. If that doesn't work, see Behruz on Slack. Yes, Slack login due also.

Weds: Bring your camera to class. We will be exploring lenses.

Last time:
Make CHOICES:

1. Flow phenomenon: Water boiling? Faucet dripping?
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.

1. Flow phenomenon: ***Why does it look like that***?

What are the forces? = a framework for interpretation of the image
Minute paper. In groups (3 or so) list all the forces that can act on a fluid.
Write on a scrap of paper to hand in.

Minute paper results:

Viscous
Shear
Gravitational
Buoyancy
Electromagnetic
Air resistance (drag)
Cohesion
Adhesion (capillary action)
Normal force
Stress
Composition of fluids
Densities of fluids
Chemical reactions
Impact
Wind

Gravitational
Buoyancy
Electromagnetic
Electrostatic
Inertial
Centripedal/centrifugal
Pressure
Body forces: gravity, buoyancy, EM
Viscosity, shear, friction
Thermal diffusivity
Interaction with other fluids
Surface tension
Intermolecular

Adhesion (capillary action)
Normal force
Stress
Strain
Thermodynamic
Heat
Convection
Osmosis
Solar radiation

Chemical reactions
Impact
Wind
Mass
Acceleration
Temperature
Phase change
Strong, weak nuclear forces
Cavitation
Vortex structures
vortex stretching
concentration gradient

Good, inclusive list. Not all are forces, but all can 'drive' a flow via a set of physics or mechanism. Heat, for example.

Force - Any action applied to an object which would cause the object to move, change the way it is currently moving, or change its shape. A **force** can also be thought of as a push (compressive **force**) or pull (tensile **force**) acting on an object.

Engineering Terms
www.pre-engineering.com › resources › engineeringterms

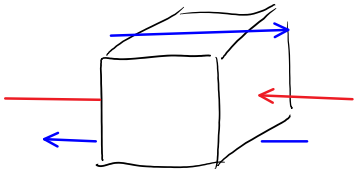
All *forces* can be categorized like this: 2 types of forces

Body

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

Surface

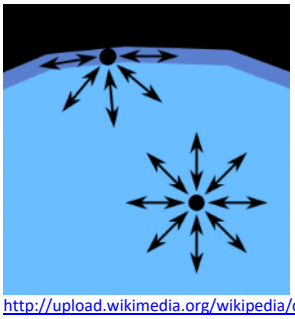
Acts on the surface of a volume of fluid



Pressure: always perpendicular to surface
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.

The only force that is not so easily categorized is SURFACE TENSION



http://upload.wikimedia.org/wikipedia/commons/thumb/f/f9/Wassermolek%

It's the result of intermolecular forces, so it affects every molecule, like a body force

But it is only obvious at interfaces between fluids, kind of like a surface force.

C3%BCleInTr%C3%
B6pfchen.svg/300px-Wassermolek%C3%BCleInTr%C3%B6pfchen.svg.png

http://www.flowvis.org/category/flow-categories/marangoni/

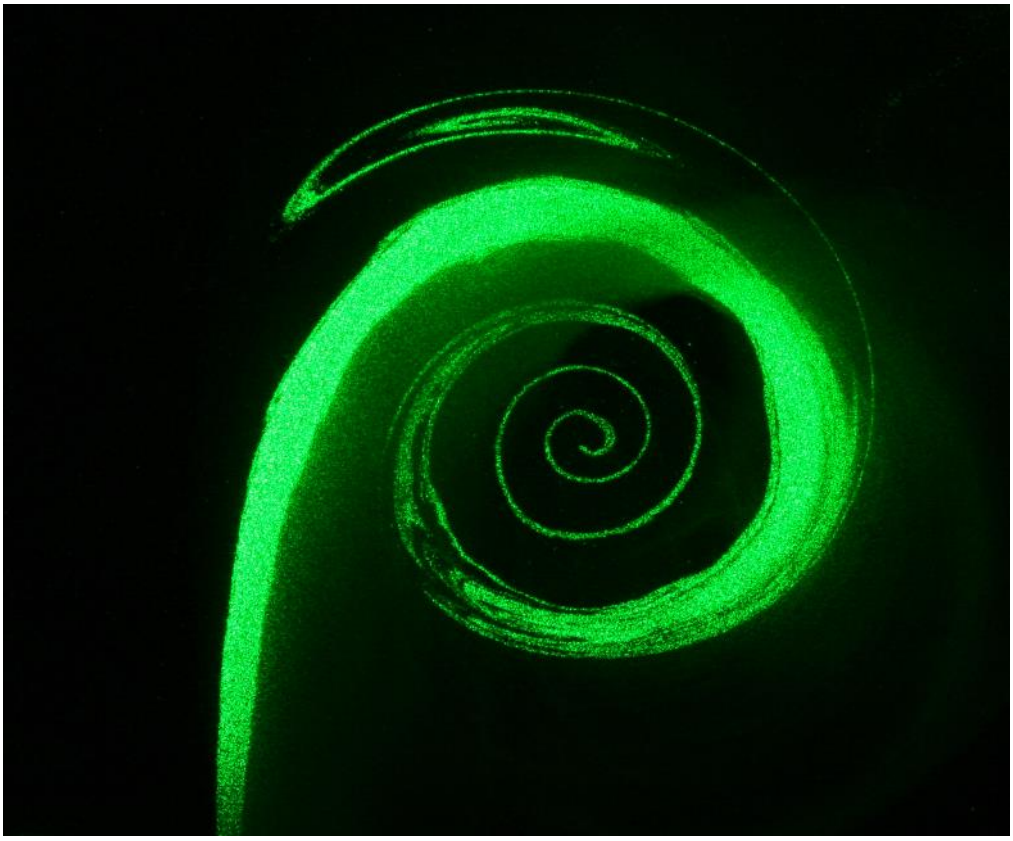
Conclusion: Whenever you are observing fluids, list the forces that may be acting, ***that make it look like that.***

