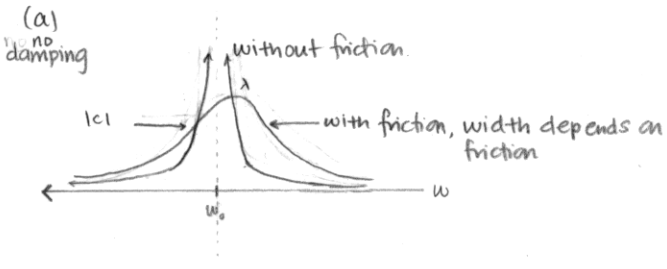
Physical Sciences 3

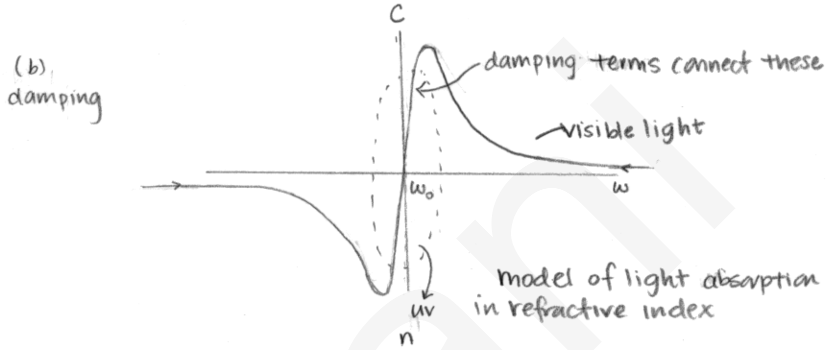
Lectures 16 and 17 – April 9, 2008 – Index of Refraction in Materials, Lenses and Microscopy

Reading for Understanding: Chapter 33 s1-3, 6

ABSORPTION OF LIGHT → photons excite e-



$C = \frac{F_0}{m(\omega_0^2-\omega^2)}$ forced periodic motion

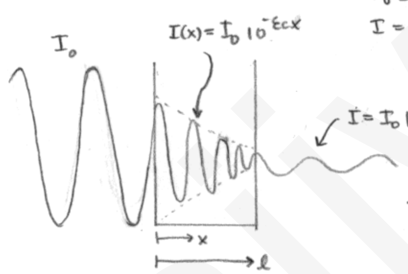


- photon momentum = $h/\lambda = hf/c$
  where $h = 6.63\times10^{-34}$ kgm²/s

Beer-Lambert Law: A = absorbance = $\log \frac{I_0}{I}$

I_0 = incidence light intensity

I = intensity after passing through material.

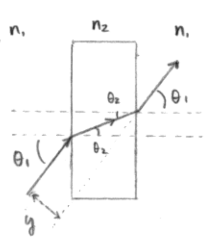


$I = I_0 10^{-\varepsilon c l}$

ε absorption coeff
l length
c concentration of particles

I = intensity = $\frac{P}{A}$ = $\frac{\text{power}}{\text{area}}$

PARALLEL SURFACES

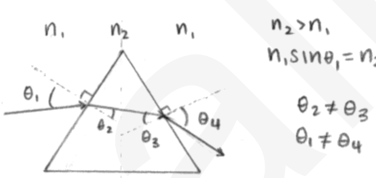


$n_2 > n_1$

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

if the two surfaces are parallel there is no overall change in direction (slight translation)

NON-PARALLEL SURFACES



$n_2 > n_1$

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$\theta_2 \neq \theta_3$

$\theta_1 \neq \theta_4$

consider a prism, where there is net rotation of the direction of light. an arrangement of prisms will focus particular parallel light rays to 1 pt.

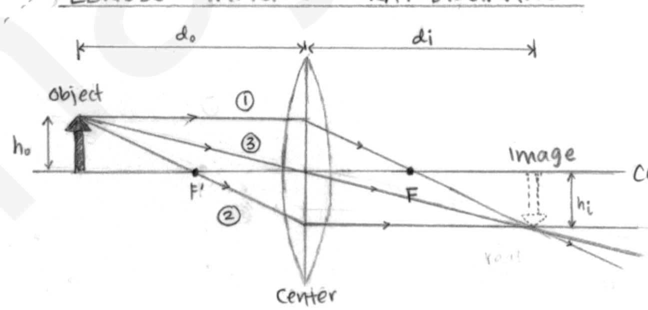
THIN LENSES

lenses focus all incoming parallel beams to 1 pt called the focal point. The distance from the center of the lens to the focal pt is the focal length (f). Power = 1/f (Diopters)

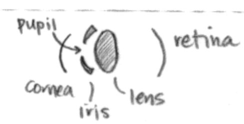
converging lenses () convex f (+)

diverging lenses)(concave f (-)

LENSES → IMAGES → RAY DIAGRAMS



CONVERGING LENS



distance from retina to lens is fixed.

① parallel ray from object to center to F

② ray to F' to center parallel behind lens

③ ray through center of lens to point

THIS PRODUCES A REAL and INVERTED IMAGE!

