**53 (IE 703) FOLI**

**2019**

# FIBER OPTICS AND LASER INSTRUMENTS

Paper : IE 703

*Full Marks : 100*

Time : Three hours

***The figures in the margin indicate full marks for the questions.***

*Answer **any five** questions.*

1. *(a)* Discuss the advantages and disadvantages of fibre optic system. 5

*(b)* Define the terms — Acceptance angle and numerical aperture.
A silica optical fiber with a core diameter large enough to be considered by ray theory analysis has a core refractive index of 1·5 and a cladding refractive index of 1·47.
Determine :
(a) The critical angle at the core-cladding interface.
(b) Numerical aperture for the fiber.
(c) Acceptance angle in air for the fiber. 3+5=8

*Contd.*

(c) A typical relative refractive index difference for an optical fiber designed for long distance transmission is 1%. Estimate the NA and the solid acceptance angle in air for the fiber when the core index is 1·46. Further calculate the critical angle at the core-cladding interface within the fiber. 7

2. (a) How optical fibers can be classified? Define and draw the refractive index profiles of different types of optical fibers. 7

(b) What are the advantages of a multi-mode fiber over single-mode fiber? A multi-mode step index fiber with a core diameter of 80$\mu m$ and a relative index difference of 1·5% is operating at a wavelength of 0·85$\mu m$. If the core refractive index is 1·48, estimate —

(i) the normalized frequency for the fiber

(ii) the number of guided modes.

Also estimate the maximum core diameter for an optical fiber with same core and cladding material and



operating at same wavelength in order that it may be suitable for single-mode operation. Further estimate the new maximum core diameter for single-mode operation, if the relative refractive index is reduced by a factor of 10. 3+5+5=13

3. (a) When the mean optical power launched into an 8$km$ length of fiber is 120$\mu W$, the mean optical power at the fiber output is 3$\mu W$.

Determine : 8

(i) The overall signal attenuation or loss in $dB$.

(ii) The signal attenuation per $km$ for the fiber.

(iii) Overall signal attenuation for a 10$km$ optical link using the same fiber with splices at 1$km$ intervals, each giving an attenuation 1$dB$.

(iv) The numerical input/output power ratio in *(iii)*.

(b) What are the different types of scattering losses in an optical fiber? Explain each. 8

(c) A long single-mode optical fiber has an attenuation of $0{\cdot}5 dB/km$ when operating at a wavelength of $1{\cdot}3 \mu m$. The fiber core diameter is $6 \mu m$ and the laser source bandwidth is $600 MHz$. Compare the threshold optical powers of stimulated Brillouin scattering and stimulated Raman scattering. 4

4. (a) What is a laser? What are the characteristics of a laser source? 5

(b) Obtain the Einstein's relation for spontaneous and stimulated emission of radiation. 10

(c) A ruby laser contains a crystal length $4 cm$ with a refractive index of 1·78. The peak emission wavelength from the device is $0{\cdot}55 \mu m$. Determine the number of longitudinal modes and their frequency separation. 5

5. (a) What are the advantages of LEDs as a fiber optic source? Derive the expression for internal quantum efficiency of an LED. 5+8=13



(b) What is responsivity of a photo-detector? A photodiode has a quantum efficiency of 65% when photons of energy $1{\cdot}5 \times 10^{-19} J$ are incident on it.

(i) At what wavelength is the photodiode operating?

(ii) Calculate the incident optical power required to obtain a photocurrent of $2{\cdot}5 \mu A$ when the photodiode is operating as described above. 7

6. (a) How a laser can be used for measurement of distance and velocity? Explain. 10

(b) What is a Hologram? Explain the basic principle of Hologram. 10

7. (a) Explain Fiber optic system for measurement of — (i) pressure (ii) liquid level. 12

(b) Write a short note on UV spectrometry. 8