

SIMG-712-90-20042      Homework #3  
Due Th, 1/6/2005

1. Fuchsin is a dye, which when in an alcohol solution appears to have a “deep red” color because it strongly absorbs green light.
  - (a) If you have a hollow prism with thin glass walls that is filled with the fuchsin+alcohol solution that is used to disperse a spectrum of white light, what would you expect to observe?
  - (b) If the fuchsin dye is crystallized to make a solid, describe the spectral reflectance (reflectance that you would expect with varying wavelength) of the surface. The statement of the problem is sufficient to figure out the answer.
2. The refractive index of crystalline quartz ( $\text{SiO}_2$ ) is measured to be 1.557 at  $\lambda = 410.0 \text{ nm}$  and 1.547 at  $\lambda = 550.0 \text{ nm}$ . These can be used to calculate the first two terms in Cauchy’s formula for the refractive index:

$$n[\lambda] - 1 \cong A \left( 1 + \frac{B}{\lambda^2} + \frac{C}{\lambda^4} + \dots \right)$$

Evaluate these terms and use them to calculate the index of refraction of quartz at  $\lambda = 610.0 \text{ nm}$ .

3. The resonant frequency  $\omega_0$  of lead glass is in the ultraviolet region of the spectrum fairly near visible light, while that for fused silica is far into the ultraviolet region. Use the dispersion equation for a single resonance to sketch the approximate index of refraction for both materials in the visible spectrum. Sketch BOTH  $n[\omega]$  and  $n[\lambda]$  for both materials.
4. A beam of “natural” (unpolarized) light is incident on a glass surface ( $n = 1.573$ ) at an angle of  $70^\circ$ .
  - (a) Sketch the incident, reflected, and transmitted (refracted) waves.
  - (b) Determine the fraction of the incident light that is reflected at the surface (power, not amplitude).
  - (c) In the reflected beam, determine the ratio of the component of the electric field in the plane of incidence to that at right angles to the plane of incidence.

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5. A fish looks upward at an unobstructed overcast sky. What is the total angular subtense of the sky viewed by the fish? Assume that the water surface is perfectly flat and that  $n = 1.33$ .
6. A diver (next to the fish) shines his flashlight at the same water surface at night so that the beam angle measured from the vertical axis is  $60^\circ$ .
  - (a) If we assume that there is no transmitted beam when there is a reflected one, where does the flashlight beam “go?”
  - (b) If oil with  $n = 1.2$  is spread on the water surface. Now where does the beam of light go?
7. Total internal reflection in a certain substance occurs exactly at  $\theta_0 = 45^\circ$ . Find Brewster’s angle in this material.