22.Light-Matter Interactions

Wednesday, November 6, 2024 2:55 PM

Please log in to Clicker and Slack

Today

Admin:

- Reading assignment: Guidebook, Dye Techniques 1 Do Not Disturb and 2 High Visibility

SPECIFIC FV techniques

Boundary techniques. Boundary between 'seeded' and unseeded fluid.
Choice depends on physics desired
I DYES **Today**. Mostly in water.
Light/matter interactions in general
2 Particles. In air (aerosols, fog, smoke)
3 Particles in water
4 Light emitting fluids
5 Index of refraction techniques

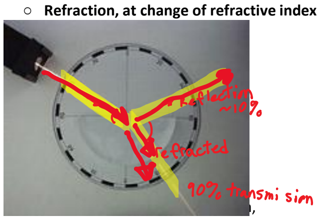
Background music in class
Silly icebreaker for all

Light-Matter Interactions

Refraction continued

Ordinary refraction - ~10% is reflected

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



Brewster's angle (also known as the **polarization angle**) is an angle of incidence at which light with a particular polarization is perfectly transmitted through a transparent dielectric surface, with *no reflection*. When *unpolarized* light is incident at this angle, the light that is reflected from the surface is therefore perfectly polarized. This special angle of incidence is named after the Scottish physicist Sir David Brewster (1781–1868).

From <https://en.wikipedia.org/wiki/Brewster%27s_angle>

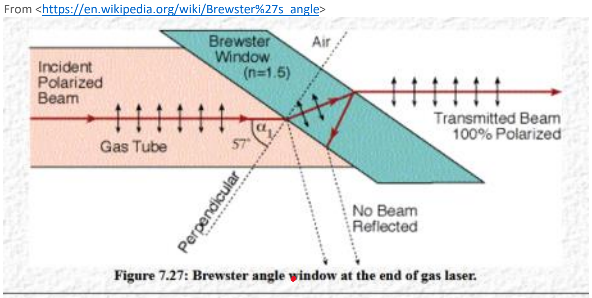
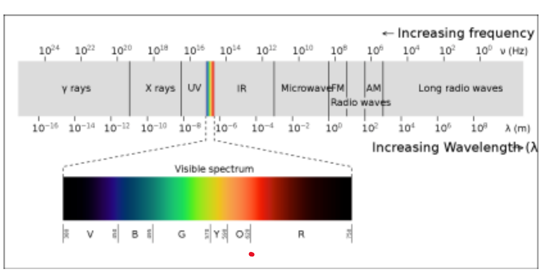


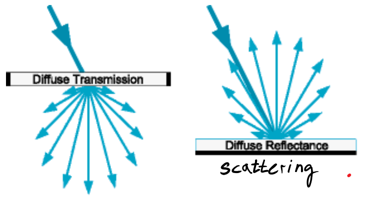
Figure 7.27: Brewster angle window at the end of gas laser.

https://perg.phys.ksu.edu/vqm/laserweb/ch-7/f7s5t1p6.htm



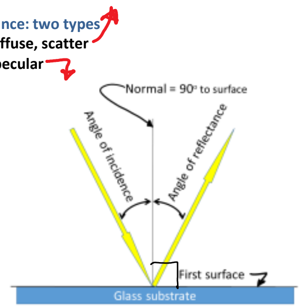
https://www.youtube.com/watch?v=wCrtk-pyP0I Plasma from grapes in a microwave
At microwave frequencies, EM wavelength is 12 cm in air, but much smaller in a grape;
n=10. Grape acts like a lens, trapping waves. Two grapes together causes focus, heating air and grape to plasma, with emissions near sodium and potassium.
https://youtu.be/wCrtk-pyP0I?t=297

- **Diffuse**



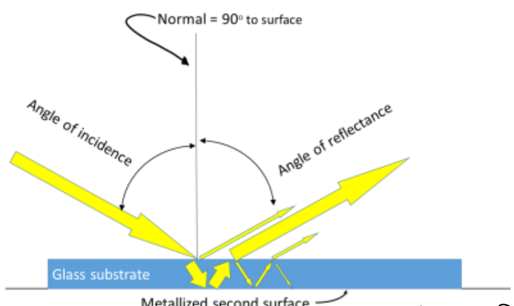
Diffuse transmission and reflectance.
http://library.thinkquest.org/26162/manili.htm
https://www.telescope-optics.net/reflection.htm

2) Reflectance: two types

- Diffuse, scatter
- Specular
- 

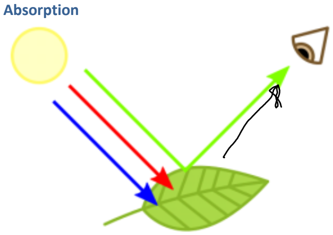
The first surface is often a naked metal (aluminum) thin film; very easily damaged. Almost impossible to clean without worsening the damage. Flat first surface mirrors good to 1 wavelength are not expensive. 1/4 wavelength mirrors and curved mirrors are expensive.

