16.DyeTech2

Thursday, April 11, 2013 3:55 PM

Admin:

Last time, talked about dyes:
1) Don't disturb flow
2) High visibility: How does light interact with matter anyways?

2)Want dye to show up - HIGH VISIBILITY

High Visibility: Want good contrast between dyed and ambient fluid.

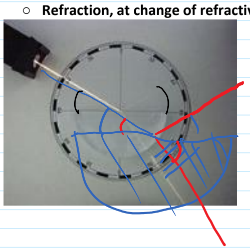
Ambient fluid = transparent = NO interaction with light
Dyed fluid = want MAXIMUM interaction with light

Minute paper: list the ways that dye (or any molecule) can interact with light (from external source, later will talk about emitted light)

SUPERPOSITION

Refraction	Emission
Absorption	Fluorescence
Diffraction	Excitation
Reflection	
Scattering/diffusion	
Transmission	

1) Transmission
- **Refraction, at change of refractive index**

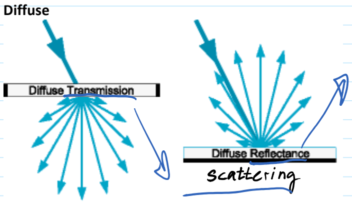


Lecture 02 Overview2
Snell's law

http://upload.wikimedia.org/wikipedia/commons/thumb/1/13/F%C3%A9nyt%C3%B6r%C3%A9s.jpg/220px-F%C3%A9nyt%C3%B6r%C3%A9s.jpg

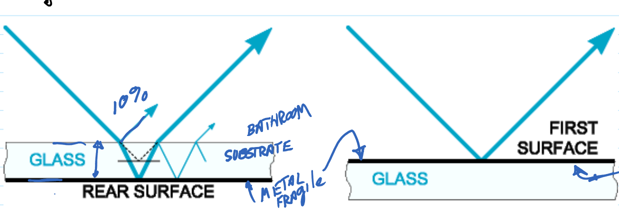
There are many flow vis techniques based on refraction; will cover later.

- **Diffuse**



Diffuse transmission and reflectance.
http://library.thinkquest.org/26162/manili.htm

2) Reflectance
- **Diffuse, scatter**
- **Specular**

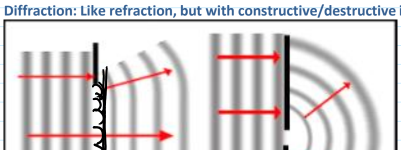


Reflection from a second surface and first surface mirror.

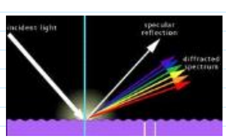
EDMUND SCIENTIFIC

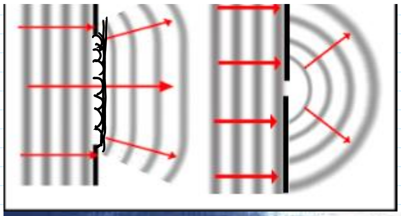
http://library.thinkquest.org/26162/manili.htm

