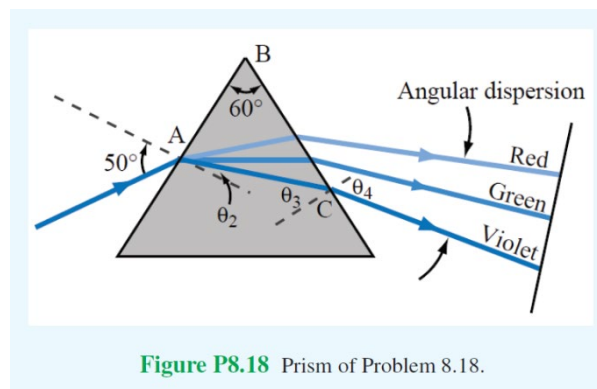


**EE 3109 Applied Electromagnetics**  
**2022/23 Semester B**  
**Week 5-7 Tutorial Questions**

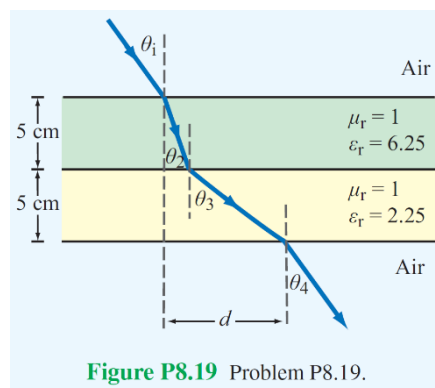
1. A plane wave of unknown frequency is normally incident in air upon the surface of a perfect conductor. Using an electric-field meter, it was determined that the total electric field in the air medium is always zero when measured at a distance of 3 m from the conductor surface. Moreover, no such nulls were observed at distances closer to the conductor. What is the frequency of the incident wave?
2. Orange light of wavelength  $0.61 \mu\text{m}$  in air enters a block of glass with  $\epsilon_r = 1.44$ . What color would it appear to a sensor embedded in the glass? The wavelength ranges of colors are violet ( $0.39$  to  $0.45 \mu\text{m}$ ), blue ( $0.45$  to  $0.49 \mu\text{m}$ ), green ( $0.49$  to  $0.58 \mu\text{m}$ ), yellow ( $0.58$  to  $0.60 \mu\text{m}$ ), orange ( $0.60$  to  $0.62 \mu\text{m}$ ), and red ( $0.62$  to  $0.78 \mu\text{m}$ ).
3. For some types of glass, the index of refraction varies with wavelength. A prism made of a material with

$$n = 1.71 - \frac{4}{30} \lambda_0 \quad (\lambda_0 \text{ in } \mu\text{m})$$

where  $\lambda_0$  is the wavelength in vacuum, was used to disperse white light as shown in Fig. P8.18. The white light is incident at an angle of  $50^\circ$ , the wavelength  $\lambda_0$  of red light is  $0.7 \mu\text{m}$ , and that of violet light is  $0.4 \mu\text{m}$ . Determine the angular dispersion (the angular spread of the light coming out from the prism) in degrees.

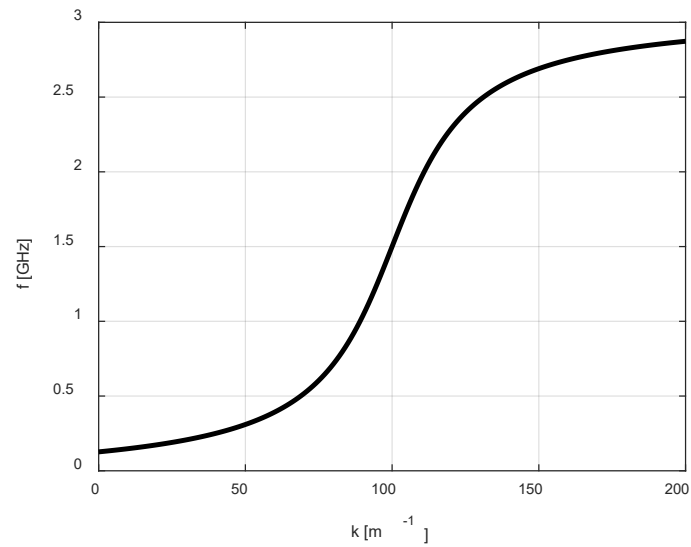


4. A parallel-polarized plane wave is incident from air at an angle  $\theta_i = 30^\circ$  onto a pair of dielectric layers as shown in Fig. P8.19.
  - (a) Determine the angles of transmission  $\theta_2$ ,  $\theta_3$  and  $\theta_4$ .
  - (b) Determine the lateral distance  $d$ .



