13.DyeTech2

Thursday, April 11, 2013
3:55 PM

Admin:
Schedule; note guest lecture 4/3
BYU Splash Lab, Prof. Tadd Truscott

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

Reflectance
absorbance
refract
can describe energy level
birefringence
transmission
diffract
propulsion

Refraction	Emission
Absorption	Fluorescence
Diffraction	Exitation
Reflection	
Scattering/diffusion	
Transmission	

1) **Transmission**
   o **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.

   o **Diffuse**

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

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

Reflection from a second surface and first surface mirror.

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

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

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

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

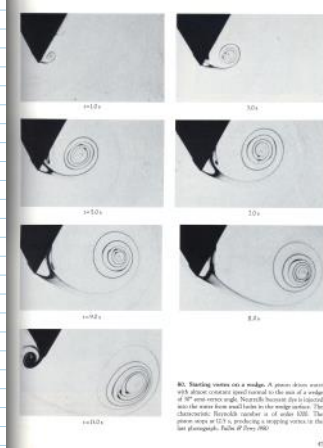Diffraction

Wave direction

NOAA / DoC
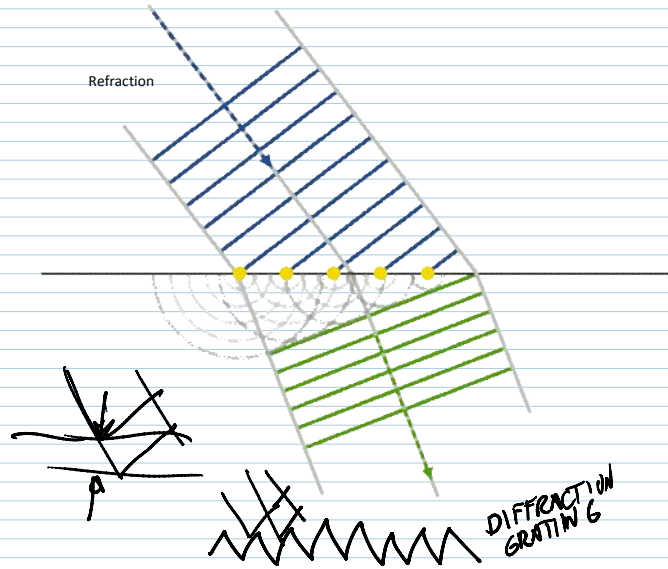
Refraction

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

DIFFRACTION GRATING

Make sure lighting and backdrop are appropriate for the type of light interaction.
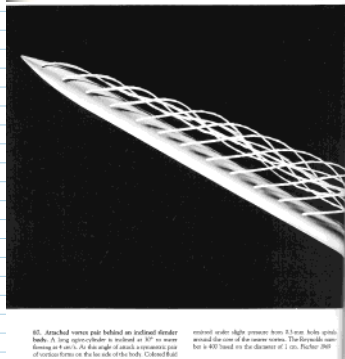
E.g.:
Dye = dark food color. Absorption is primary, so use bright backdrop
Dye = milk. Scatter is primary; use black backdrop

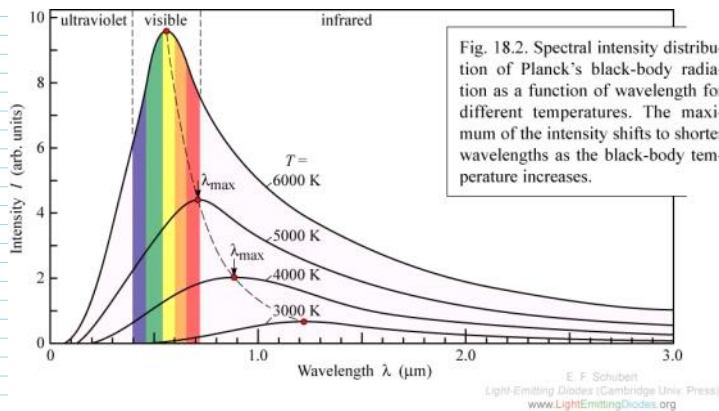Minute paper: Which is better for a dark backdrop: smooth or rough/matte?

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

laser light trap
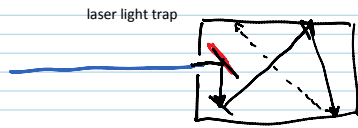
3) Special Techniques

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.

E. F. Schubert
Light-Emitting Diodes (Cambridge Univ. Press)
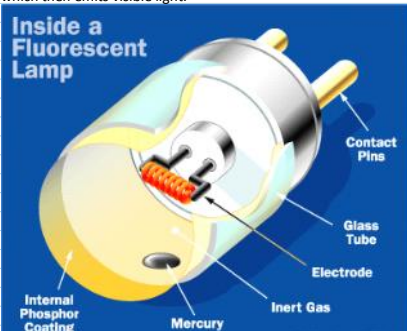www.LightEmittingDiodes.org

https://www.phy.qu estu.ca/rknop/classe s/enma/2010-10/wik i/images/8/84/Black _body.jpg

Luminescence = cold body emission, usually at specific λ.
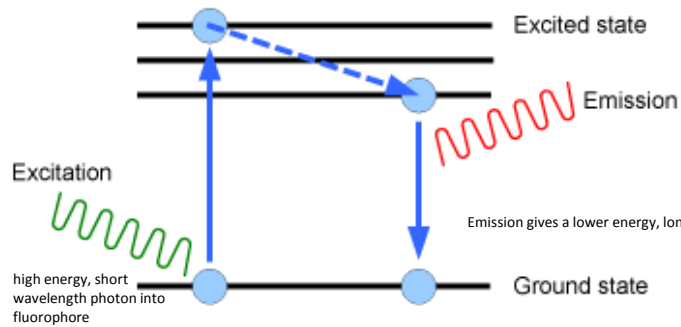***Fluorescence*** = absorption at a specific short λ, emits at a longer λ.
　　E.g. some laundry detergents and fabric softeners absorb in the UV, and emit blue or orange
　　Fluorescent bulbs: Current is conducted through mercury vapor, energizes it to emit UV photons which hit a phosphor coating on the inside of the tube, which then emits visible light.

