FERMILAB
ENGINEERING NOTE

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SUBJECT

Physics 2C 3/12

NAME

DATE | REVISION DATE

① Color : Some Facts
② Resolution of Optical Instruments

LAST CLASS (OF NEW MATERIAL)

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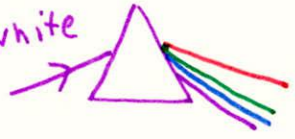
① 

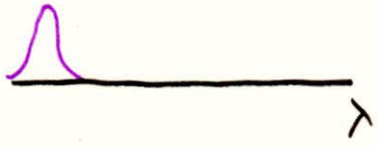
- Color is ↑perception
- White light = mixture of all colors
- index of refraction differs slightly for different colors ("chromatic aberration")
  ⇒ prism can "disperse" light

Note: Although color ~ frequency, it's not exact

Consider "purple":

vs.

"violet":

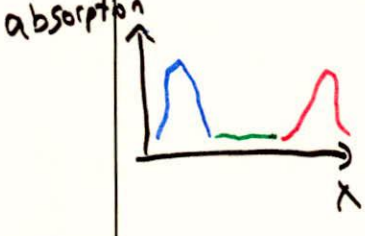


Although they may look similar, one is monochromatic and the other is polychromatic

- Related: what is the frequency for pink?

- The color of objects comes from the light they predominantly reflect!

  eg. plants are green because chlorophyll predominantly absorbs blue and red light!



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Why is the sky blue?

When light scatters (reflects) off big particles (rel. to λ), the scattering angle doesn't depend on λ, but when the particles are small (atoms or molecules) rel. to λ, scattering does depend on λ

$$I \propto \lambda^{-4} (1 + \cos^2\theta)$$

$$\frac{I_{blue}}{I_{red}} = \left(\frac{650\,nm}{450\,nm}\right)^4 \approx 4$$

so sky is blue (not looking at sun)

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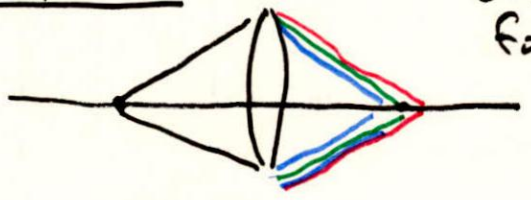
② Resolution

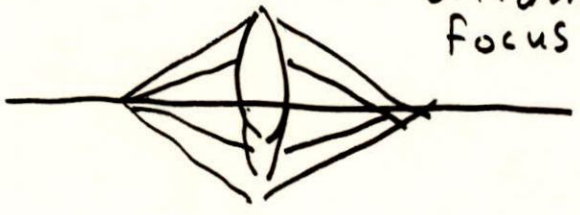
Two defects w/ lenses

chromatic aberration



different wavelengths focus to diff. points

spherical aberration

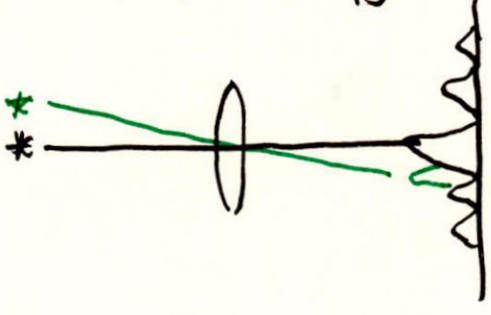


different angles focus at different points

Due to diffraction

angular resolution of a lens

$$\theta_{min} = \frac{1.22\lambda}{D}$$



$$2\theta_{min} = \frac{2.44\lambda}{D}$$

minimum angle you can resolve is when objects are θ_{min} apart!

Given the usual picture of a prism dispersing light, which of the following can you determine?

red bends less

bigger n bends light more

A) n increases as λ increases
B) n increases as λ decreases

bigger n for blue light

$\theta \approx \frac{5\,cm}{200\,m} \simeq 2.5\times10^{-4}$ rad.

Someone sitting on the opposite side of the football field puts his arm up in the air. Can you distinguish whether he is making the peace sign with his fingers or something else?
(Use 200 m for the distance between the person and you.
Use 600 nm for the wavelength of light.
Use 2.5 mm for the diameter of the pupil of the eye.
Use 5 cm for the distance between fingers.)

$\theta_{min} = \frac{2.44\lambda}{D} = \frac{2.44\,(600_{nm})}{2.5\,mm} = 5.8\times10^{-4}$ rad

1. Yes
2. No