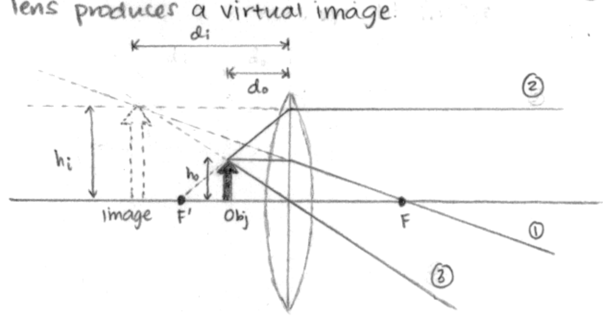
f+ d_i+ d_o+

The Lens Equation:

$m = \frac{h_i}{h_o} = \frac{-d_i}{d_o}$ (−) upright image $h_i>0$ $d_i<0$; (+) inverted image $h_i<0$ $d_i>0$

$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$ real image $d_i>0$ (opposite side d_o); virtual image $d_i<0$ (same side d_o)

- object placed within focal length of converging lens produces a virtual image.



CONVERGING LENS

inverted, upright image

f+ d_i− d_o+

Far-sighted people have problems with the near pt without converging corrective lens, focus is behind the retina.

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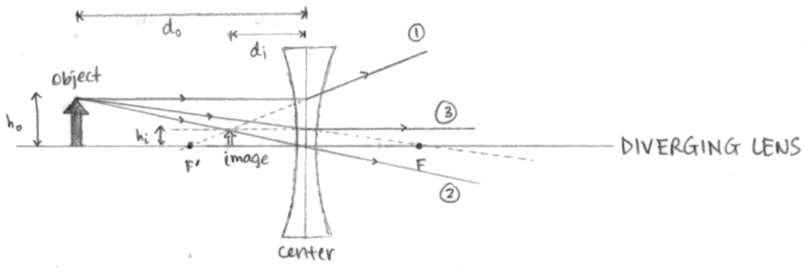
LENSES → IMAGES → RAY DIAGRAMS (cont'd)



① parallel ray from object to center, coming from F'

② ray through center of lens

③ ray as if to go to F to center, then parallel

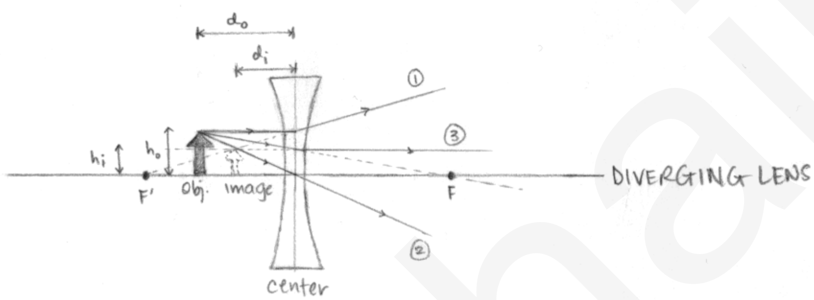
THIS PRODUCES A VIRTUAL, UPRIGHT IMAGE
f− d_i− d_o+

The Lens Equation: (repeated)

$m = \frac{h_i}{h_o} = \frac{-d_i}{d_o}$ (−) upright image $h_i>0$ $d_i<0$
(+) inverted image $h_i<0$ $d_i>0$

$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$ real image $d_i>0$ (opposite side d_o)
virtual image $d_i<0$ (same side d_o)

- Object placed within the focal length of diverging lens produces a virtual image.

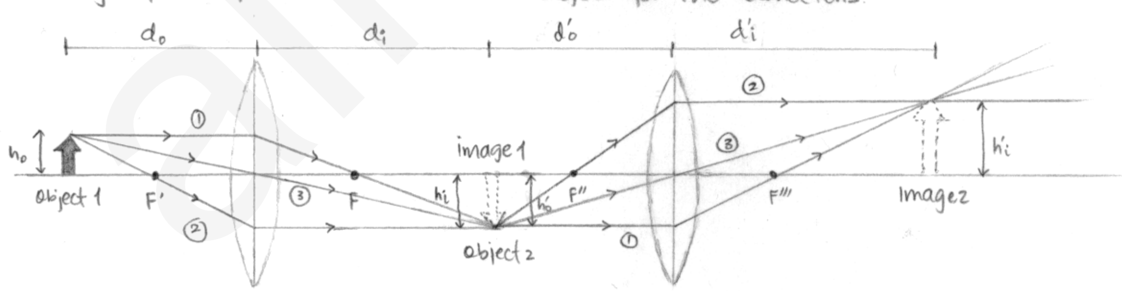


THIS PRODUCES A VIRTUAL, UPRIGHT IMAGE
f− d_i− d_o+

near-sighted people have a problem with the far point without diverging corrective lens, the focus is in front of the retina.

TWO LENSES

The image of the first lens becomes the object for the second lens.



NOTE
d_o is negative when the object is on the opposite side of the incoming light.

$\frac{1}{f_{equiv}} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{f_1 f_2}{f_1+f_2}$
for two lenses at the same location, an approximation

for any lens combination, focal length is defined as the final image location for light coming in from infinitely far away ($d_o \to \infty$).
∴ use the thin lens equation