B.TECH/ECE/7TH SEM/ECEN 4142/2021

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

(ii) Type of fiber that has the highest modal dispersion.
(a) step index single mode (b) step index multimode
(c) graded index Single mode (d) graded index multimode.

(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 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) Lasing action in a two level laser system is due to
(a) Spontaneous emission process
(b) Stimulated emission process
(c) Spontaneous and Stimulated emission process
(d) none of the above.

(vi) 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%

(vii) The wavelength that Si can absorb is 1.12μm. What is the approximate band gap of Si.
(a) 1.1eV (b) 1.4eV (c) 1.74eV (d) 2.3 eV.

(viii) 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.

(ix) EDFA operates at the following window/windows
(a) Low dispersion window (around 1.3 μm)
(b) Low attenuation window (around 1.55 μm)
(c) Both the windows
(d) None of these.

(x) In SONET, STS-1 level of electrical signalling has the data rate of
(a) 51.84 Mbps (b) 155.52 Mbps
(c) 466.56 Mbps (d) none of the mentioned.

Group – B

2. (a) What are the functions of core and cladding in an optical fiber? Explain how the multimode optical rays are propagated through the Graded-Index optical fiber with a suitable diagram. [(CO1,CO2)(Remember/LOCQ , 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)(Analyze/IOCQ, Evaluate/HOCQ, Apply/IQCQ)]

(2 + 3) + (2 + 4 + 1) = 12

3. (a) Explain intermodal dispersion and material dispersion in optical fibers. How can they be minimized? [(CO1,CO2)(Analyze/IOCQ, Remember/LOCQ)]

(b) What is meant by dispersion-shifted fibers? A step index single-mode optical fiber exhibits material dispersion of 6 ps nm^{-1} km^{-1} at an operating wavelength of 1.55 μm. Assume that n_1 =1.45 and Δ = 0.5%. Estimate the diameter of the core needed to make the total dispersion of the fiber zero at this wavelength. [(CO1,CO2,CO6) (Remember/LOCQ, Evaluate / HOCQ)]

(3 + 2) + (2 + 5) = 12

Group – C

4. (a) With neat diagram, explain the operation of surface-emitting double hetero structure LED. Also mention its advantages. [(CO1, CO3)(Analyze/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,
(i) Internal power efficiency
(ii) External power efficiency. [(CO3, CO6)(Evaluate/HOCQ)]

4 + 2 + 6 = 12

5. (a) What do you mean by external quantum efficiency? Identify the factors influence external quantum efficiency of LED.
[(CO3)(Remember/LOCQ, Analyze/IOCQ)]

(b) In an InGaAsP / InP LED, internally generated optical power is 30 mW at 1550nm. Estimate the (i) Internal Quantum Efficiency (ii) Internal Power Efficiency (iii) External Power Efficiency at InP (r.i = 3.5)-Air interface. Assume, the drive current is 39mA and 1.6V p.d. is applied across the device. [(CO3,CO6)(Evaluate/HOCQ)]

(c) Compare the basic features of surface emitting and edge emitting LED? [(CO3, CO6)(Analyze/IOCQ)]

(1 + 2) + 6 + 3 = 12

Group – D

6. (a) Discuss the operation of *p-i-n* photo detector with appropriate diagrams.
[(CO1, CO4)(Analyze/IOCQ)]

(b) Derive the relation between quantum efficiency and responsivity of a photodiode. Photons of wavelength 0.8 μm are incident on a p-n photodiode at a rate of 5×10^{10} s^{-1} & on average the electrons are collected at the terminals of the diode at the rate of 1.5×10^{10} s^{-1}. Specify the quantum efficiency and responsivity of the photodiode. [(CO4, CO6)(Analyze/IOCQ, Evaluate/HOCQ)]

5 + (3 + 4) = 12

7. (a) Distinguish between WDM and DWDM. What is the base frequency and channel spacing specified by ITU for DWDM?
[(CO5), Understand/LOCQ, Remember/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), (Analyze/IOCQ), (Understand /LOCQ)]

(4 + 2) + (4 + 2) = 12

Group – E

8. (a) What are the different layers in SONET? Explain the frame structure of SONET.
[(CO5)(Understand/LOCQ)]

(b) Outline the features of basic optical fiber network topologies.
[(CO5)(Analyse/IOCQ)]

(2 + 4) + 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	30.2 %	37.5%	32.3%

Course Outcome (CO):

After completing the course the student 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

Department & Section	Submission link:
ECE_I	https://classroom.google.com/c/NDA1Mzk0MTM5MDI2/a/NDYzOTg1ODk0MTEy/details
ECE_II	https://classroom.google.com/w/NDA1MzIyMzE1Mjcx/tc/MjI3NzgyNTU4Mzkw