

**OPTICAL FIBER COMMUNICATION
(ECEN 4223)**

Time Allotted : 3 hrs

Full Marks : 70

Figures out of the right margin indicate full marks.

*Candidates are required to answer Group A and
any 5 (five) from Group B to E, taking at least one from each group.*

Candidates are required to give answer in their own words as far as practicable.

**Group – A
(Multiple Choice Type Questions)**

1. Choose the correct alternative for the following: **10 × 1 = 10**
- (i) A step index fiber has a core refractive index 1.5 and cladding refractive index 1.46. Its numerical aperture is
(a) 0.156 (b) 0.244 (c) 0.344 (d) 0.486.
 - (ii) The attenuation caused by Rayleigh scattering is proportional to
(a) $1/\lambda$ (b) $1/\lambda^3$ (c) $1/\lambda^4$ (d) $1/\lambda^6$.
 - (iii) Calculate the energy of the infrared light at $1.55 \mu\text{m}$
(a) 0.5 eV (b) 0.8 eV (c) 1.55 eV (d) 1.8 eV
 - (iv) Which type of fiber has the highest modal dispersion?
(a) Step index single mode (b) Step index multimode
(c) Graded index single (d) Graded index multimode.
 - (v) Which wavelength is most suitable for pumping of EDFA?
(a) $0.85 \mu\text{m}$ (b) $1.3 \mu\text{m}$ (c) $0.98 \mu\text{m}$ (d) $1.55 \mu\text{m}$.
 - (vi) Given that, Ge has a bandgap of 0.67 eV, what is the maximum wavelength that will be absorbed by it?
(a) 7080 nm (b) 4560 nm (c) 1850 nm (d) 1100 nm.
 - (vii) A p-n photodiode, on an average, generates one electro-hole pair per five incident photons at a wavelength of 900 nm. Assuming all the photo-generated electrons are collected, what is the quantum efficiency of the diode?
(a) 20 % (b) 30% (c) 40% (d) 50 %.
 - (viii) What is the standard form of SONET?
(a) Single optical network (b) Single orthogonal network
(c) Synchronous optical network (d) None of above.
 - (ix) The scheme of WDM is similar to
(a) FDM for RF transmission (b) TDM
(c) SDM (d) OTDM.

- (x) On which factors the response of the photodiode depends?
(a) Diffusion time of photo carrier outside the depletion region
(b) Diffusion time of photo carrier inside the depletion region
(c) RC time constant
(d) All of above.

Group- B

2. (a) What are the functions of core and cladding in an optical fiber? Why should their refractive indices be different? What is the importance of the numerical aperture of an optical fiber? *[[CO1](Remember/LOCQ)](Analyse/IOCQ)]*
(b) The velocity of light in the core of the step-index fiber is 2.01×10^8 m/s, and the critical angle at the core-cladding interface is 80° . Determine the numerical aperture and acceptance angle for the fiber in the air. The velocity of light in a vacuum is 3×10^8 m/s. *[[CO1](Evaluate/HOCQ)]*
(2 + 2 + 2) + (3 + 3) = 12
3. (a) Derive the expression for material dispersion in optical fiber. *[[CO1,CO2](Analyse/IOCQ)]*
(b) Define bending loss and connector loss for optical fiber. *[[CO1](Remember/LOCQ)]*
(c) What are the causes of attenuation? *[[CO1,CO2](Analyse/IOCQ)]*
4 + (2 + 2) + 4 = 12

Group - C

4. (a) Describe the working principle of heterojunction LED with a proper band diagram. *[[CO3](Analyse/IOCQ)]*
(b) Describe in brief the internal and external quantum efficiency of LED. *[[CO3](Remember/LOCQ)]*
(c) A Burrus type p-n GaAs LED is forward biased with a current of 100 mA and a voltage of 2 eV. Each emitted photon possess an energy of 1.43 eV, and the refractive index of GaAs is 3.7. The configuration of LED is such that we may neglect back emission and self absorption within the semiconductor. Assuming that internal quantum efficiency 65%. Calculate the internal power efficiency and external power efficiency of the device. *[[CO3](Analyse/IOCQ)]*
4 + 2 + 6 = 12
5. (a) What is population inversion? Find the threshold condition for lasing operation. *[[CO3](Remember/LOCQ)]*
(b) Describe the operation of Injection LASER diode. What is index guiding? *[[CO3](Remember/LOCQ)]*
(3 + 3) + (4 + 2) = 12

Group - D

6. (a) Derive the relation between quantum efficiency and the responsivity of a photodiode. *[[CO4](Analyse/IOCQ)]*

- (b) Discuss the operation of the avalanche photodetector with appropriate diagrams. [[CO4](Remember/LOCQ)]
- (c) An APD has a quantum efficiency of 75% at 900 nm. When illuminated with an optical power of 0.8 μ W at this wavelength. Estimate the multiplication factor of the diode such that it produces an output photocurrent of 10 μ A. [[CO4](Analyze/IOCQ)]
- 4 + 5 + 3 = 12**
7. (a) Explain the principle of operation of WDM with relevant block diagrams. [[CO5](Remember/LOCQ)]
- (b) With the help of energy level diagram, explain the principle of operation of EDFA. [[CO5](Analyze/IOCQ)]
- 5 + 7 = 12**

Group - E

8. (a) What do you mean by SONET? Describe the different layers in SONET. [[CO5](Remember/LOCQ)]
- (b) Explain the frame structure of SONET. [[CO5](Analyze/IOCQ)]
- (c) Name different network topologies. [[CO5](Remember/LOCQ)]
- (2 + 4) + 4 + 2 = 12**
9. Write short notes on (Any two)
- (i) Step index optical fiber.
- (ii) Surface Emitting LED.
- (iii) Raman amplifier. [[CO1,CO3,CO4](Remember/LOCQ)]
- 6 + 6 = 12**

<i>Cognition Level</i>	<i>LOCQ</i>	<i>IOCQ</i>	<i>HOCQ</i>
<i>Percentage distribution</i>	<i>50</i>	<i>43.75</i>	<i>6.25</i>

Course Outcome (CO):

After the completion of the course students will be able to

1. Apply the basic idea of electronics, physics and solid state devices and explain the operation of different components in an optical communication system.
2. Understand the properties of optical fiber and categorize the transmission characteristics of a wave through the optical fiber.
3. Analyze the structure of various optical sources and can classify them according to the performance, efficiency and application.
4. Explain the operation of optical detectors and can analyze the performance parameters of a detector.
5. Recognize the current optical technologies used for long distance communication and their application in optical networks.
6. Solve the problems related to optical fiber communication and can justify the physical significance of the solutions.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*

