Team 3 images due Tuesday?

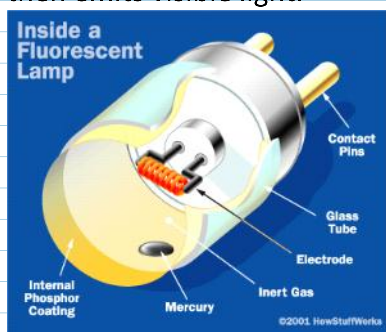
Light Emitting fluids

Black Body Radiation = yellow flame color, from BBR of soot particles. Random λ (wavelength) photons from thermal energy

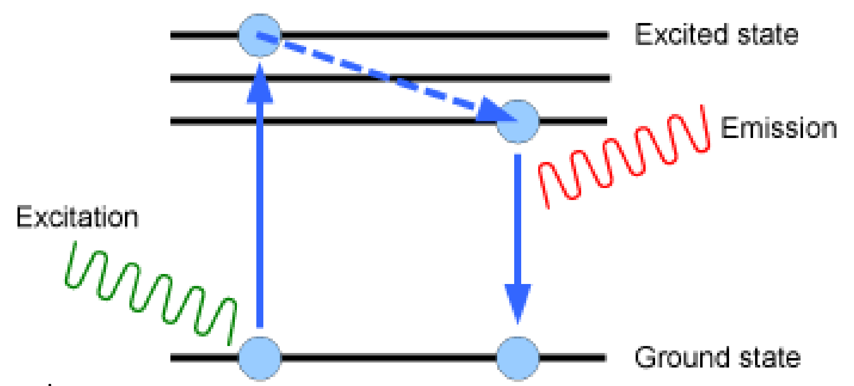
Luminescence = cold body emission, usually at specific λ.
Fluorescence = absorb at a specific short λ, emit at a longer λ.

E.g. some laundry detergents and fabric softeners absorb in the UV, and emit blue or orange

Fluorescent bulbs: Current is conducted through mercury vapor, energizes it to emit UV photons which hit a phosphor coating on the inside of the tube, which then emits visible light.



http://home.howstuffworks.com/fluorescent-lamp.htm/



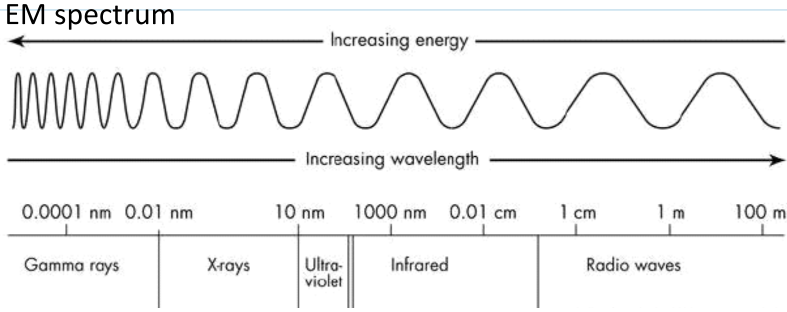
http://www.art.ca/en/preclinical/optical-molecular-imaging/fluorescence.php

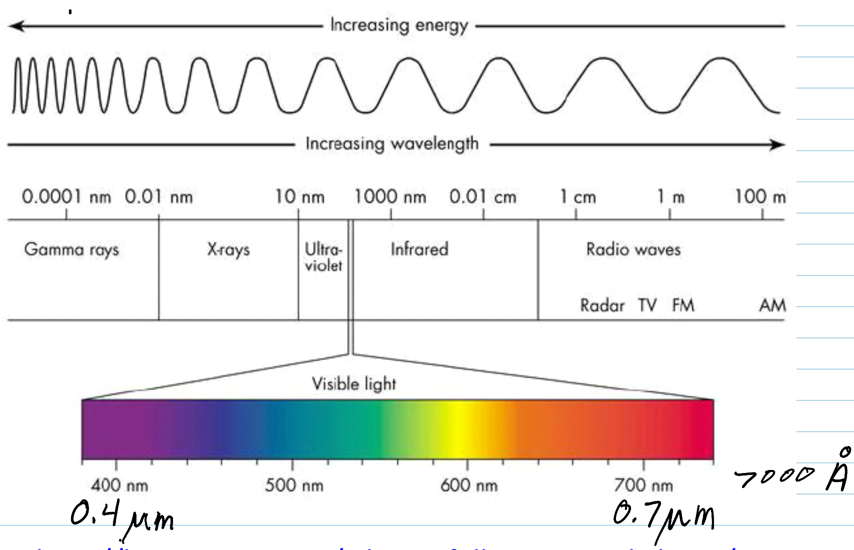
high energy, short wavelength photon into fluorophore

Emission gives a lower energy, longer wavelength photon.

