

OPTICAL FIBRE 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) In a step-index fiber, what is the cut-off frequency of the LP₁₁ mode?
(a) 0.0 (b) 2.405 (c) 3.832 (d) 5.520
- (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) 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.
- (iv) A ray of light is passing from a silica glass of refractive index 1.48 to another silica glass of refractive index 1.46. What is the range of angles (measured with respect to the normal to the interface) for which this ray will undergo total internal reflection?
(a) 0°–80° (b) 81°–90°
(c) 90°–180° (d) 180°–360°
- (v) The power in the LED reaches maximum at
(a) $E_g + kT$ (b) kT
(c) E_g (d) After $E_g + kT$
- (vi) In a laser, what role does the optical cavity play?
(a) Generates electricity
(b) Amplifies light through repeated reflections
(c) Cools the laser medium
(d) Absorbs excess light
- (vii) Gain in EDFA depends on the following factors
(a) Doping concentration (b) Length of the doped fiber
(c) Pump power (d) All of these.

- (viii) 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 %
- (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 the data rate of an OC-3 signal in SONET?
 (a) 51.84 Mbps (b) 155.52 Mbps
 (c) 622.08 Mbps (d) 1.244 Gbps

Fill in the blanks with the correct word

- (xi) _____ is the type of dispersion caused by the variation in the speed of light with wavelength in an optical fiber.
- (xii) _____ is the type of optical amplifier commonly used in long-distance fiber optic communication systems.
- (xiii) The device used to split an optical signal into multiple paths is called a _____.
- (xiv) The transmission of light signals over long distances in an optical fiber can be enhanced by using _____ to regenerate the signal.
- (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. [[CO6](Evaluate/HOCQ)]
2 + 6 + 4 = 12
3. (a) Explain intermodal dispersion and material dispersion in optical fibers. How can they be minimized? [[CO2](Analyse/IOCQ)]
- (b) What is meant by dispersion-shifted fibers? A step index single-mode optical fiber exhibits material dispersion of $6\text{ps nm}^{-1}\text{ km}^{-1}$ at an operating wavelength of $1.55\text{ }\mu\text{m}$. Assume that $n_1=1.45$ and $\Delta=0.5\%$. Estimate the diameter of the core needed to make the total dispersion of the fiber zero at this wavelength. [[CO6](Evaluate/HOCQ)]
5 + 7 = 12

Group - C

4. The Fresnel reflection coefficient at a fiber core of refractive index n_1 is given approximately from the classical Fresnel formulas by:

$$r = \left(\frac{n-1}{n+1} \right)^2$$

- (i) Estimate the optical loss due to Fresnel reflection at a fiber core from GaAs each of which have refractive indices of 1.5 and 3.6 respectively.
- (ii) Calculate the optical power coupled into a step index fiber of 200 μm core diameter with an NA of 0.3 from a GaAs surface-emitting LED with an emission diameter of 90 μm and a radiance of 40 $\text{W sr}^{-1} \text{cm}^{-2}$. Comment on the result.
- (iii) Estimate the optical power emitted into air for the device in (ii).

[[C03](Apply/IOCQ)]Analyse/HOCQ]]

(4 + 4 + 4) = 12

- 5. (a) What do you mean by external quantum efficiency? Identify the factors influence external quantum efficiency of LED.
 - (b) Compare the basic features of surface emitting and edge emitting LED? Explain the working principle of edge emitting LED with proper diagram? What is responsivity of an LED?
- Measure the output power from an n+-p GaAs LED with an electron current of 3.0 mA and efficiency $\eta_0=50\%$. Also calculate responsivity if $\lambda=1\mu\text{m}$.

[[C03, C06]]Analyse/IOCQ, Remember/LOCQ, Evaluate / HOCQ]]

3 + (2 + 3 + 1 + 3) = 12

Group - D

- 6. (a) Describe the working principle of avalanche photo detector. Define responsivity and efficiency of a photo detector.
- (b) A p-n photodiode has a quantum efficiency of 70% for photons of energy $1.52 \times 10^{-19} \text{ J}$. Calculate the wavelength at which the diode is operating. ($1 \text{ J} = 6.24 \times 10^{18} \text{ eV}$). Also find the optical power required to achieve a photocurrent of 3 μA .

[[C04](Analyse/IOCQ)]

[[C06](Evaluate/HOCQ)]

6 + 6 = 12

- 7. (a) Explain the principle of operation of WDM with relevant block diagrams.
- (b) With the help of energy level diagram, explain the principle of operation of EDFA. Compare the advantages of EDFA over SOA.

[[C05](Understand/LOCQ)]

[[C05](Analyse/IOCQ)]

5 + 7 = 12

Group - E

- 8. (a) Outline the features of LAN, MAN and WAN optical fiber network topologies in Detail.
- (b) Differentiate Bus, Star and Ring optical fiber network topologies.

[[C05](Understand/LOCQ)]

[[C05](Understand/LOCQ)]

6 + 6 = 12

9. Write short notes on any three of the following:

(i) SONET Frame structure

(ii) FSO

(iii) Fabry -Perot Filters

(iv) Raman amplifier.

[[CO5] Understand /LOCQ]

(4 × 3) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	38.5	26	35.5