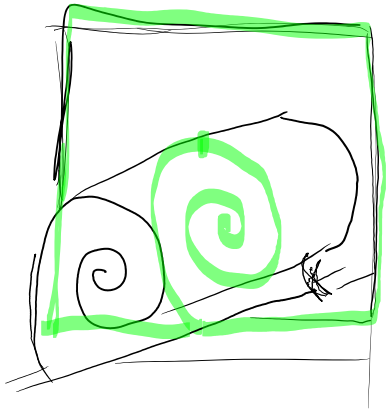
2. Visualization Techniques

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

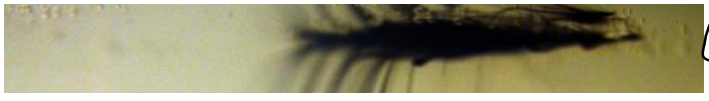
a. Seeded Boundary techniques:

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.

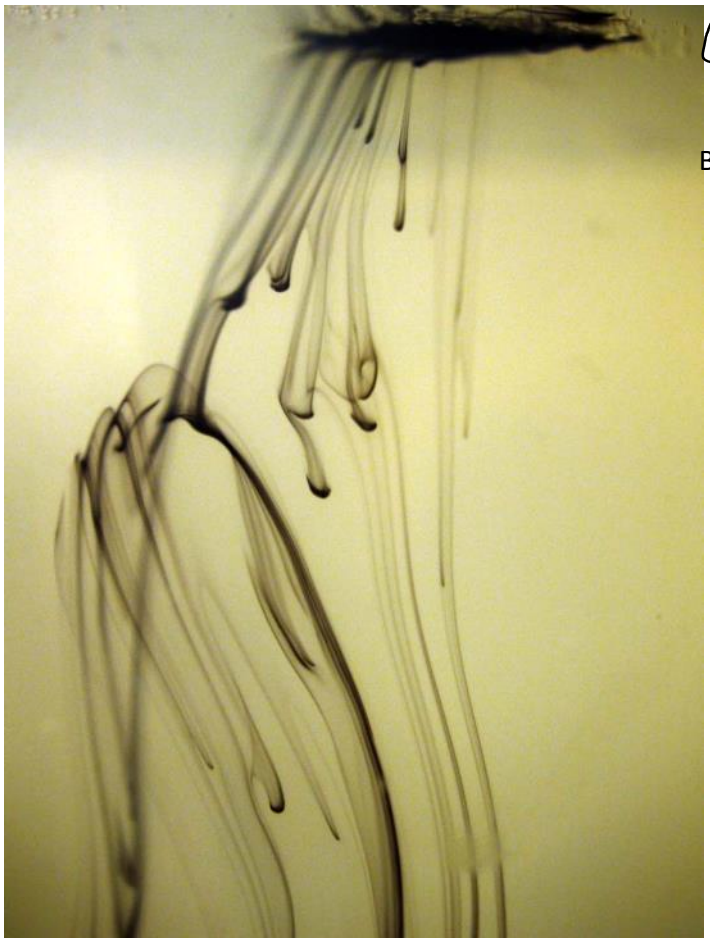




Stage fog illuminated by a sheet of laser light forms a suddenly started laminar planar jet at Re = 330. Tanner Ladtkow, Geneva Wilkesanders, Tim Read, Andrea Fabri. Team Project 3, 2006



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



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

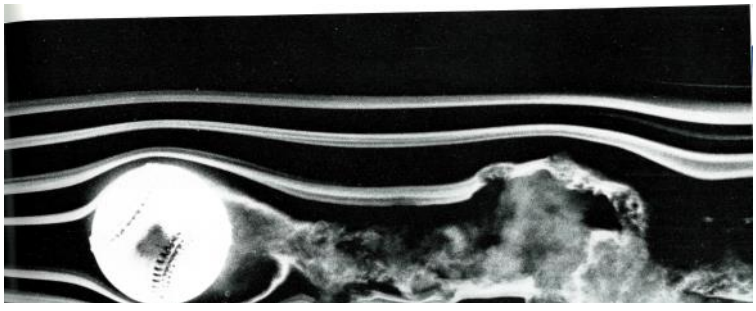
White gas (naptha) pool flame.
Team 1 Spring 2009

