FIBER OPTIC COMMUNICATION
(ECEN 4142)

Time Allotted : 3 hrs   **Full Marks : 70**

Figures out of the right margin indicate full marks.

*Candidates are required to answer Group A and
<u>any 5 (five)</u> from Group B to E, taking <u>at least one</u> 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)   The higher the refractive index number of a medium
          (a) the higher the speed of light
          (b) the lower the speed of light
          (c) has no effect on the speed of light
          (d) the shorter the wavelength propagation.

    (ii) Light is guided within the core of a step-index fiber by
          (a) refraction at the core-air interface
          (b) total internal reflection at the core-cladding interface
          (c) total internal reflection at the outer surface of the cladding
          (d) change in the speed of light within the core.

    (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) The material for making an efficient LED should be
          (a) an indirect band gap type semiconductor
          (b) a direct band gap type semiconductor
          (c) a metal
          (d) an insulator.

    (v)   Which of the following pairs are suitable for making a heterojunction?
          (a) Si and Ge   (b) Si and GaAs
          (c) GaAs and AlAs   (d) GaAs and GaAlAs.

    (vi) A photoconducting detector can be constructed from
          (a) an intrinsic semiconductor   (b) an extrinsic semiconductor
          (c) polycrystalline material   (d) all of these.

    (vii) For a photo-diode with responsivity of 0.50 A/W and optical power of about 18µW,
          what would be the value of generated photocurrent?
          (a) 3 µA   (b) 6 µA   (c) 9 µA   (d) 12 µA.

(viii) A 1x 10 coupler has an input signal 0dBm. What is the power level at each output port?
    (a) 0 dBm   (b) -1 dBm   (c) -3 dBm   (d) -10 dBm.

(ix) Gain in EDFA depends on the following factors
    (a) Doping concentration   (b) Length of the doped fiber
    (c) Pump power   (d) All of these.

(x) Which of the following is a non-linear inelastic process?
    (a) SRS   (b) SPM   (c) CPM   (d) FWM.

Group- B

2. (a) Explain the phenomenon of ray propagation in Graded-Index optical fibers drawing its refractive index profile.   [(CO1, CO2)(Understand/LOCQ)]
  (b) Derive expressions for acceptance angle and numerical Aperture, highlighting their relationship.   [(CO1, CO2)(Analyze/IOCQ)]
  (c) Calculate the refractive indices of core and cladding of an optical fiber with numerical aperture of 0.33 and their relative refractive index difference of 0.02. Find out the acceptance angle and critical angle.   [(CO2)(Evaluate/HOCQ)]
                                    4 + 4 + 4 = 12

3. (a) What is Attenuation of optical fibers. Differentiate between Rayleigh scattering and Mie scattering   [(CO1, CO2)(Understand/LOCQ)]
  (b) A symmetric step –index (SI) planar waveguide is made of glass with n_1=1.5 and n_2= 1.49. The thickness of the guide layer is 9.83 μm and guide is excited by a source of wavelength λ=0.85 μm. What is the range of the propagation constants? What is the maximum number of modes supported by the guide?   [(CO2)(Evaluate/HOCQ)]
  (c) Derive the intermodal dispersion of multimode step index fiber. [(CO2)(Apply/IOCQ)]
                                    (2 + 2) + 4 + 4 = 12

Group - C

4. (a) What do you mean by external quantum efficiency? Identify the factors influence external quantum efficiency of LED.   [CO3](Analyze/IOCQ)]
  (b) Draw and explain the working principle of edge emitting LED with proper diagram.   [(CO3)(Apply/IOCQ)]
  (c) Calculate the injection efficiency of a GaAs diode in which Na=10^{23} m^{-3} and N_d=10^{21}m^{-3}. Assume that at RT = 300 k, μ_e=0.85m^2 V^{-1}s^{-1}, μ_h=0.04m^{2}V^{-1}s^{-1}, and $L_e \approx L_h$.   [(CO3)(Evaluate/HOCQ)]
                                    4 + 4 + 4 = 12

5. (a) What is meant by population inversion?   [(CO1, CO3)(Understand/LOCQ)]
  (b) Derive Einstein relationship connecting absorption, stimulated emission and spontaneous emission.   [(CO1, CO3)(Analyze/IOCQ)]
  (c) Compare LASER and LED as source in fiber optic communication system (designed especially for commercial purposes).   [(CO3)(Analyze/IOCQ)]
                                    4 + 4 + 4 = 12

Group – D

6. (a) What is the significance of intrinsic layer in PIN diodes? Define impact ionization for avalanche photodiode. [(CO4)(Analyze/IOCQ)]
    (b) Derive the relation between quantum efficiency and responsivity of a photodiode. [(CO4)(Analyze/IOCQ)]
    (c) With the help of energy level diagram, explain the principle of operation of EDFA. [(CO4, CO6)(Analyze/IOCQ)]
    4 + 4 + 4 = 12

7. (a) Draw and explain unidirectional and bidirectional multichannel fiber optic communication system using DWDM with suitable block diagram. [(CO5)(Analyse/LOCQ)]
    (b) Explain the basic principle of SOA. What requirement must be met so that a semiconductor DH functions efficiently as an optical amplifier? [(CO5)(Analyse/IOCQ)]
    (4 + 2) + (2 + 4) = 12

Group – E

8. (a) Outline the features of LAN, MAN and WAN optical fiber network topologies in detail. [(CO5)(Analyse/IOCQ)]
    (b) Differentiate Bus, Star and Ring optical fiber network topologies. [(CO5)(Understanding/LOCQ)]
    6 + 6 = 12

9. Write short notes on any three of the following: **(3 × 4) = 12**
    (i) Single Mode Optical Fiber
    (ii) Dense Wavelength Division Multiplexing (DWDM)
    (iii) Surface Emitting LED
    (iv) Graded Index Optical Fiber. [(CO2, CO3, CO4)(Remember /LOCQ)]

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	37.5	50	12.5

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