3) Diffraction: Like refraction, but with constructive/destructive interference



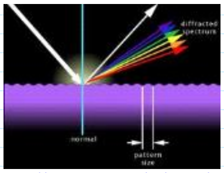
HUYGEN



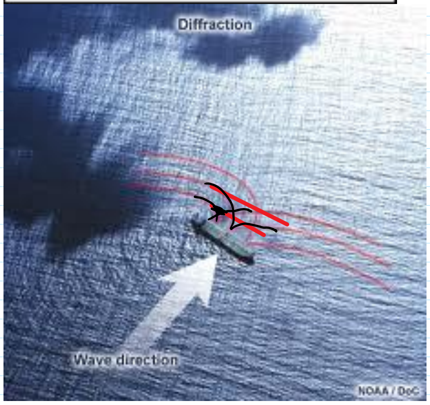


HUYGEN

http://www.meted.ucar.edu/marine/ripcurrents/NSF/media_gallery.php



http://www.tufts.edu/as/tampl/projects/micro_rs/theory.html



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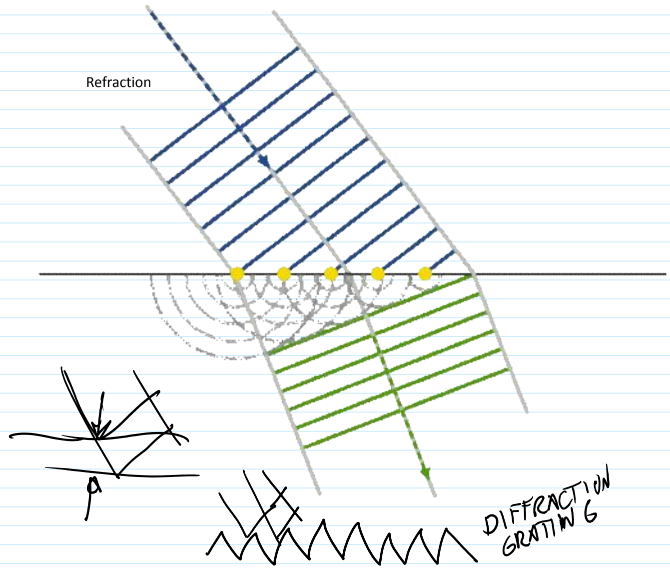


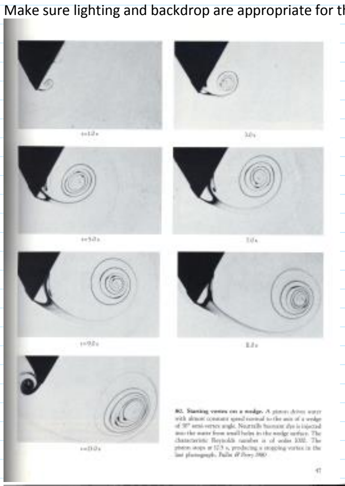
http://www.ualberta.ca/~pogosyan/teaching/PHYS_130/FALL_2010/lectures/lect35/lecture35.html

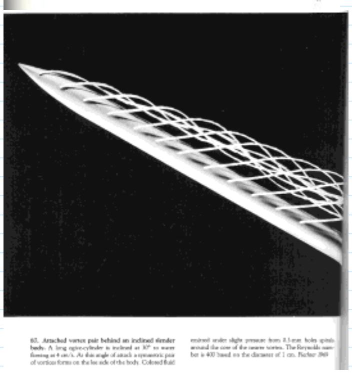
4) **Absorption**

Normal sight in white light; all colors (wavelengths) are absorbed except the one we see, which is diffuse reflected to our eyes

- Big 4: Refraction, reflection, diffraction, absorption.
- Dispersion, any of these, but
  - Affected differently based on wavelength
    - leads to chromatic aberration, prisms, cloud iridescence (maybe diffraction around particles; interference)
    - Birefringence = 2 indexes of refraction

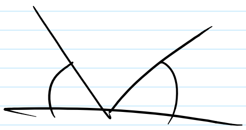
Make sure lighting and backdrop are appropriate for the type of light interaction.

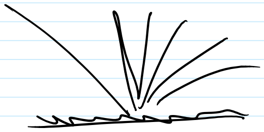




E.g.:
Dye = dark food color. Absorption is primary, so use bright backdrop
Dye = milk. Scatter is primary; use black backdrop

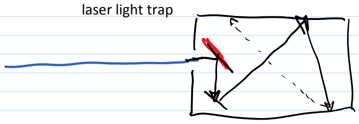
Minute paper: Which is better for a dark backdrop: smooth or rough/matte?





