Physics Department

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

October 9, 2016

ALL QUESTIONS ARE COMPULSORY

1. Give brief answers to the following: **(5x2=10)**
   a) Consider a directional coupler made of a pair of identical single mode waveguides. If at the input, equal power is launched into the two waveguides, for what values of phase difference between the two inputs will power in each waveguide not change with z?
   b) Consider a medium specified by the following refractive index variation with frequency:
   $$n(\omega) = P + Q\omega^2 + \frac{R}{\omega^2}$$
   where P, Q and R are constants. At what value of ω will a pulse propagate without dispersion in such a medium?
   c) A higher order LP mode of an appropriate optical fiber is given by the following expression:
   $$\psi = Ar^2 e^{-r^2/w_0^2}\cos 2\phi$$
   State which LP_{lm} mode this field could represent.
   d) I wish to design a single mode fiber for operation at 1300 nm with core and cladding refractive indices of 1.451 and 1.447. What core radius would you choose to achieve largest effective index of the LP_{01} mode?
   e) A pulse centered at the wavelength of zero material dispersion is launched into a single mode optical fiber. Will the pulse undergo temporal broadening? Give reasons for your answer.

2. Consider a multimode parabolic index planar waveguide with
   $$n^2(x) = n_1^2\left[1 - 2\Delta\left(\frac{x}{a}\right)^2\right]; \qquad 0 < |x| < a$$
   $$= n_1^2[1 - 2\Delta] = n_2^2; \qquad |x| > a$$
   A ray is launched on the plane $z = 0$ at $x = x_0$ making an angle θ_0 with the z-axis.
   a) Obtain the expression for the ray path in terms of x_0 and θ_0.
   b) What is the range of θ_0 for the ray to be guided? **(5)**

3. Consider a step index single mode fiber with $n_1 = 1.451$ and $n_2 = 1.447$ operating at a wavelength of 1 μm with $V = 2.25$.
   a) What is the core radius of the fiber?
   b) From the expression for the field distribution of the mode, show that the mode has no zero crossing along the radial direction.

   You may use the empirical formula: $b(V) = \left(1.1428 - \frac{0.996}{V}\right)^2$. **(5)**

(Please turn over for some useful formulas)