Wavelength change = Stokes shift: some heat lost from excited state, and/or returns to ground state + highest vibrational mode.

EM spectrum





http://lumenistics.com/what-is-full-spectrum-lighting/

Chemoluminescence - Cyalume: chemical reaction releases photon, which then drives fluorescence. Needs mix of chemicals for reaction, and choice of color.
Flames: C_2, CH^+ , radicals = highly reactive intermediate molecules (between reactant and product species) that only exist in the thin reaction zone. Excited by reactions, emit blue photons to get to lower energy state. Also, hot soot gives off black body radiation; yellow glow.

Electroluminescence - LEDs, sodium vapor, mercury vapor lamps etc. Specific λ.
E.g. electric pickle http://www.youtube.com/watch?v=tMhXCG6k6oA
Laser : population inversion, specific λ, resonant cavity with mirrors.

II Particles, heavy seeding

Number density high enough to look like a dye

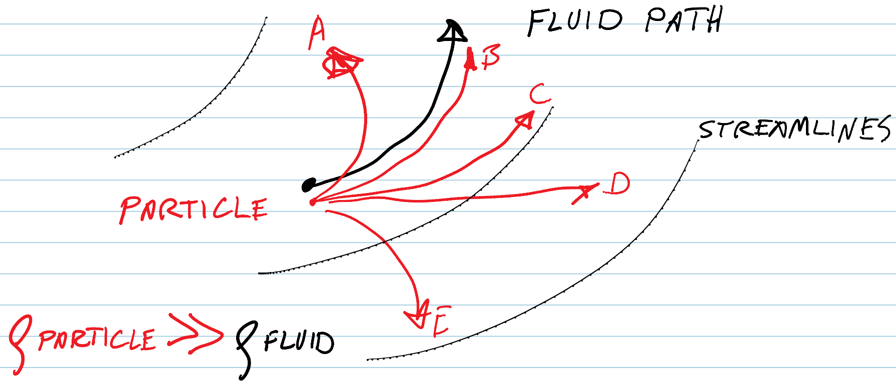
Similar considerations to dyes:
1)Particles must track with the flow ← BIG DIFFERENCE
Dyes are molecules, track with the flow just fine.

2)Want particles to NOT disturb flow
3)Want particles to show up - HIGH VISIBILITY

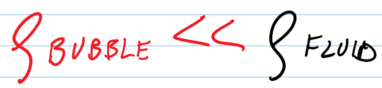
1) When will particles track well, be good tracers?

Minute paper: Consider a curved streamline. Consider a small particle,

much denser than the fluid, BUT small enough that gravity is negligible compared to forces of the fluid on the particle. (diameter ~ 100µm) ← human hair diameter
What will the particle path look like compared to the fluid path?



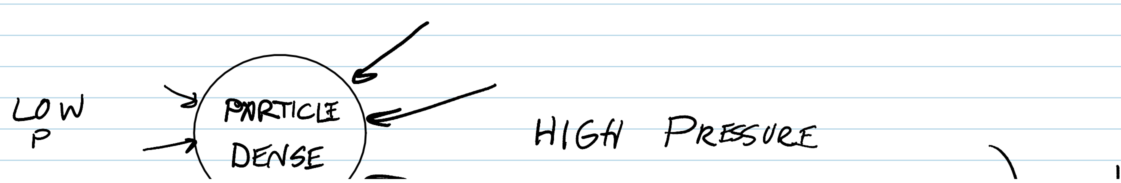
Next, consider same scenario, but a bubble instead of a particle.

