ECE Integrated Optics **Not to be Returned**

Problem Set # 4

1. EFFECTIVE-INDEX METHOD FOR CHANNEL WAVEGUIDES

A raised-strip type channel waveguide has the following parameters (figure below): $n_c = 1.90$, $n_f = 2.20$, $n_s = 2.10$, $h = 1.0\mu m$, and $w = 1.0\mu m$. Laser light of freespace wavelength $\lambda_0 = 1.0\mu m$ is coupled into the channel waveguide. The effective-index method is going to be used for the approximate calculation of the effective indices of the guided modes. (a) Assume that only the effective indices of the TE-like modes are needed. For a TE-like mode the electric field has the largest component along the y direction, i.e. $E_x \simeq 0$ and $E_y \neq 0$. A TE-like mode is denoted by $E_y^{\nu\mu}$ where ν is the mode number that correspond to the x direction and μ is the mode number that correspond to the y direction. Find how many and which TE-like guided modes, $E_y^{\nu\mu}$, can be supported by this channel waveguide, and draw qualitatively transverse field intensity patterns in the xy plane for each guided mode. (b) Find the effective indices $N_{\nu\mu}$ of the $E_y^{\nu\mu}$ guided modes supported by this channel waveguide.

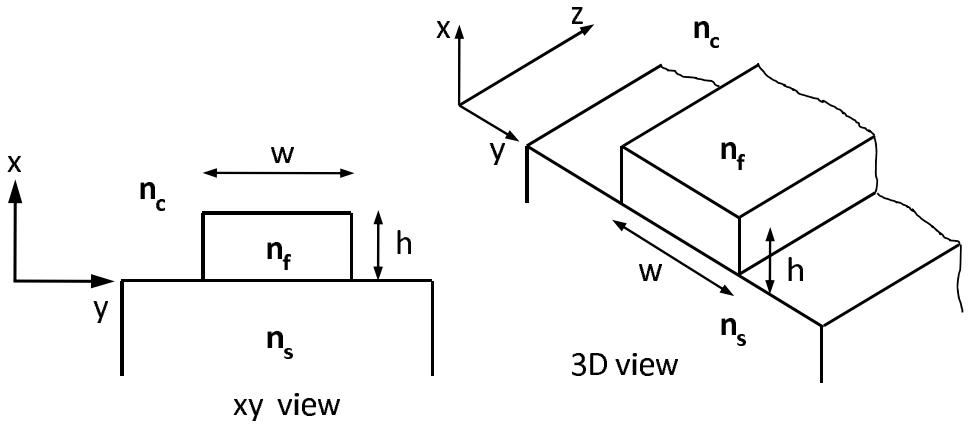

Figure 1: Views of a rib waveguide.

2. COUPLING COEFFICIENT BETWEEN TWO SLAB WAVEGUIDES (TE MODE)

The two waveguides shown in the figure are designed to support a single TE mode. The electric fields (for the fundamental TE mode) for each waveguide are

$$\vec{E} = \begin{cases} \hat{y} 2E_{fi} \cos(k_{fxi} h_i - \phi_{si}) \exp[-\gamma_{si}(x_i - h_i)] \exp(-j\beta_i z) & \text{for } h_i < x_i < \infty, \\ \hat{y} 2E_{fi} \cos(k_{fxi} x_i - \phi_{si}) \exp(-j\beta_i z) & \text{for } 0 < x_i < h_i, \\ \hat{y} 2E_{fi} \cos\phi_{si} \exp(\gamma_{si} x_i) \exp(-j\beta_i z) & \text{for } -\infty < x_i < 0, \end{cases}$$

where $i = A, B$ (A corresponds to waveguide A and B correpsonds to waveguide B in the figure) and $\phi_{si} = \tan^{-1}(\gamma_{si}/k_{fxi})$. (a) Calculate coefficients $2E_{fi}$ ($i = A, B$) to normalize the modes of the two waveguides. In order to avoid calculations use the equations that express the time-average power that were given in class. (b) Calculate the coupling coefficient C_{AB} when the two waveguides are brought together (at a distance s as shown in the figure).

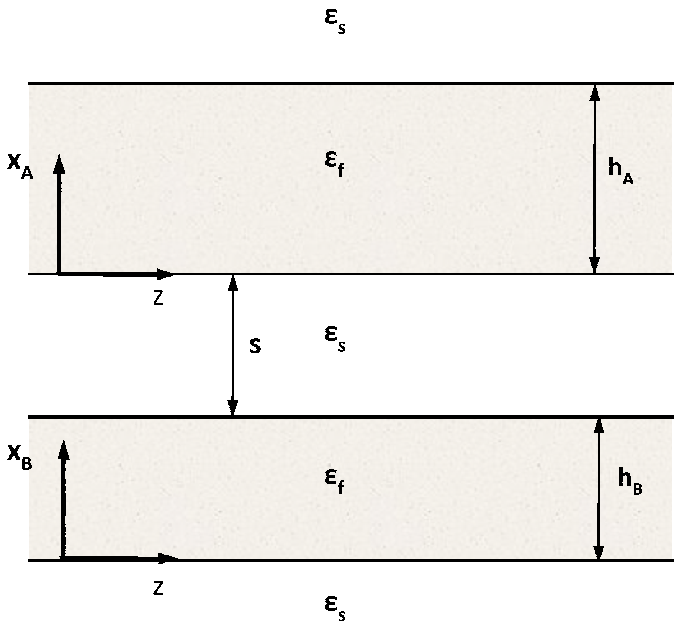

Figure 2: A simple directional coupler.