

**OPTICAL FIBER COMMUNICATION
(ECEN 4223)**

Time Allotted : 2½ hrs

Full Marks : 60

Figures out of the right margin indicate full marks.

*Candidates are required to answer Group A and
any 4 (four) from Group B to E, taking one from each group.*

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

Group – A

1. Answer any twelve:

12 × 1 = 12

Choose the correct alternative for the following

- (i) Given that, *Ge* has a bandgap of 0.7 eV, what is the maximum wavelength that will be absorbed by it?
 - (a) 1100 nm
 - (b) 1130 nm
 - (c) 1850 nm
 - (d) 4560 nm
- (ii) Multimode step index fiber has
 - (a) Large core diameter & large numerical aperture
 - (b) Large core diameter and small numerical aperture
 - (c) Small core diameter and large numerical aperture
 - (d) Small core diameter & small numerical aperture
- (iii) For a photo-diode with responsivity of 0.50 A/W & 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
- (iv) Type of fiber that has the minimum modal dispersion.
 - (a) Step index single mode
 - (b) Step index multimode
 - (c) Graded index multimode
 - (d) None of above
- (v) In spontaneous emission, the light source in an excited state undergoes the transition to a state with
 - (a) Higher energy
 - (b) Moderate energy
 - (c) Lower energy
 - (d) All of these

- (vi) The wavelength that Si can absorb is $1.12\mu\text{m}$. What is the approximate band gap of Si?
 - (a) 1.1 eV
 - (b) 1.4 eV
 - (c) 1.74 eV
 - (d) 2.3 eV
- (vii) The scheme of WDM is similar to
 - (a) FDM for RF transmission
 - (b) TDM
 - (c) SDM
 - (d) OTDM
- (viii) How many numbers of frame are sent per second by SONET ?
 - (a) 1000
 - (b) 2000
 - (c) 4000
 - (d) 8000
- (ix) EDFA operates at the following windows
 - (a) Around 1300 nm
 - (b) Around 1550 nm
 - (c) Around 980 nm
 - (d) None
- (x) Which of the following materials is not suitable for making an LED?
 - (a) GaAs
 - (b) Si
 - (c) InGaAsP
 - (d) AlGaAs

Fill in the blanks with the correct word

- (xi) _____ material is not suitable for making an LED.
- (xii) The Type of fibre refers to the abrupt of change in refractive index from core to cladding is called as _____.
- (xiii) A step index fiber has a core refractive index 1.5 and cladding refractive index 1.46. Its numerical aperture is _____.
- (xiv) The emission process involved in the lasing action in a two level laser system is _____.
- (xv) The attenuation caused by Rayleigh scattering is proportional to_____.

Group - B

2. (a) A step-indexed fiber has a core and cladding refractive indices of 1.5 & 1.4 respectively and supports an optical signal of 820 nm. Calculate the core radius & NA for a single mode propagation. [[C01,C02, C06](Evaluate/HOCQ)]]
- (b) What are Acceptance angle and Numerical Aperture. Derive expressions for acceptance angle & numerical aperture, highlighting their relationship. [[C01,C02] (Understand/LOCQ) Apply/IOCQ]]]

- (c) Why optical communication is preferred over other conventional electrical Communication?
[[CO1](Remember/LOCQ)]
4 + 4 + 4 = 12
3. (a) Write down the difference between single mode optical fiber and multimode optical fiber.
[[CO2](Remember/LOCQ)]
- (b) Explain intermodal dispersion and material dispersion in optical fibers. How can they be minimized?
[[CO2](Apply/LOCQ)]
- (c) 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.
[[CO2](Evaluate/HOCQ)]
4 + 4 + 4 = 12

Group - C

4. (a) With neat diagram, explain the operation of surface-emitting double hetero structure LED. Also mention its advantages.
[[CO3](Analyse/IOCQ)](Understand/LOCQ)]
- (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 internal power efficiency and external power efficiency.
[[CO3](Apply/IOCQ)]
6 + 6 = 12
5. (a) Derive Einstein relationship connecting absorption, stimulated emission and spontaneous emission.
[[CO3](Analyse/IOCQ)]
- (b) Compare LASER and LED as source in fiber optic communication system (designed especially for commercial purposes).
[[CO3](Remember/LOCQ)]
- (c) A double heterostructure GaAs/GaAlAs ILD operating at 850nm has a cavity length of 500 μm , and refractive index of the cavity is 3.7. How many longitudinal modes are emitted? What is the mode separation in terms of frequency (Hz) and wave length?
[[CO3](Evaluate/HOCQ)]
5 + 3 + 4 = 12

Group - D

6. (a) Establish the relation between quantum efficiency and responsivity of a photodiode.
[[CO5](Analyse/IOCQ)]
- (b) Discuss the operation of Avalanche photo detector with appropriate diagram.
[[CO4](Remember/LOCQ)]
- (c) An APD has a quantum efficiency of 75% at 900nm. When illuminated with optical power of 0.8 μW at this wavelength, it produces an output photocurrent of 10 μA . Calculate the multiplication factor of the diode.
[[CO2](Analyse/HOCQ)]
4 + 5 + 3 = 12

7. (a) Distinguish between WDM and DWDM. [[C05](Analyse/IOCQ)]
 (b) What are the characteristics of optical amplifier? [[C05](Remember/LOCQ)]
 (c) With the help of energy level diagram, explain the principle of operation of EDFA. [[C05](Apply/IOCQ)]
4 + 3 + 5 = 12

Group - E

8. (a) What are the three topologies used for fiber optics network? Describe the different optical networks. [[C05,C06](Analyse/IOCQ)]
 (b) What is SONET? What are the different layers in SONET? Describe the physical layers of SONET. [[C05,C06](Apply/IOCQ)]
(3 + 3) + 6 = 12
9. Write short notes on **any three** of the following
 (i) SDH
 (ii) Dense Wavelength Division Multiplexing (DWDM)
 (iii) Surface Emitting LED
 (iv) FSO. [[C03, C05, C06](Remember/LOCQ)]
(3 × 4) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	42.7	41.7	15.6

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.*