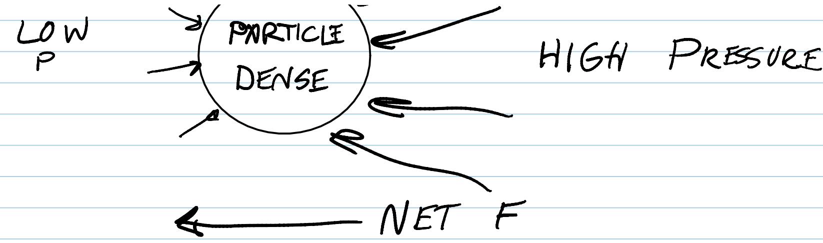


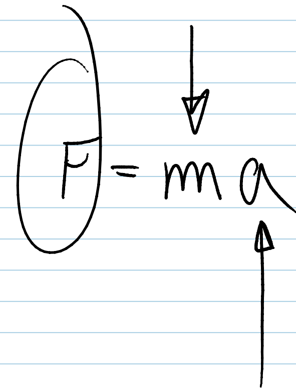
Ever been hit in the back of the head by a balloon when you are accelerating in a car?

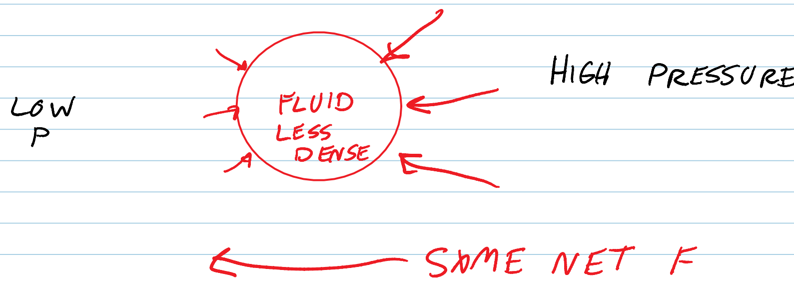
For particles (or bubbles) to track with the surrounding fluid, they must accelerate the same as the neighboring fluid

Newton's Second Law: $\sum F = ma$
Forces on particle:
Body: gravity, neglect.
Surface: normal = pressure
parallel = shear
} from fluid





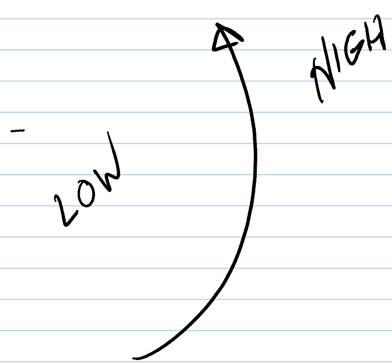




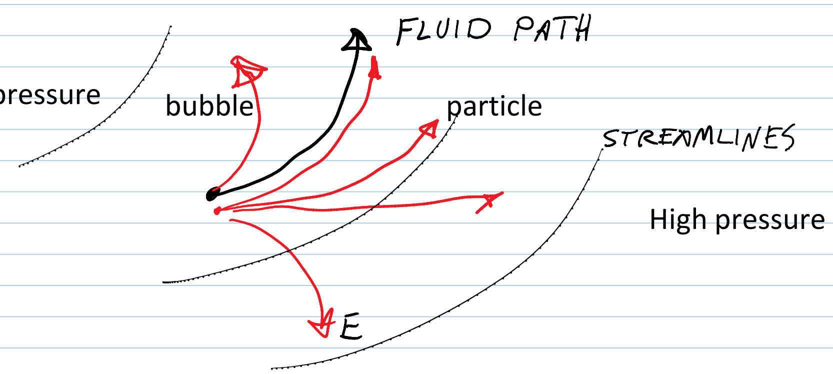
Which will accelerate more?

What makes streamlines curve?

(what is a streamline?)



Streamlines curve because of pressure gradient. Low P is inside curve



Rules of thumb:

- In water, particles of 100 μm diameter or less, any density, will track most flows.
- In air, particles of 1 μm diameter or less, any density, will track most flows.

Similar considerations to dyes:
1) Particles must track with the flow
2) Want particles to NOT disturb flow
3)Want particles to show up - HIGH VISIBILITY

2)Want particles to NOT disturb flow

- As with dyes, minimize injection differential velocity; inject at local flow speed.
- Want particles to not introduce new forces. Avoid:
  - soluble particles
  - surface tension
  - chemical reactions
  - significant change of density
  - particle-particle interaction
    - Number density of particles = # of particles / unit volume. (Contrast to mass/volume of solid alone). Keep low enough to avoid interactions.
    - Particle-particle interaction (collisions, drag) lead to non-Newtonian effects. Slurries, oobleck, blood, shampoo, silly putty, other polymers. Gets into 'complex fluid' categories. Interesting field.

