Physics Department

Fiber and Integrated Optics (EPL442/PYL413): Minor I

August 29, 2016

Maximum marks: 20

ALL QUESTIONS ARE COMPULSORY

1. Give brief answers to the following:
   a) Consider a symmetric planar waveguide with the following refractive index profile:

$$n^2(x) = n_1^2; \quad |x| < \frac{a}{2}$$
$$= n_2^2; \quad \frac{a}{2} < |x| < \frac{b}{2}$$
$$= n_3^2; \quad |x| > \frac{b}{2}$$

   with $n_1 > n_3 > n_2$. Write down the expression for E_y of the TE_0 guided mode in all regions. **(2)**

   b) Draw schematic diagrams of the transverse intensity patterns of E_{21}^x and E_{13}^y modes of a channel waveguide. **(2)**

   c) Show that for the TE_0 mode in a planar waveguide with refractive index variation $n(x)$ there is no power flow along the x-direction. **(3)**

2. The fundamental TE mode in a planar step index waveguide operating at 1000 nm with $n_1 = 1.5$ and $n_2 = 1.48$ has $n_{eff} = 1.49$.
   a) Obtain the thickness of the film.
   b) What is the depth of penetration of the mode in the lower index region?
   c) If the operating wavelength is increased to 1300 nm, will the effective index of the same mode be lesser than or greater than 1.49? **(4)**

3. Consider a rectangular channel waveguide with $n_1 = 1.51$ and $n_2 = 1.50$ with $a = 4$ μm and $b = 8$ μm operating at a wavelength of 1μm.
   a) Write down expressions for the separable refractive index profile which can be used as an approximation to evaluate the propagation characteristics of the given waveguide.
   b) Write down an expression for the Ey field of the E_{12}^y mode in the core region of the waveguide ($|x| < 2\ \mu m$, $|y| < 4\ \mu m$) and in the region $|x| > 2\ \mu m$, $|y| < 4\ \mu m$ in terms of β_x and β_y, where symbols have their usual meanings. **(4)**

4. Consider a directional coupler made up of two single mode channel waveguides. Given that the coupling coefficient between the waveguides is $\pi/2$ cm^{-1},
   a) What should be the length of the coupler so that entire power transfer can take place between the waveguides if they are identical?
   b) What is the value of $\Delta\beta$ ($= \beta_1 - \beta_2$) between the two waveguides so that the maximum transfer of power between the two waveguides is 50%?
   c) What is the corresponding length of the coupler where power launched in waveguide 1 gets divided equally between the two waveguides? **(5)**