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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) What does index of refraction measure ? 1
- (b) How is a skew ray different from a meridional ray ? 3
- (c) Define Numerical Aperture of a fiber.
On what factors it depends ? 3
- (d) Define the relative refractive index difference for an optical fiber and show how it may be related to the numerical aperture. 3

Contd.

(e) What are the photon energies in electron volts (eV) of light at wavelengths 0.88, 1.3 and $1.55\mu\text{m}$? 3

(f) Calculate the transmission distance over which the optical power will attenuate by a factor of 10 for fiber with loss of 20dB/km . 3

(g) How would you classify optical fiber based on the variations in the composition of core material? 4

2. (a) Define the terms : Phase and Group velocity. 3

(b) State the merits and demerits of single-mode fiber. 3

(c) Name the five different types of intrinsic losses that appear in a fiber joint. 5

(d) Explain the mechanism that causes distortion of pulses in an optical fiber. 3

(e) A fiber optic link of length 50km has a rated 0.2dB/km loss. The maximum power required to run the photodector is 20nW . What power must be supplied by a source ? 3

(f) A p-n photodiode has a quantum efficiency of 70% for photons of energy $1.52 \times 10^{-19}\text{J}$.

Calculate :

(i) The wavelength at which the diode is operating
(ii) The responsivity of the photodiode.

3

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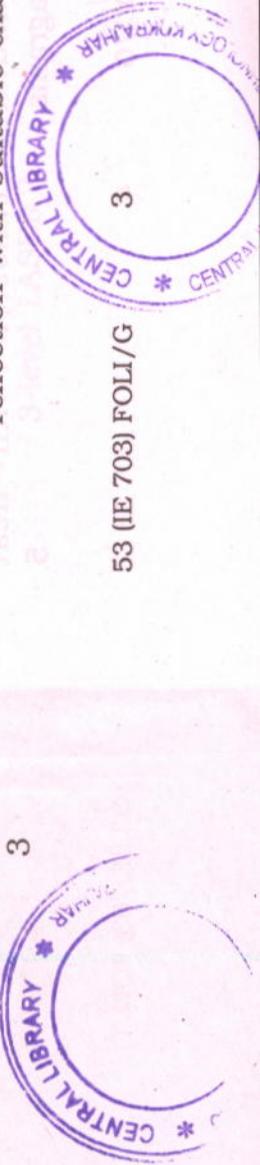
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3

(b) What can be done to minimize bending loss in optical fiber ? 2

(c) State the different categories of reflection with suitable examples. 3



- (d) An SI fiber has an NA of 0.18 and a cladding RI of 1.46.
Determine :
- The acceptance angle of the fiber when it is placed in water ($RI_{water} = 1.33$)
 - The critical angle at core cladding interface.
 - What is the difference in mode travel times for a fiber with a core index of 1.5 and V-number of 120 ?
 - State the differences between a splice and a connector.
 - What is the function of the intrinsic layer in a PIN ?
- 4
3
3
3
2
- 4.
- State and describe the basic components of a Laser.
 - What are the differences in characteristics between a PIN and APD detector ?
 - Differentiate between spontaneous and stimulated emission with neat diagrams.
- 6
4
5



- (d) The data for two LEDs are given below and if one from these has to be chosen as a source for a fiber optic system with the given requirements, which LED would be your choice ?

System requirements

LED characteristics	
Parameter	
O/P power	1mW
Rise time	1ns
NA	1.10
Supply voltage	2.3V
Forward currents	10mA
LED1	LED2
2mW	
10ns	
1.70	
3V	
50mA	

- * Bandwidth = 20MHz
- * O/P power of $10\mu W$ after 1.5km (loss of $3dB/km$)
- * Electric power : 1 Watt
- * Fiber NA : 1.2

5. (a) Describe the main components of a LIDAR system. Also make a comparison between LIDAR and RADAR.
- 4+4=8
- (b) State the differences between intrinsic and extrinsic fiber optic sensors with suitable examples.
- 5
- (c) List out the properties of LASER compared to ordinary light.
- 4
- (d) Why we prefer 4-level LASER over 3-level LASER ?
- 3

6. (a) A 4-port directional coupler has 4:1 splitting ratio and excess loss equals to 18dB, directionality equals to 12dB. 5

(i) What fraction of input power goes to each of the port ?

(ii) Compute the loss due to radiation and scattering.

(b) With suitable diagram, explain the operation of He-Ne LASER. 5

(c) State few applications of directional coupler. 3

(d) List out the features of Nd : YAG laser compared to ruby laser. 5

(e) Define the term : Dark current noise. 2

- (c) With the help of a neat diagram, explain how the Laser Doppler Velocimeter (LDV) can be used for measurement of fluid velocities. 4

8. Write short notes on : (any four) 5×4=20

- Ruby Laser
- Mode locking
- Fiber optic current sensor
- Quantum efficiency
- Population inversion.



7. (a) What is Sagnac effect ? Explain the working principle of Fiber optic gyroscope. 6
- (b) List out the differences between a Photograph and a Hologram. Explain the process of recording and reconstruction of a transmission hologram. 4+6=10