Smooth is good if you can control what the specular reflection shows. If not, rough is better.

laser light trap



3) Special Techniques

Light Emitting fluids

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

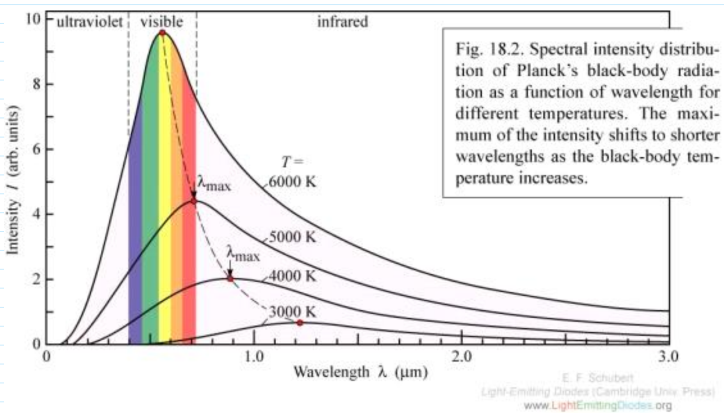


Fig. 18.2. Spectral intensity distribution of Planck's black-body radiation as a function of wavelength for different temperatures. The maximum of the intensity shifts to shorter wavelengths as the black-body temperature increases.

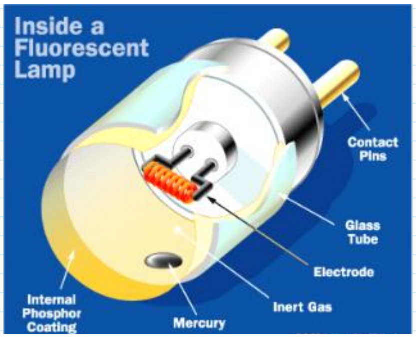
https://www.phy.questu.ca/rknop/classes/enma/2010-10/wiki/images/8/84/Black_body.jpg

Luminescence = cold body emission, usually at specific λ.

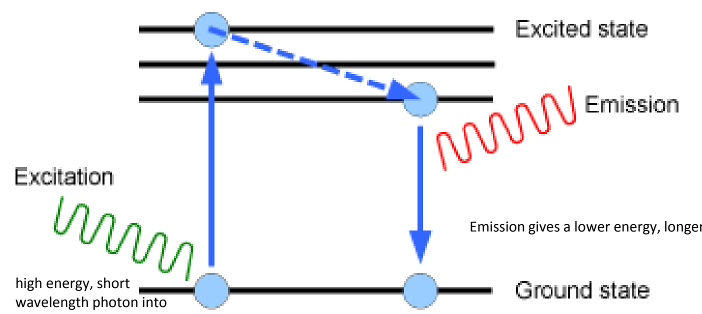
Fluorescence = absorption at a specific short λ, emits at a longer λ.

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/



Emission gives a lower energy, longer wavelength photon.

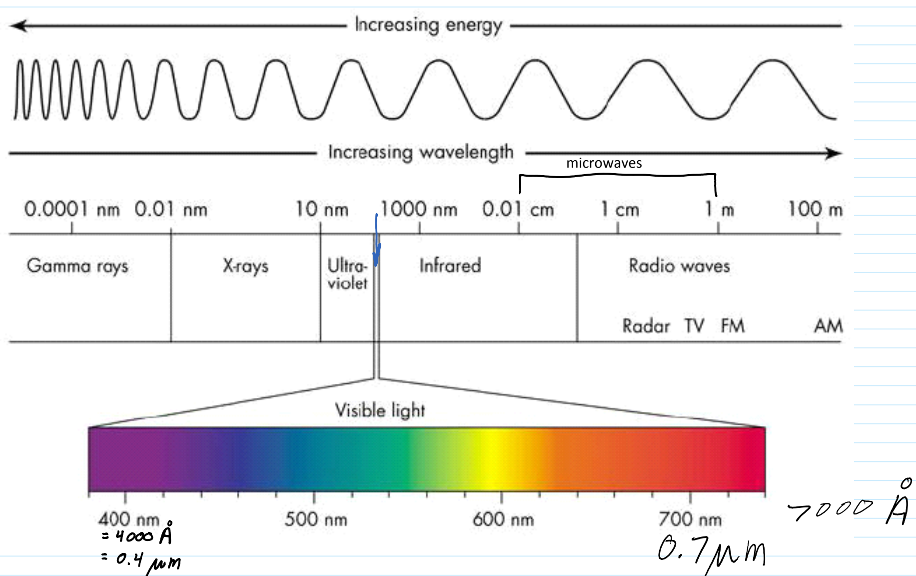
high energy, short wavelength photon into fluorophore

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

Wavelength change = Stokes shift:

- some heat lost from excited state,
- and/or returns to ground state + highest vibrational mode, not all the way down.