Domestic mirrors are all second surface mirrors. Robust but you get extra ghost reflections.

- 

Anti Reflective

3) Absorption

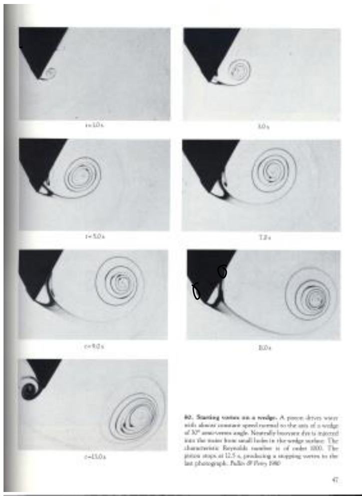


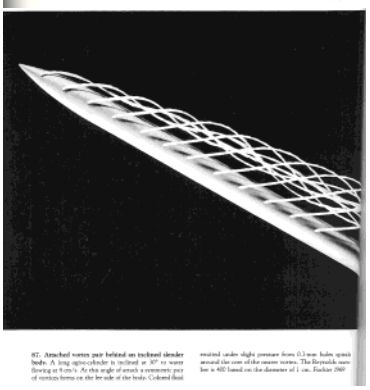
This is why grow lights are often purple.
Plants reflect green, so they don't use the green, in theory.
They absorb the long (red) and the short (blue) wavelengths.

- Light that strikes a surface that is not reflected or transmitted is generally absorbed; the photons are converted to heat energy.
- In the world around us that we see, most of the light hitting objects is absorbed.
- White light, i.e. light from the sun and from our common light sources are broad-band, and contain a range of wavelengths.
- When an object has color that means that it has absorbed all the light hitting it except for the wavelengths corresponding to that color, so an object that looks red will have absorbed all the wavelengths except for the red ones, which are then reflected back into our eyes.
- White objects reflect the whole visible spectrum, and
- black objects absorb across the whole spectrum, but even then, not all the light that strikes a black object is absorbed; some is reflected or we wouldn't be able to see it at all. (Vantablack discussed below)

From <https://www.flowvis.org/Flow%20Vis%20Guide/dye-techniques-2-high-visibility/>

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





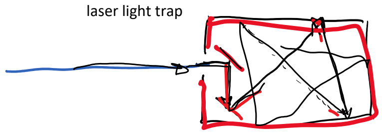
E.g.:
Dye = dark food color. Absorption is primary, so use bright backdrop
Dye = milk. Scatter is primary; use black backdrop

Group discussion: Which is better for a dark backdrop like the above picture:

A) smooth, maybe shiny
B) matte, not shiny, maybe textured?

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

laser light trap



For maximum absorption:

Vantablack is the trademarked name (owned by Surrey NanoSystems Limited)[1] for a chemical substance made of vertically aligned carbon nanotube arrays[2] and is one of the darkest artificial substances[3] known, absorbing up to 99.965% of radiation in the visible spectrum.[4][5]

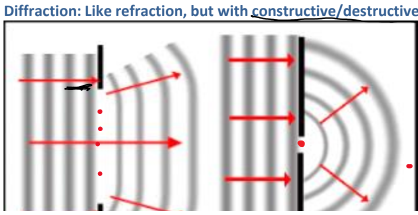
From <https://en.wikipedia.org/wiki/Vantablack>

Vantablack S-VIS, a sprayable paint that uses randomly-aligned carbon nanotubes and only has high absorption in the visible light band, has been exclusively licensed to Anish Kapoor's studio for artistic use.[18] This has caused outrage among some other artists, including Christian Furr and Stuart Semple, who made a special pink, and disallowed Kapoor from using it.

Competing materials have emerged.

From <https://en.wikipedia.org/wiki/Vantablack#Exclusive_licence_within_arts>

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



HUYGEN's
Principle
(new to students)

Fraunhofer diffraction, for incoming plane waves
Fresnel diffraction, for incoming spherical waves
(light source very close)

Each point on a plane wave front acts like a spherical wave front. Constructive interference from neighboring points makes the result add up to the plane wave. An isolated part of a wave will then spread spherically.

