

- (c) A light ray propagates through a multimode optical fiber making an angle of  $20^\circ$  with the fiber axis. If the length of the fiber is 3 km, determine the total distance traveled by the ray inside the fiber. 3



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Total Pages : 06

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M. Sc. (Physics) (Fourth Semester)

Optical Fiber Communication (PHP-234-V)

Time : 3 Hours]

[Maximum Marks : 75

- Note : It is compulsory to answer all the questions (1.5 marks each) of Part A in short. Answer any *four* questions from Part B in detail. Different sub-parts of a question are to be attempted adjacent to each other.

**Part A**

1. (a) Why depletion region increases in reverse bias ? 1.5
- (b) What is the difference between internal and external photo-electric effect ? 1.5
- (c) Calculate the energy of a photon emitted by an LED operating at a wavelength of 850 nm. 1.5

- (d) What do you understand by fiber-bending losses ? 1.5
- (e) Why the Ruby laser generally operates in pulsed mode rather than Continuous Wave (CW) mode ? 1.5
- (f) A photon of wavelength 620 nm is incident on a semiconductor. Calculate the photon energy and comment on whether it can excite an electron across a 1.8 eV band gap. 1.5
- (g) Define Attenuation. If the input power is 10 mW and output power is 2 mW, calculate the attenuation in dB. 1.5
- (h) Can the refractive index profile parameter  $a$  in a graded-index fiber be zero ? Explain your answer. 1.5
- (i) What is Rayleigh scattering in optical fibers ? Why does it decrease with increasing wavelength ? 1.5
- (j) What is intrinsic absorption ? 1.5

## Part B

2. (a) Explain the ray theory of light propagation in optical fibers and derive the expression for Numerical Aperture and acceptance angle. 6
- (b) Distinguish between step-index and graded-index fibers in terms of refractive index profile and light propagation. 6
- (c) Discuss the important detector parameters: Quantum efficiency, Responsivity, Long wavelength cut-off. 3
3. (a) Explain the working principle of Ruby laser with the help of energy level diagrams. 6
- (b) Discuss material dispersion and waveguide dispersion and explain, how they combine to produce chromatic dispersion. 6
- (c) Write a short note in fiber optic sensors. 3

4. (a) What are the requirements of a good optical detector ? Explain with the help of a neat diagram, the working of a PIN photodiode. 6

(b) Describe the mechanism of intermodal dispersion in a multimode step index fiber. If  $n_1$  and  $n_2$  be the core and cladding refractive index respectively, what is the shortest and longest path length of an optical signal in fiber of length  $Z$  ? 6

(c) An optical fiber has : Core radius  $a = 4.5 \mu\text{m}$  Numerical Aperture  $NA = 0.20$ , Operating wavelength  $\lambda = 1.3 \mu\text{m}$ . Calculate the normalized frequency (V-number) of the fiber. 3

5. (a) Explain the architecture of a fiber optic communication system. Discuss the role of fiber couplers and its various types in ensuring efficient data transmission. 8

(b) Explain optical fiber fabrication technique with the help of a neat diagram. Why is the fiber drawing process important in optical fiber fabrication ? 7

6. (a) Derive the wave equation for light propagation in an optical fiber using Maxwell's equations. Explain how different modes are formed in a planar waveguide. 8

(b) Describe the non-linear scattering processes in optical fibers. Explain the mechanisms of Stimulated Brillouin Scattering (SBS) and Stimulated Raman Scattering (SRS). 7

7. (a) Explain intermodal dispersion in multimode step index fibers. A multimode fiber has intermodal dispersion of  $12 \text{ ns/km}$ . Calculate the total pulse broadening after  $6 \text{ km}$  transmission. 6

(b) Describe the properties and applications of the following :  
Glass fibers, Active glass fibers, Plastic optical fibers (POF). 6