SLOT: B2

Vellore – 632014, Tamil Nadu, India

SCHOOL OF ELECTRONICS ENGINEERING

FALL SEMESTER 2024-2025

CAT-1

Programme: B.Tech	**Branch: ECE, BML**	**Course code: BECE308 L**
Course Name: Optical Fiber Communications		**Date and Time: 26/08/2024, 2.00 to 3.30 PM**
Class Nbr: VL2024250102791 VL2024250102793 VL2024250102798 VL2024250102803 VL2024250102805 VL2024250102807	**Max Marks: 50**	**Duration: 90 mins**
Faculty name(s): ***Dr. G. Aarthi, Dr. S. Rajalakhsmi, Dr.N.Sangeetha, Dr.Subhra Sankha sarma, Dr.Tangudu Ramji.Dr.Jagana Bihari Padhy***		

General instruction(s): 1. Answer ALL

S.No	**Question**	**Marks**	**CO**	**BL**
1.	a. The velocity of light in the core of a step index fiber is $2.01\times 10^8 m/s$, and the critical angle at the core–cladding interface is 80°. Determine the numerical aperture and the acceptance angle for the fiber in air? Assuming it has a core diameter suitable for consideration by ray analysis. The velocity of light in a vacuum is $2.998\times 10^8 m/s$.	**5**	**1**	**2**
	b. A multimode step index fiber has a relative refractive index difference of 1% and a core refractive index of 1.5. The number of modes propagating at a wavelength of 1.3 μm is 1100. Estimate the diameter of the fiber core?	**5**	**1**	**2**
2.	a. Discuss the advantages and disadvantages of fiber optic communications.	**5**	**1**	**1**
	b. What is Holey Fiber. Discuss the potential applications of Holey fibers.	**5**	**1**	**1**
3.	a.(i) A single-mode step index fiber with a core refractive index of 1.49 has a critical bending radius of 10.4 mm when illuminated with light at a wavelength of 1.30μm. If the cutoff wavelength for the fiber is 1.15μm calculate its relative refractive index difference. (ii) A multimode graded index fiber has a refractive index at the core axis of 1.46 with a cladding refractive index of 1.45. The critical radius of curvature which allows large bending losses to occur is 84μm when	**5**	**2**	**2**

	the fiber is transmitting light of a particular wavelength. Determine the wavelength of the transmitted light.			
	(i) 0.47% (ii) 0.86µm			
	b. Describe how macro bending losses occur in the optical fibers.	**5**	**2**	**2**
4.	Compare the optical bandwidth, bitrate and rms pulse broadening per kilometer for the following three fibers:(consider NRZ encoding) (i) a multimode step index fiber with core index $n_1 = 1.79$ and $\Delta = 1.0$ %, (ii) a graded index fiber having an optimum parabolic index profile and the same n_1 and Δ as in (i), the same type of graded index fiber as in (ii) but with $\Delta = 0.5$ %.	**10**	**2**	**3**
	(i) $n_1 = 1.79$ $\Delta = 1\%$ Multimode step index fiber $\sigma_s(1Km) = \frac{Ln_1\Delta}{2\sqrt{3}c} = \frac{10^3 \times 1.79 \times 0.01}{2\sqrt{3} \times 2.998 \times 10^8}$ $= 17.2\ ns\,Km^{-1}$ $B_{T(max)} = \frac{0.2}{\sigma_s} = \frac{0.2}{17.2 \times 10^{-9}}$ $= 11.6\ Mbit/s$			

For NRZ encoding

$$B_{T(max)} = 2 B_{opt}$$

$$B_{opt} = \frac{B_{T(max)}}{2}$$

$$= \frac{11.6}{2}$$

$$B_{opt} = 5.8 \text{ MHZ}$$

(ii) Multimode Graded index fiber

$n_1 = 1.79 \quad \Delta = 1.0\%$

$$\sigma_{g\,(1km)} = \frac{L n_1 \Delta^2}{20\sqrt{3}c} = \frac{10^3 \times 1.79 \times (0.01)^2}{20\sqrt{3} \times 2.998 \times 10^8}$$

$$= 17.2 \text{ ps km}^{-1}$$

$$B_{T(max)} = \frac{0.2}{\sigma_g} = \frac{0.2}{17.2 \times 10^{-12}}$$

$$= 11.6 \text{ Gbit/s}$$

$$B_{opt} = \frac{B_{T(max)}}{2}$$

$$= \frac{11.6}{2}$$

$$= 5.8 \text{ GHZ}$$

	(iii) Multimode Graded index fiber $n_1 = 1.79 \qquad \Delta = 0.5\%$ $\underset{(1km)}{\sigma_g} = \frac{L n_1 \Delta^2}{20\sqrt{3}c} = \frac{10^3 \times 1.79 \times (0.005)^2}{20\sqrt{3} \times 2.998 \times 10^8}$ $= 4.3 \text{ ps km}^{-1}$ $B_{T(max)} = \frac{0.2}{\sigma_g}$ $= 46.5$ Gbit/s $B_{opt} = \frac{B_{T(max)}}{2} = 23.25$ GHZ			
5.	a. Determine the wavelength of the light signal launched by a laser source of spectral width 900 MHz through a 50 km long single mode fiber of core diameter 6 μm and attenuation coefficient 0.5 dB km^{-1} when the threshold power for stimulated Brillouin scattering to occur is 100 mW $P_B = 4.4 \times 10^{-3} d^2 \lambda^2 \alpha_{dB} \nu$ $100 \times 10^{-3} = 4.4 \times 10^{-3} \times 6^2 \times$ $\lambda^2 = 1.40 \ \mu m^2$	**5**	**2**	**3**
	b. From Kerr nonlinearity explain self phase modulation and the chirping effect.	**5**	**2**	**3**

1.

(2) $\sin^{-1}(n_2/n_1) = 80° = \theta_c$

(a)

Critical Angle

$\theta_c = \sin^{-1}\left(\frac{n_2}{1}\right)$

$n_2 = \sin(\theta_c) = \sin(80°)$

$n_2 = 0.984$

$NA = \sqrt{n_1^2 - n_2^2}$

$NA = \sqrt{1^2 - (0.984)^2}$

$NA = 0.178$

$N.A. = \sin(\theta a)$

Acceptance Angle $(\theta a) = \sin^{-1}(0.178)$

$(\theta a) = 10.3°$

(b) $V = \frac{2\pi}{\lambda} a \cdot n_1 \cdot (2\Delta)^{1/2}$

$V = \frac{2\pi}{\lambda} \cdot a \cdot (NA)$

$\Delta = 0.01$

$n_1 = 1.5$

$M = \frac{V^2}{2} = 1100$

$\lambda = 1.3\,\mu m$

$V^2 = 2200$

$V = \sqrt{2200}$

$V = 46.9$

$46.9 = \frac{2 \times 3.14}{(1.3 \times 10^{-6})} \times (a) \times (1.5) \times (\sqrt{2 \times 0.01})$

$46.9 = (4.83 \times 10^{6}) \times a \times 1.5 \times 0.1414$

$a = 0.0000457\ \mu m$

d = diameter of core $= 2a$

$d = 91.56\,\mu m$.