2) High visibility

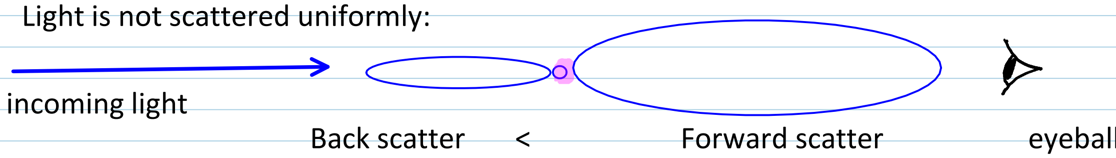
Particles only scatter light. Interaction depends on size (d) compared to λ.

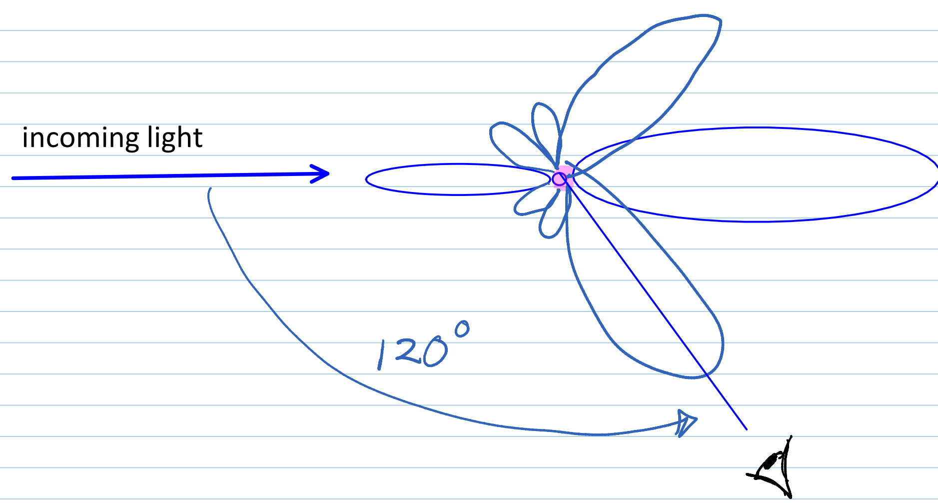
d ~O(λ) : Mie scattering regime.
e.g. visible light =0.7 - 0.4μm, so diameters of 1 μm to 0.1μm (100 nm, 1000 A).

- Scattering efficiency drops as particles get smaller. Better tracking, but less light.
- Independent of wavelength; no colors from particles this small.
- Particles large enough to have color are too big to track well.

"NASA wing tip vortex. Information for ID # EL-1996-00130," n.d., http://lisar.larc.nasa.gov/UTILS/info.cgi?id=EL-1996-00130.

Light is not scattered uniformly:

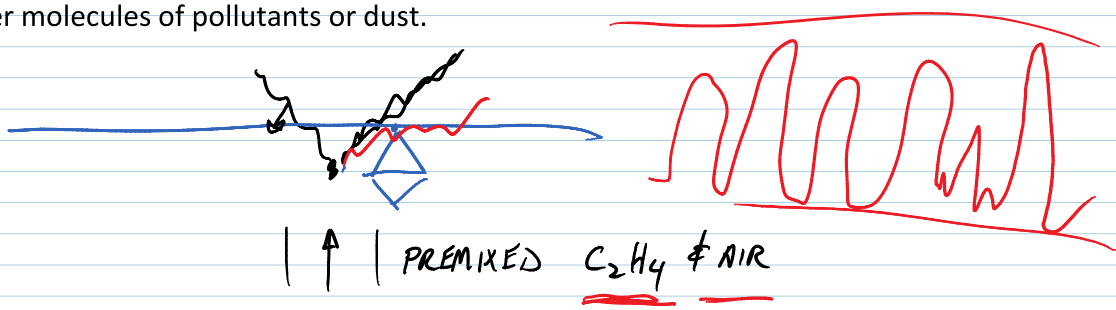




Often a strong lobe at 120 degrees to incoming light.

Smaller particles, $d \ll \lambda$,
Rayleigh scattering regime. Elastic collision of photons with particles. No energy exchange.
Blue sky is Rayleigh scattering; sunlight scattered by molecules of air, preferentially blue. Longer wavelengths are too long to interact much; are only seen at sunset due to long passage through atmosphere, and when scattered by

larger molecules of pollutants or dust.



http://www.youtube.com/watch?v=DOUfyDHxkYQ&feature=related
NCFMF film 'Flow Visualization'
Hydrogen bubble technique