Inside a Fluorescent Lamp

Contact Pins
Glass Tube
Electrode
Internal Phosphor Coating
Mercury
Inert Gas

http://home.howstuffworks.com/fl uorescent-lamp.htm/

Excited state

Emission

Excitation

high energy, short wavelength photon into fluorophore

Excited state

Emission

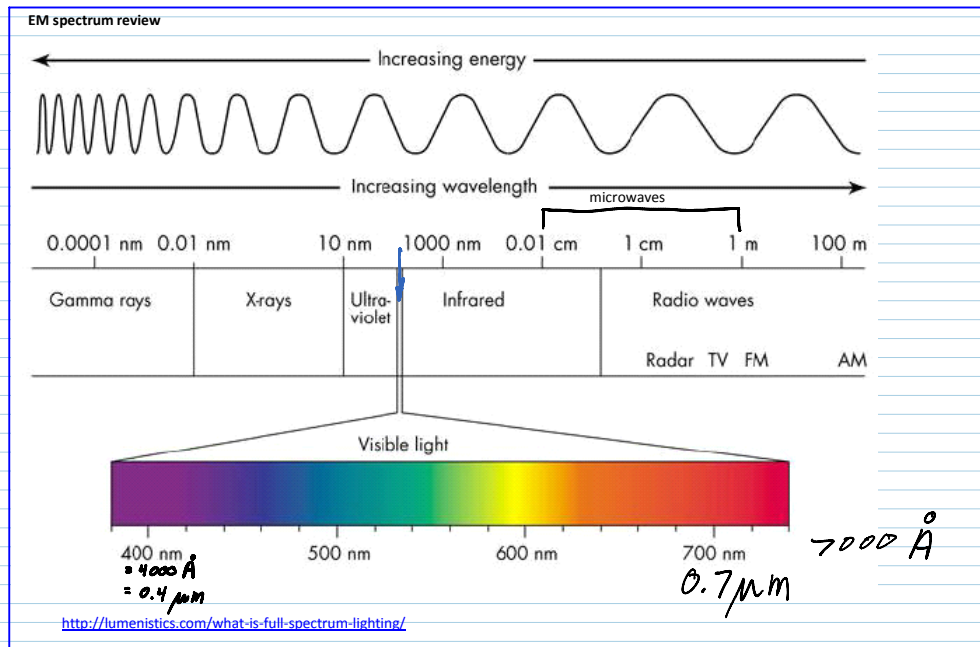Emission gives a lower energy, longer wavelength photon.

Ground state

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

Increasing energy

Increasing wavelength

microwaves

0.0001 nm 0.01 nm   10 nm   1000 nm   0.01 cm   1 cm   1 m   100 m

Gamma rays   X-rays   Ultra-violet   Infrared   Radio waves

Radar   TV   FM   AM

Visible light

400 nm   500 nm   600 nm   700 nm

= 4000 Å
= 0.4 μm

7000 Å

0.7 μm

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: Big difference from dyes
1)Particles must track with the flow
          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 in water)

                                                            human hair diameter
What will the particle path look like compared to the fluid path?

Fluid path

A B C

streamline

PARTICLE

D

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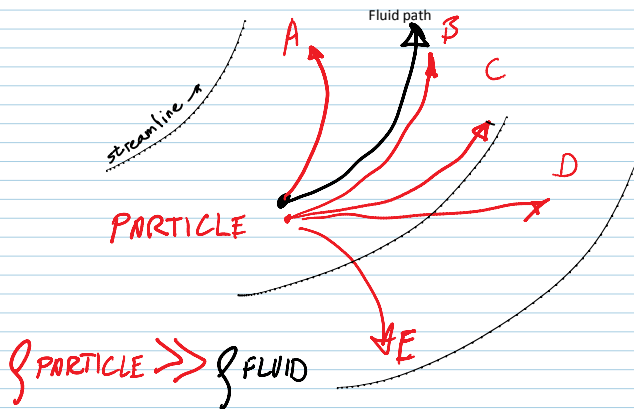
$\rho_{PARTICLE} \gg \rho_{FLUID}$

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?
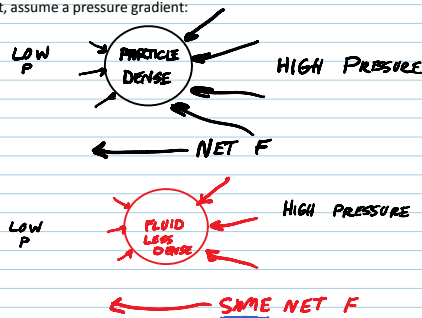http://www.youtube.com/watch?v=XXpURFYgR2E

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:

LOW P   PARTICLE DENSE   HIGH PRESSURE

NET F

LOW P   FLUID LESS DENSE   HIGH PRESSURE
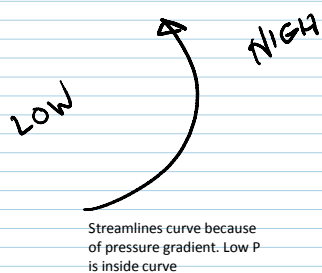
SAME NET F

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

What makes streamlines curve?

(what is a streamline?)

LOW   HIGH

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

Fluid path

A   B

Fluid path

A

B

C

D

streamline

BUBBLE

PARTICLE

E

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