Group – E

8. (a) Explain with a basic block diagram a fiber optic communication system.

   (b) If the step index fiber has a core of refractive index 1.5, a cladding of refractive index 1.48 and a core diameter of 100 μm, calculate:
   (i) NA of the fiber
   (ii) Angles α_m, θ_m, φ_c
   (iii) Pulse broadening per unit length due to multipath dispersion
   (iv) What are the minimum and maximum number of reflections per meter for the rays guided by it?

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

9. (a) What do you mean by Kerr and Pockels effect? How can the amplitude of the optical signal be modulated for longitudinal electro optic modulator?

   (b) Calculate the change in refractive index due to the longitudinal electro-optic effect for a 1 cm wide KDP crystal for a applied voltage of 5 KV. If the wavelength of the light being propagated through the crystal is 550 μm, calculate the net phase shift between two polarization components after they emerge from the crystal also calculate V_π for the crystal.
   Sketch and explain Mach–Zehnder interferometric sensor.

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

OPTO ELECTRONICS AND FIBER OPTICS
(AEIE 3233)

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 of core with refractive index 1.50 and a cladding with a refractive index of 1.46 has its numerical aperture as
   (a) 0.156 (b) 0.224 (c) 0.344 (d) 0.486.

   (ii) A LED is emitting a mean wave length 0.90μm and its spectral width 18 nm. What is its spectral half width?
   (a) 0.02 (b) 0.05 (c) 0.90 (d) 18.

   (iii) Which of the following is not suitable for making an LED?
   (a) GaAs (b) Si (c) InGaAsP (d) GaAlAs.

   (iv) A photo conducting detector can be constructed from
   (a) an intrinsic semiconductor (b) an extrinsic semiconductor
   (c) polycrystalline material (d) all of the above.

   (v) CO_2 laser is
   (a) an atomic laser (b) a molecular laser
   (c) an ionic laser (d) an excimer laser.

   (vi) What kind of change can be measured by a-fiber interferometer
   (a) intensity (b) phase
   (c) wavelength shift (d) all of the above.

   (vii) The responsivity of a given p-i-n diode is 0.5 AW^{-1} for a wave length 1 μm. What is the output photo current when optical power of 0.2 μW at this wavelength incident on it
   (a) 0.1 μA (b) 1 μA (c) 10 μA (d) 1 A.

(viii) Which of the following measurands can not be measured by a microbent sensor?
(a) displacement (b) temperature
(c) pressure (d) electric current.

(ix) In a longitudinal electro-optic modulator, half wave voltage is that voltage which introduces the following phase shift between two polarization component.
(a) π/4 (b) π/2 (c) π (d) 2π.

(x) If two optical fibers with different diameters are to be spliced, which of the following mechanical spices will be most suitable?
(a) Snug tube splice (b) Loose tube splice
(c) Spring groove splice (d) V-groove splice.

Group – B

2. (a) What do you mean by quantum efficiency and responsivity of an Opto-electronics detector?

(b) A p-n photodiode has a quantum efficiency of 70% for photon of energy $1.52*10^{-19}$ J.
Calculate
(i) the wavelength at which the diode is operating
(ii) the optical power required to achieve a photocurrent of 3 μA when the wavelength of incident photon is that calculated in part (a).

(3 + 3) + (3 + 3) = 12

3. (a) What are the factors responsible for making the responsivity versus wavelength for a practical si diode deviate from a ideal curve? How can the quantum efficiency of such a diode be improved?

(b) A p-i-n photodiode, on an average, generates one electron-hole pair per two incident photons at a wavelength of 0.85 μm. Assuming all the photo generated electrons are collected, calculate:
(i) the quantum efficiency of the diode
(ii) maximum possible band gap energy (in eV) of the semiconductor, assuming that the incident wavelength to be a long wavelength cut-off
(iii) mean output photo current when the incident optical power is 10 μw.

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

Group – C

4. (a) What are homo-junction and heterojunction? Discuss unique properties of P-n-N, DH-LED and sketch with proper levelling the energy level diagram of such configuration.

(b) A double heterojunction InGaAsP-LED operating at 1310 nm has radiative and non-radiative recombination times of 30 ns and 100 ns respectively. The injected current is 40 mA. Calculate:
(i) the internal quantum efficiency of the LED
(ii) bulk recombination life time
(iii) internal power level.

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

5. (a) Derive the expression of the external quantum efficiency of a LED.

(b) Assuming that the LED is forward biased with a current of 120 mA and a voltage of 1.5 V, and the emitted photon possess energy 1.43 eV. Also assuming that the refractive indices of the core and cladding of the optical fiber are 1.5 and 1.48 respectively. Calculate:
(i) the internal power efficiency of the device
(ii) external power efficiency of the diode, if it is emitting in air
(iii) overall source fiber coupling and the optical loss (in dB).

6 + (2 + 2 + 2) = 12

Group – D

6. (a) What do you mean by absorption, spontaneous emission, and stimulated emission? Derive the relations of different coefficient of Einstein relation of ILD. Hence find the ratio of rate of stimulated emission to the rate of spontaneous emission.

(b) An ILD operating at temperature of 1000 K with an average operating wavelength 0.5 μm. Determine the ratio rate of stimulated emission to the rate of spontaneous emission.

(3 + 4 + 2) + 3 = 12

7. (a) Derive an expression of threshold condition for Laser oscillation with explanation. Briefly discuss about laser application on medical diagnosis.

(b) A GaAs injection laser with refractive index 3.6 has a cavity length of 500 μm and the loss coefficient is 20 cm^{-1}. The measured differential quantum efficiency is 45%. Calculate the internal quantum efficiency of semiconductor laser.

(4 + 3) + 5 = 12