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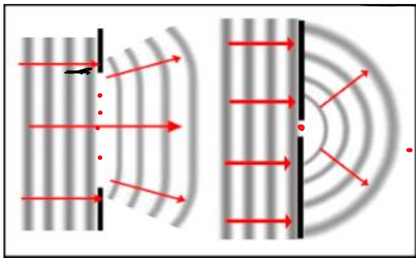
Fresnel diffraction, for incoming spherical waves
(light source very close)



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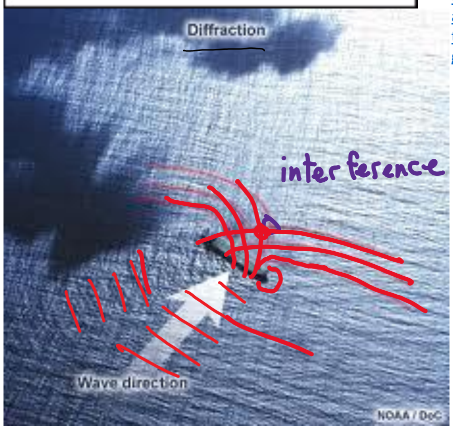
http://www.meted.ucar.edu/marine/ripcurrents/NSF/media_gallery.php



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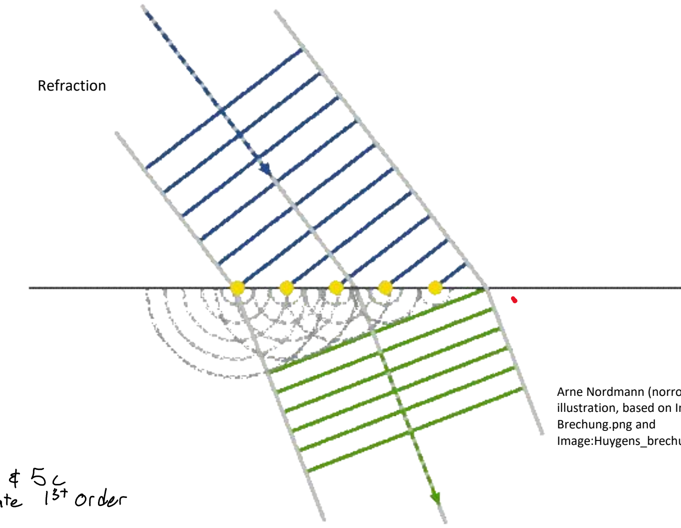
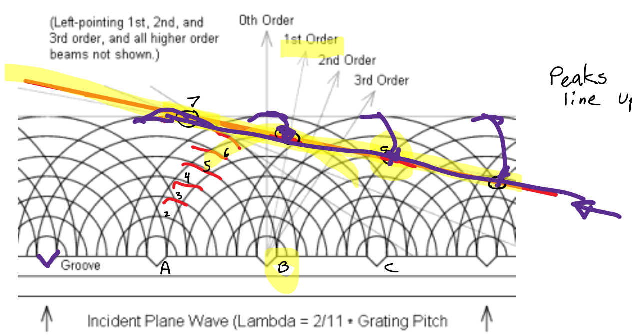
Refraction

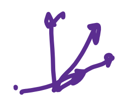


Arne Nordmann (norro) - Own illustration, based on Image:Wellen-Brechung.png and Image:Huygens_brechung.png



Diffraction Grating

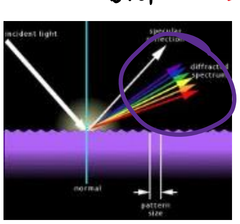
Peaks 7A, 6B & 5C line up to create 1st order



http://exoplanet.as.arizona.edu/~lclose/a302/lecture14/lecture_14.html

- Dispersion, any of these, but
  - Affects differently based on ***wavelength***
    - leads to chromatic aberration, prisms, cloud iridescence (maybe diffraction around particles; interference)

Dispersion → color aberrations



1^{st} orders

https://wiki.metropolia.fi/display/Physics/Diffraction

Minute Paper:
Sketch two setups showing how light interacts with dye: One a scattering setup (the dye scatters light), and one an absorbance setup. Show a typical light path from light source to dye to camera for each. If you are on zoom, In your breakout room, somebody share your screen; a whiteboard is one of the options. In View Options you can all select Annotate. Don't forget to save a jpg