FIBER OPTIC COMMUNICATION
(ECEN 4142)

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) 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.

(ii) 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) 0.344 (c) 0.244 (d) 0.486.

(iii) The attenuation caused by Rayleigh scattering is proportional to
(a) $1/\lambda$ (b) $1/\lambda^3$ (c) $1/\lambda^4$ (d) $1/\lambda^6$.

(iv) The power in the LED reaches maximum at
(a) Eg + Kt (b) KT (c) Eg (d) After Eg + kT.

(v) What type of emission process is used in a laser?
(a) Spontaneous emission (b) Stimulated emission
(c) Thermal emission (d) Radiative recombination.

(vi) Which property of laser light allows it to be used in fiber optic communications?
(a) High power consumption (b) Incoherence
(c) High divergence (d) High coherence and monochromaticity.

(vii) Which of the following tunable filters is most suitable for DWDM?
(a) Mach-Zehnder interferometer (b) Fabry-Perot filters
(c) Acousto-optic tunable filters (d) Fiber Bragg gratings.

(viii) The greatest wavelength of photons that a photodiode built of a semiconductor with a bandgap of 2eV can detect is around
(a) 620 nm (b) 700 nm (c) 740 nm (d) 1240 nm.

(ix) In which configuration, the ring and star topologies are combined?
(a) Mesh (b) Fringe (c) Data (d) Singular.

(x) Which of the following is NOT a function of the SONET transport overhead?
(a) Monitoring network performance (b) Providing encryption for data
(c) Error detection (d) Synchronization.

Fill in the blanks with the correct word

(xi) The phenomenon that allows light to be guided through an optical fiber is called _____.

(xii) _____ is the type of optical amplifier commonly used in long-distance fiber optic communication systems.

(xiii) _____ refers to the weakening of the optical signal as it travels through the fiber.

(xiv) In an optical fiber, _____ occurs when different modes of light travel at different speeds, leading to pulse broadening.

(xv) _____ is the type of noise that arises due to the random nature of photon detection at the receiver.

Group - B

2. (a) Why optical communication is preferred over other conventional electrical Communication? *[(CO1)(Remember/LOCQ)]*

(b) What is Acceptance angle and Numerical Aperture? Derive expressions for Acceptance angle & Numerical Aperture, highlighting their relationship. *[(CO2)(Remember/LOCQ)]*

(c) A step-indexed fiber has a core and cladding refractive indices of 1.48 & 1.46 respectively and supports an optical signal of 820 nm. Calculate the core radius & NA for a single mode fiber. *[(CO2)(Evaluate/HOCQ)]*

2 + 6 + 4 = 12

3. (a) What is total internal reflection? Why is it necessary to meet the condition of total internal reflection at the core–cladding interface? *[(CO2)(Analyse/IOCQ)]*

(b) A step-index fiber has an acceptance angle of 20° in air and a relative refractive index difference of 3%. Estimate the NA and the critical angle at the core–cladding interface. *[(CO2)(Evaluate/HOCQ)]*

6 + 6 = 12

Group - C

4. (a) Describe the operation of Injection LASER diode. [(*CO3)(Understand/LOCQ)]*

(b) A typical gas laser is emitting a spectral line centred at 632.8nm, whose gain curve has a half width of 3.003×10^{-3}nm. If the cavity length of the laser is 20cm. Calculate the number of longitudinal modes excited. Take the refractive index inside the gas medium to be 1. *[(CO3)(Apply/IOCQ)]*

6 + 6 = 12

5. (a) What is population inversion? Find the threshold condition for lasing operation. *[CO1,CO3][Remember/LOCQ, Analyze/IOCQ]]*

(b) Explain the operation principle of edge emitting laser and justify its advantages with suitable diagram. *[CO3,] [Analyze/IOCQ]*

(c) Estimate the mirror reflectivities needed in a GaAs-AlGaAs double heterostructure laser in which the fabry perot cavity length is 20μm and cavity loss is $10cm^{-1}$. The optical confinement factor is unity and threshold gain in the medium is 10^3cm^{-1}. *[(CO3,CO6)(Evaluate/HOCQ)]*

5 + 3 + 4 = 12

Group - D

6. (a) Describe the working principle of avalanche photo detector. Define responsivity and efficiency of a photo detector filter. *[(CO4)(Understand/LOCQ)]*

(b) A p-n photodiode has a quantum efficiency of 70% for photons of energy 1.52×10^{-19} J. Calculate the wavelength at which the diode is operating. (1 J = 6.24×10^{18} eV). Also find the optical power required to achieve a photocurrent of 3 μA. *[(CO4)(Evaluate/HOCQ)]*

6 + 6 = 12

7. (a) Prove that $R = \frac{\eta e \lambda}{hc}$ where R = responsivity, e = electronic charge, h = plank's constant, λ = wavelength and c = wavelength of light. *[(CO5)(Analyse/IOCQ)]*

(b) Explain the working principle of SOA with a suitable diagram. *[(CO5)(Remember/LOCQ)]*

(c) What do you mean by NEP of a photodetector? *[(CO5)(Remember/LOCQ)]*

4 + 5 + 3 = 12

Group - E

8. (a) Describe the differences between SONET and SDH in terms of their physical layer implementation. What are the key variations in terms of framing, data rates, and signal hierarchy? *[(CO5)Understand/LOCQ](Analyse/HOCQ)]*

(b) Describe the process of multiplexing in SONET/SDH. How does the physical layer handle multiple lower-rate signals within a higher-rate signal? *[(CO5)Understand/LOCQ] (Analyse/HOCQ)]*

6 + 6 = 12

9. (a) Illustrate the working of a Time Division Multiplexing (TDM) system in a PON. How does it manage multiple users? *[(CO5)(Analyse/HOCQ)]*

(b) What is the importance of the splitter in a PON network, and how does it affect network performance? *[(CO5)(Remember/LOCQ) (Apply/IOCQ)]]*

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	35.42	31.25	33.33