SIMG-303-20033 Homework #5

Due W, 4/21/2004

0. In Hecht Chapter 8 on *Polarization,* read sections 8.1 - 8.4 on the *nature of polarized light, polarizers,* and *birefringence.* Skim chapter 5 on *Geometrical optics.*

1. Describe completely the state of polarization of each of the following waves:

   (a) $\underline{\mathbf{E}}[z,t] = \underline{\hat{\mathbf{x}}} E_0 \cos[k_0 z - \omega_0 t] - \underline{\hat{\mathbf{y}}} E_0 \cos[k_0 z - \omega_0 t]$

   (b) $\underline{\mathbf{E}}[z,t] = \underline{\hat{\mathbf{x}}} E_0 \sin\left[2\pi\left(z \cdot \lambda_0^{-1} - \nu_0 t\right)\right] - \underline{\hat{\mathbf{y}}} E_0 \sin\left[2\pi\left(z \cdot \lambda_0^{-1} - \nu_0 t\right)\right]$

   (c) $\underline{\mathbf{E}}[z,t] = \underline{\hat{\mathbf{x}}} E_0 \sin[\omega_0 t - k_0 z] + \underline{\hat{\mathbf{y}}} E_0 \sin\left[\omega_0 t - k_0 z - \frac{\pi}{4}\right]$

   (d) $\underline{\mathbf{E}}[z,t] = \underline{\hat{\mathbf{x}}} E_0 \sin[\omega_0 t - k_0 z] + \underline{\hat{\mathbf{y}}} E_0 \sin\left[\omega_0 t - k_0 z + \frac{\pi}{2}\right]$

2. A beam of linearly polarized light is incident on an ideal linear polarizer. Find the angle between the axis of the directlion of oscillation of the electric field and the ideal linear polarizer if the 25% of the "irradiance" (or "intensity") is transmitted.

3. Sketch a diagram of the windshield and dashboard of a car and use it to explain the useful direction of polarization of polaroid sunglasses.

4. Prove Malus' law that the intensity transmitted by a pair of ideal linear polarizers oriented with their axes at angle θ_0 is proportional to $\cos^2[\theta_0]$.

5. Consider two ideal linear polarizers that are placed with their polarizations axes orthogonal. A third ideal linear polarizer is placed betweent these two and rotated at a constant rate ω_0 [radians per second]. Show that the emerging light "intensity" oscillates at four times the rotation frequency.

6. The wavelength of unpolarized light from a mercury source is $\lambda = 546.072\,\text{nm}$. If incident on a plate of glass at an angle $\theta_i = 58°01'$, the reflected light is seen to be completely linear polarized. Find the refractive index of the glass.

7. A source of left-hand circularly polarized light at $\lambda_0 = 656\,\text{nm}$ should be converted to right-hand circularly polarized light by passing it through a thickness of quartz (SiO_2), which has $n_s = 1.551$ and $n_f = 1.542$.

   (a) Compute the *minimum* thickness of a plate that will accomplish the task.

   (b) (EXTRA CREDIT) From the result of (a), you can see that such a plate is not very practical. Modify the design of the plate to create a practical device.