HW #4

due 2/22/18 5PM No later than 2/26/18 5PM

1. An optical fiber has a core diameter of $8\mu m$ and numerical aperture of 0.18.

a) What is the maximum source diameter and numerical aperture for optimum coupling?

b) For a laser beam with wavelength of $1.55\mu m$ and the maximum source diameter in a), what is the divergence angle? Considering the size and angle issues, does this beam provide optimum coupling?

c) To ensure optimum coupling, what is the maximum distance between the laser and the fiber.

d) Is it wise to reduce the beam diameter to 50% of the value used in b)? Justify your answer with the new divergence angle. Notice: This has advantage of relaxing the requirements on alignment.

2. Consider a fiber with a core diameter of $50\mu m$, core refractive index of 1.485 and a cladding refractive index of 1.465 at $\lambda_o = 850nm$. Consider operating this fiber at $\lambda_o = 850nm$ and laser source with linewidth of 2nm. Assume the material has zero dispersion wavelength $\lambda_0 = 1360nm$ and dispersion slope of $S_0 = 0.09ps/km - nm^2$.

a) Calculate the V parameter.

b) Based on the answer in a), is this a single mode fiber. If not, calculate the number of modes.

c) Suppose we want to achieve single mode operation for 1900nm to 2100nm wavelength range. What is the maximum core refractive index if other parameters remain the same.

3. A step-index multimode glass fiber has a core diameter of 60 µm and cladding refractive index of 1.46. If it is to have a limiting intermodal dispersion (D_{modal}) of 10ns/km, find its acceptance angle. Also calculate the maximum bit rate for transmission over a distance of 10km. (modified Problem 2.2 on page 103 2nd Ed (p. 108 3rd Ed.)) and also estimate the maximum bit rate (data rate) with conservative limit. (Notice that $n_1 \approx n_2$ but Δ is non-zero.)

4. Consider a fiber with core diameter of $8\mu m$ and refractive index of 1.467 and a cladding refractive index of 1.464 both refractive indices at 1300nm where the fiber is to be operated using a laser source with linewidth of 2nm. Assume the material has zero dispersion wavelength $\lambda_0 = 1360nm$ and dispersion slope of $S_0 = 0.09ps/km - nm^2$.

a) Calculate the V parameter.

b) Based on the answer in a), is this a single mode fiber. If not, calculate the number of modes.

c) Suppose we want to a single mode operation for 800nm to 1100nm wavelength range. What is the maximum core diameter if other parameters remain the same.

Extra-Credit for undergraduate (regular for graduate)

5. Derive an expression for the cutoff wavelength λ_{cutoff} of a step index fiber with core radius *a*, core refractive index n_1 , and cladding refractive index n_2 . Calculate the cutoff wavelength of a fiber with core radius $a = 5\mu m$ and $\Delta = 0.002$. (modified Problem 2.4 page 103 2nd Ed (p. 108 3rd Ed.)) (Notice that you can assume the fiber has typical refractive index of glass.)

Extra-Credit

6. Derive the D_{modal} formula for a step index fiber with core index n_1 , cladding index n_2 and length L using the following steps:

a) Find the traveling time along the central path.

b) Find the traveling time along the zig-zag path at maximum acceptance angle.

c) Find the difference in time delay $\Delta \tau$ between paths a) and b).

d) Find $D_{modal} = \Delta \tau / L$.

(Note: You can find the answers in the textbook. However, you need to show your steps and diagrams in obtaining these answers. Just copying equations will not count much.)