## Group – E

8. (a) What is SONET? What are the different layers in SONET? Describe the physical layers of SONET.

   (b) Describe the different optical networks.

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

9. Write short notes on any three of the following:
   (i) Single Mode Optical Fiber
   (ii) Distributed Feedback LASER
   (iii) Surface Emitting LED
   (iv) Graded Index Optical Fiber.

**(3 × 4) = 12**





# FIBER OPTIC COMMUNICATION
# (ECEN 3241)

**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) An impulse is launched into one end of a 30km optical fiber with a rated total dispersion of 20nS/Km. What will be the width of the pulse at the other end?
   (a) 20nS (b) 100nS (c) 300nS (d) 600nS.

   (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 LED should be
   (a) an indirect band gap type semiconductor
   (b) 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) Given GaAs has a band gap of 1.43eV. What is the wavelength that is emitted by GaAs LED?
   (a) 0.867 μm (b) 0.970 μm (c) 0.789 μm (d) 0.660 μm.

(vii) The responsivity of a given p-i-n diode is 0.5 $Aw^{-1}$ for a wavelength of 1 μm. An incident optical power of 0.2 μw of this wavelength strikes the p-i-n diode. What is the output photo current?
(a) 0.1 μA (b) 1 μA (c) 10 μA (d) 1A.

(viii) Which of the following detectors give amplified output?
(a) p-n photodiode (b) p-i-n photodiode
(c) avalanche photodiode (d) photovoltaic photodetector.

(ix) EDFA operates at which of 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? Why should their refractive indices be different? What is the importance of the Numerical Aperture of an optical fiber?

(b) Draw the Electric field distribution for the first three modes in a planar waveguide. Calculate the maximum thickness of the guide slab of a symmetrical planar waveguide so that it supports the first 10 modes. Take $n_1 = 3.6$, $n_2 = 3.58$ and $\lambda = 90$ μm. Also calculate the maximum and minimum values of the propagation constant β.

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

3. (a) Explain the phenomenon of propagation of optical signal through a Graded Indexed Optical Fiber.

(b) A step-index fiber has a numerical aperture of 0.17 and a core diameter of 100 μm. Determine the normalized frequency parameter of the fiber when light of wavelength 0.85 μm is transmitted through it. Also estimate the number of guided modes propagating in the fiber.

(c) Obtain the following expression for material dispersion parameter

$$D_m = \frac{\lambda}{c}\left|\frac{d^2 n}{d\lambda^2}\right|$$

where the symbols have their usual meaning.

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





## Group – C

4. (a) Derive Einstein co-efficient for two level laser system.

(b) Explain with suitable diagram the operation principle of quantum well laser. What do you mean by modes of a laser?

(c) Calculate the mirror reflectivities needed in a GaAs-AlGaAs double heterostructure laser in which the fabry perot cavity length is 20 μm and cavity loss is $10cm^{-1}$. The optical confinement factor is unity and threshold gain in the medium is $10^3 cm^{-1}$.

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

5. (a) Describe the working principle of heterojunction LED with proper band diagram.

(b) Describe in brief the internal and external quantum efficiency of LED.

(c) A Burrus type p-n GaAs LED is forward biased with a current of 120mA and a voltage of 1.5eV. Each emitted photon possess an energy of 1.43eV, and refractive index of GaAs is 3.7. The configuration of LED is such that we may neglect back emission and self absorption within semiconductor. Assuming that internal quantum efficiency 60% calculate the internal power efficiency and external power efficiency of the device.

**4 + 4 + 4 = 12**

## Group – D

6. (a) Discuss the operation of *p-i-n* photo detector with appropriate diagrams.

(b) Derive the relation between quantum efficiency and responsivity of a photodiode.

(c) Photons of wavelength 0.8 μm are incident on a p-n photodiode at a rate of $5 \times 10^{10}$ $s^{-1}$ and on average the electrons are collected at the terminals of the diode at the rate of $1.5 \times 10^{10}$ $s^{-1}$. Calculate the quantum efficiency and responsivity of the photodiode.

**5 + 4 + 3 = 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.

**5 + 7 = 12**