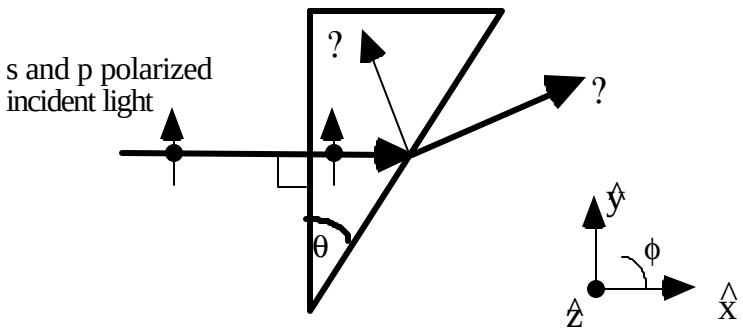
Homework 6 - Fibers to Diffraction

P. Herman

1. Model a cylindrical fiber waveguide as a one-dimensional dielectric slab with $n_c = 1.500$ and $n_f = 1.525$ and 2 km length. The fiber operates at 1.3-μm wavelength and suffers 0.5-dB/km loss.
   (a) Determine the acceptance angle for air coupling, the numerical aperture, and the maximum bit rate. (15.962º, 0.2750, 2.95 Mbits/sec)
   (b) Specify a cladding thickness that attenuates the evanescent wave intensity by 10^{10} beginning at the core-cladding interface. Consider an incident ray grazing the interface at 10º angle. (32.12 μm for $\beta = 0.3584$ radians/μm)
   (c) Consider two 1 - mW sources: an LED producing a uniform intensity in a cone with 60º apex angle and a laser diode with a 10º cone angle. Account for 3-D geometric coupling into the fiber, estimate Fresnel losses at the fiber input and output, and include absorption by the glass to specify the signal power received by a detector. (see separate sheet)

2. A prism is made from a negative uniaxial crystal with $n_z = n_e = 1.4864$ and $n_x = n_y = n_o = 1.6584$. Prism angle θ is selected to pass only one polarization through the second surface.
   (a) Sketch the shape of a Huygen wavelet travelling left-to-right in the x-y plane ($\phi = -90º$ to $+ 90º$) of the crystal for parallel and perpendicular polarization. (Label carefully). Repeat for the x-z plane. (see separate sheet)
   (b) What is the permitted range of θ? ($37.08º < \theta < 42.281º$)
   (c) Which polarization passes the second surface. (perpendicular)



3. Use the Sellmeier dispersion formula

$$n^2 = 2.7359 + \frac{0.01878}{\lambda_o^2 - 0.01822} - 0.01345\,\lambda_o^2$$

(question #2 in Homework #4) to calculate the maximum bit rate supported on a 50-km fiber link for a 1.33-μm wavelength source. The fiber is single mode but suffers group velocity dispersion due to a 1.0-nm source bandwidth. Assume a $\theta = 0º$ propagation angle. (758 MBit/sec)

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4. A 3-cm long Pockel cell acts as a 1/2 - wave plate when 2-kV is applied longitudinally to the cell. What is the electro-optic constant at 800-nm wavelength, given a 1.6 index of refraction? ($r_{ij} = 4.88 \times 10^{-11}$ m/V)

5. Specify three parameters, and whether they should be increased or decreased in order to reduce the focal spot size produced by a lens illuminated with parallel monochromatic light.

6. Estimate the diameter of a HeNe laser beam projected onto the moon's surface, 3.8×10^5 km from the earth. The 0.633 μm wavelength light leaves the laser cavity through a 1mm diameter stop. (580 km)

7. How far must two similar lasers be separated on earth in order to be resolved by an astronaut on the moon's surface? Assume the eye iris opening is 2 mm in diameter. (146 km)

8. A pocket microscope used for viewing gems has an aberration free objective lens of 5 mm focal length and 4 mm diameter and an eyepiece lens of 2 cm focal length. For an eye focused at infinity, the lenses are separated by 5 cm.
   (a) Determine the minimum feature size in microns just resolved by the objective lens for 0.5 μm wavelength light. (0.915 μm)
   (b) What minimum eyepiece lens diameter is necessary to obtain the resolution in part (a)? (2.67 mm)