

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) Optical fiber communication works on the principle of
 - (a) interference
 - (b) total internal reflection
 - (c) diffraction
 - (d) photo electric effect.
 - (ii) Type of fiber that has the highest modal dispersion.
 - (a) Step index single mode
 - (b) Step index multimode
 - (c) Graded index Single
 - (d) Graded index multimode
 - (iii) Pulse broadening in GI fibers is due to
 - (a) intermodal dispersion
 - (b) intramodal dispersion
 - (c) both (a) and (b)
 - (d) none of these.
 - (iv) Which of the following pairs are suitable for making heterojunction?
 - (a) Si_Ge
 - (b) Si_GaAs
 - (c) GaAs_AlAs
 - (d) GaAs_AlGaAs.
 - (v) The material for making an efficient LED should be
 - (a) an indirect band gap type semiconductor
 - (b) a metal
 - (c) a direct band gap type semiconductor
 - (d) an insulator.
 - (vi) A photoconducting detector can be constructed from
 - (a) an intrinsic semiconductor
 - (b) an extrinsic semiconductor
 - (c) polycrystalline material
 - (d) all of these.
 - (vii) Which of the following detectors give amplified output?
 - (a) p-n photodiode
 - (b) p-i-n photodiode
 - (c) avalanche photodiode
 - (d) photovoltaic photodetector.

- (viii) What are the components of DWDM?
(a) Laser transmitter, highly sensitive receiver (b) EDFA, OADM
(c) Mux, Demux (d) All of above.
- (ix) In SONET, each synchronus transfer signal STS _n is composed of
(a) 2000 frames (b) 4000 frames
(c) 8000 frames (d) 16000 frames.
- (x) The attenuation caused by Rayleigh scattering is proportional to
(a) $1/\lambda$ (b) $1/\lambda^3$ (c) $1/\lambda^4$ (d) $1/\lambda^6$.

Group - B

2. (a) Using simple ray theory, describe the mechanism for the transmission of light within a graded index optical fiber. [(CO1)(Remember/LOCQ)]
- (b) How can you explain the Numerical Aperture (NA) of skew rays is greater than meridional rays? [(CO1,CO2)(Remember/LOCQ Apply/ IQCQ)]
- (c) A silica optical fiber with core diameter large enough to be considered by ray theory analysis has a core refractive index of 1.50 and cladding refractive index of 1.47. Determine (i) the critical angle at the core cladding interface (ii) the NA for the fiber (iii) the acceptance angle in air for fiber.
[(CO1,CO2, CO6)(Evaluate/HOCQ)]
3 + 3 + 6 = 12
3. (a) Differentiate between single mode optical fiber and multimode optical fiber. Derive the material dispersion of single mode step index fiber.
[(CO1,CO2)(Analyze/IOCQ)]
- (b) A cylindrical step index fiber with a core diameter of 7.2 μm and a relative index difference of 1% is operating at a wavelength of 1.55 μm . If the core refractive index is 1.46, estimate: (i) the normalized frequency for the fiber (ii) the number of guided modes.
[(CO1,CO2,CO6)(Evaluate/HOCQ)]
(2 + 4) + 6 = 12

Group - C

4. (a) What do you mean by external quantum efficiency? Identify the factors influence external quantum efficiency of LED. Compare the basic features of surface emitting and edge emitting LED?
[(CO2, CO3)(Remember/LOCQ, Analyze/IOCQ)]
- (b) A Burrus type p-n (r.i. of 3.4 and band gap 1.36 eV) LED is coupled to a SIF using epoxy resin (r.i. of 1.45). The radiative and non-radiative recombination life times be 50 ns and 100ns respectively. The LED is forward biased with a current of 120 mA and a voltage of 3V. Estimate,
(i) Internal power efficiency
(ii) External power efficiency. [(CO3,CO6)(Analyze/IOCQ, Evaluate/HOCQ)]
(2 + 2 + 2) + 6 = 12

5. (a) Discuss the mechanism of optical feedback to provide oscillation and hence amplification within the laser. Indicate how this provides a distinctive spectral output from the device. [(CO1,CO3)(Remember/LOCQ, Analyze/IOCQ)]
- (b) A ruby laser contains a crystal of length 4cm with a refractive index of 1.78. The peak emission wavelength from the device is 0.55 μm . Determine the number of longitudinal modes and their frequency separation. [(CO3,CO6)(Evaluate/HOCQ)(Analyze/IOCQ)]
- 6 + 6 = 12**

Group - D

6. (a) Explain the working principle of p-i-n photodiode with diagram. [(CO5)(Understand/LOCQ)]
- (b) A silicon p-i-n photodiode has an intrinsic region with a width of 20 μm and a diameter of 500 μm in which the drift velocity of electrons 10^5 m/s. When the permittivity of device material is 10.5×10^{-13} F/cm, calculate (i) the drift time of carriers across the depletion region; (ii) the junction capacitance of photodiode. [(CO5,CO6)(Evaluate/HOCQ)(Analyze/IOCQ)]
- 6 + 6 = 12**
7. (a) Explain the principle of operation of WDM with relevant block diagrams. [(CO5)(Understand/LOCQ)]
- (b) With the help of energy level diagram, explain the principle of operation of EDFA. Compare the advantages of EDFA over SOA. [(CO5)(Understand/LOCQ Analyze/IOCQ)]
- 4 + (4 + 4) = 12**

Group - E

8. (a) Outline the features of LAN, MAN and WAN optical fiber network topologies in detail. [(CO5)(Understand/LOCQ)]
- (b) Describe the physical layer of SONET. What is SDH? [(CO5)(Analyze/LOCQ)]
- 6 + 6 = 12**
9. Write short notes on any three of the following: **(4 × 3) = 12**
- (i) Step index optical fiber.
 - (ii) Avalanche Photodetector
 - (iii) FDDI
 - (iv) PON (Passive Optical Network). [(CO5)(Understand/LOCQ)]

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	38.54	42.71	18.75

Course Outcomes (CO):

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