Light emission shows hot soot region
Black body radiation: Red to yellow to white

Blue = specific emission from C_2 or CH radicals

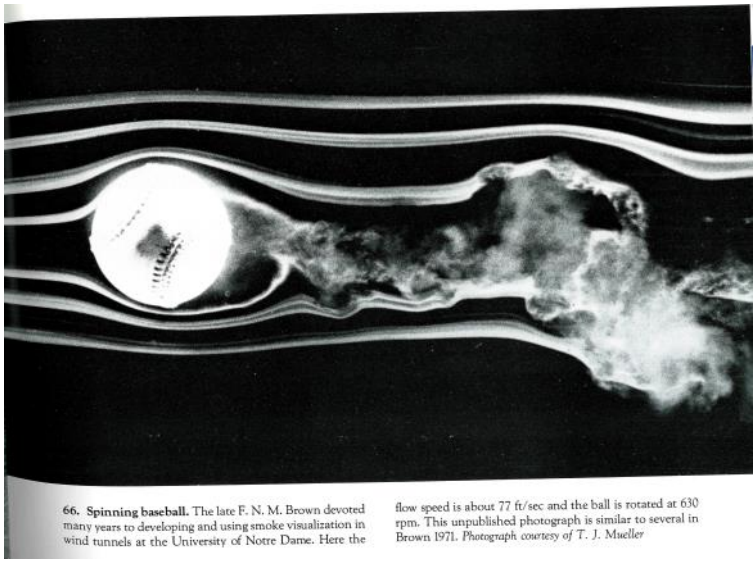
Seeded boundary technique is characterized by dense seeding, can't see individual particles:

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



individual particles.

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



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?

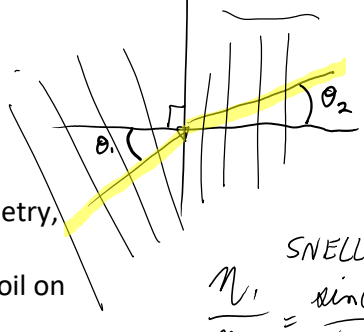
Most knew that it had to do with light bending. One person knew it had to do with speed of light

$$n = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in medium}} = \frac{c}{v} = \frac{\lambda_0}{\lambda_{medium}}$$

$\eta = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in medium}} = \frac{c}{v} = \frac{\lambda_0}{\lambda_{medium}}$

eetah

Frequency & color do not change
Wavelength λ shrinks
wavespeed v slows in denser media
$v = \lambda f$

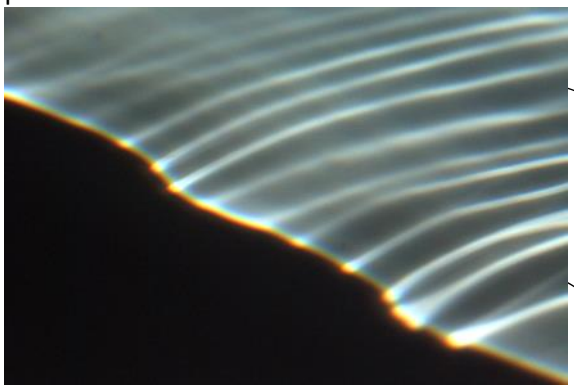


= 1.5 for glass
= 1.3 for water, plexiglas, approximately
=1.00029 in air

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

SNELL'S LAW

$\frac{\eta_1}{\eta_2} = \frac{\sin\theta_2}{\sin\theta_1}$



CAUSTICS

DISPERSION

$\eta(f)$

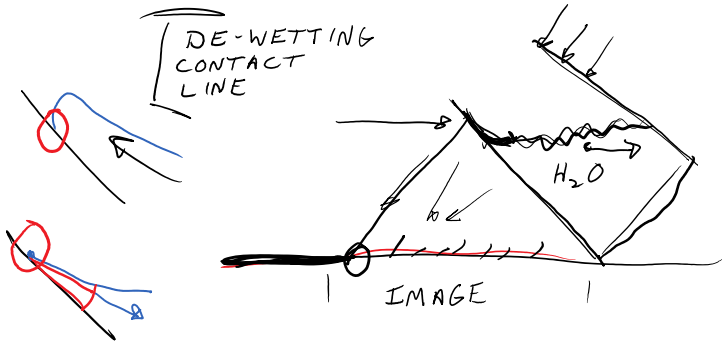
depends on frequency of light

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

SUNLIGHT ~ ALMOST PARALLEL LIGHT RAYS



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

Now, chat with a neighbor about what you are planning for your Get Wet project.