EM spectrum review



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.
Bioluminescence - Fireflies, deep sea fish, worms. Good for flow vis?

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. Gas dynamic laser: after supersonic expansion, lower vibrational states relax before higher ones = inversion. A type of 'chemical laser'

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 from dyes

Heavy seeding

Number density high enough to look like a dye

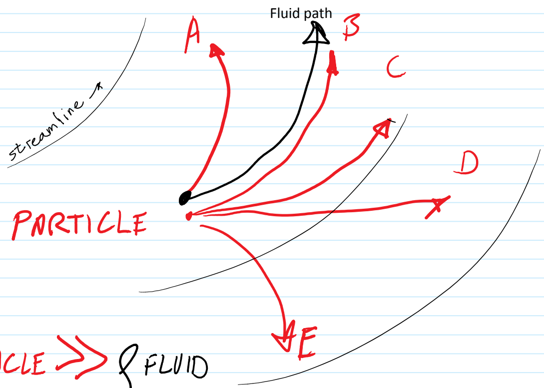
Similar considerations to dyes:
1) Particles must track with the flow ← Big difference from dyes
Dyes are molecules, track with the flow just fine.

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 ~ 100 μm in water) ← human hair diameter

What will the particle path look like compared to the fluid path?



$\rho_{PARTICLE} \gg \rho_{FLUID}$

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

$\rho_{BUBBLE} \ll \rho_{FLUID}$

Ever been hit in the back of the head by a balloon when you are accelerating in a car?
http://www.youtube.com/watch?v=XXpURFYgR2E

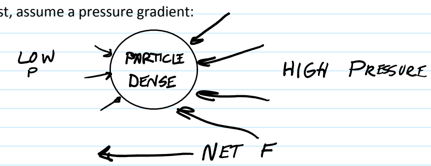
For particles (or bubbles) to track with the surrounding fluid, they must accelerate the same as the neighboring fluid

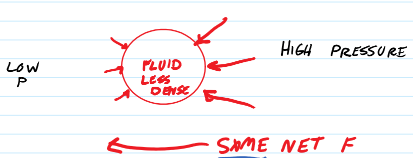
Forces **on particle**:
Body: gravity, neglect.

Surface:	normal = pressure parallel = shear

} from fluid

First, assume a pressure gradient:

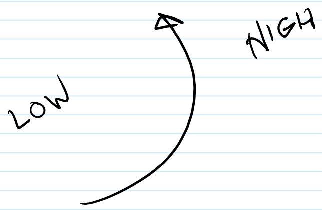




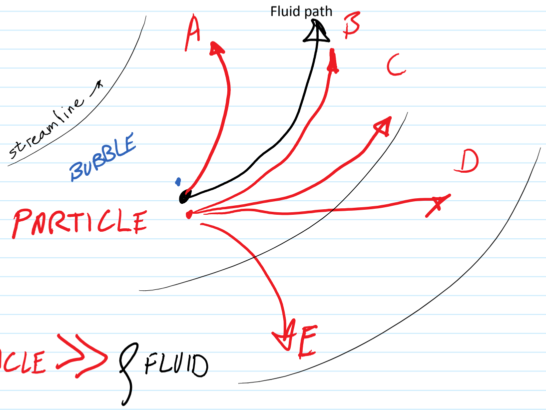
Which particle will accelerate more?
Newton's Second Law: $\sum F = ma$

What makes streamlines curve?

(what is a streamline?)



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



$\rho_{PARTICLE} \gg \rho_{FLUID}$