5. A plane wave in air with  $\mathbf{E}^i = 20e^{-j(3x+4z)}\hat{\mathbf{y}}$  [V/m] is incident upon the planar surface of a dielectric material, with  $\epsilon_r = 4$ , occupying the half-space  $z \geq 0$ . Determine:
  - (a) The polarization (TE or TM) of the incident wave.
  - (b) The angle of incidence.
  - (c) The time-domain expressions for the reflected electric and magnetic fields.
  - (d) The time-domain expressions for the transmitted electric and magnetic fields.
  - (e) The average power density carried by the wave in the dielectric medium. (We will cover this in week 6.)
  
6. A plane wave in air with  $\mathbf{H}^i = 0.02e^{-j(8x+6z)}\hat{\mathbf{y}}$  [A/m] is incident upon the planar surface of a dielectric material, with  $\epsilon_r = 9$ , occupying the half-space  $z \geq 0$ . Determine:
  - (a) The polarization (TE or TM) of the incident wave.
  - (b) The angle of incidence.
  - (c) The time-domain expressions for the reflected electric and magnetic fields.
  - (d) The time-domain expressions for the transmitted electric and magnetic fields.
  - (e) The average power density carried by the wave in the dielectric medium. (We will cover this in week 6.)
  
7. Natural light is randomly polarized, which means that, on average, half the light energy is polarized along any given direction (in the plane orthogonal to the direction of propagation) and the other half of the energy is polarized along the direction orthogonal to the first polarization direction. Hence, when treating natural light incident upon a planar boundary, we can consider half of its energy to be in the form of parallel-polarized waves and the other half as perpendicularly polarized waves. Determine the fraction of the incident power reflected by the planar surface of a piece of glass with  $n = 1.5$  when illuminated by natural light at  $70^\circ$ .
  
8. A parallel-polarized beam of light with an electric field amplitude of 10 (V/m) is incident in air on polystyrene with  $\mu_r = 1$  and  $\epsilon_r = 2.6$ . If the incidence angle at the air-polystyrene planar boundary is  $60^\circ$ , determine the following:
  - (a) The reflectivity and transmissivity.
  - (b) The power carried by the incident, reflected, and transmitted beams if the spot on the boundary illuminated by the incident beam is  $1 \text{ m}^2$  in area.
  
9. A 50-MHz right-hand circularly polarized plane wave with an electric field modulus of 30 [V/m] is normally incident in air upon a dielectric medium with  $\epsilon_r = 9$  and occupying the region defined by  $z \geq 0$ .
  - (a) Write an expression for the electric field phasor of the incident wave, given that the field is a positive maximum at  $z = 0$  and  $t = 0$ .
  - (b) Calculate the reflection and transmission coefficients.
  - (c) Write expressions for the electric field phasors of the reflected wave, the transmitted wave, and the total field in the region  $z \leq 0$ .
  - (d) Determine the percentages of the incident average power reflected by the boundary and transmitted into the second medium.

10. (Adapted from the MIT OCW Lecture on EM Waves) The figure below shows the dispersion curve for a certain medium. (Do not make any assumptions about the mathematical form of this curve.)



- (a) For approximately what frequency(ies) are the phase and group velocities equal?
- (b) For which frequency range will the group velocity be faster than the phase velocity?
- (c) What frequency would you choose for transmitting a pulse at the highest possible speed? How big is this speed?

Sources: Ulaby Ch8 Q12, 13, 17, 19, 27, 28, 31, 35, 36