OPTICAL INSTRUMENTATION
(AEIE 4126)

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) Practically, in order to create an electron-hole pair in p-n diode, the energy of the incident photon should be
(a) less than the E_g (b) greater than the E_g
(c) equal to E_g (d) all of these.

(ii) Which of the following materials is not suitable for making an LED?
(a) GaAs (b) Silicon (c) InGaAs (d) AlGaAS.

(iii) Which of the following material suitable for making a heterojunction?
(a) Si and Ga (b) Si and GaAs
(c) GaAs and AlAs (d) GaAs and AlGaAs.

(iv) Given that Germanium has a band gap of 0.67eV, what is the maximum wavelength that will be absorbed by it?
(a) 7080nm (b) 4560nm (c) 1850nm (d) 1100nm.

(v) Two optical fiber with numerical aperture 0.17 and 0.20 are to be spliced. What will be the loss at the joint in the forward direction?
(a) zero (b) 1.41 dB (c) 1.82 dB (d) 2.50 dB.

(vi) Population inversion takes place in
(a) two and three layer structure (b) two and four layer structure
(c) three and four layer structure (d) all of the above.

(vii) LASER is chosen as an opto electronics sources due to
(a) highly monochromatic (b) highly directional
(c) highly intense (d) all of these

(viii) A quarter-wave plate will introduce a phase difference (between two emerging beam) of
(a) π/4 (b) π/2 (c) π (d) 3π/4.

(ix) A 2 × 2 directional coupler has an input power level of 10 μw. The power available at output ports 1, 2 are 45 μw, and 45 μw respectively. What is the coupling ratio?
(a) 45% (b) 50% (c) 90 % (d) 100%.

(x) OTDR stands for _____
(a) optical time domain reflectometer (b) optical transfer data rate
(c) optical time data registers (d) none of the mentioned.

Fill in the blanks with the correct word

(xi) _____ kind of change can be measured by an all-fiber interferometer.

(xii) In terms of electronics circuit analogy optical resonator is equivalent to _____.

(xiii) The refractive index of a graded index fiber in terms of profile parameter is _____.

(xiv) A step index fiber has a core with a refractive index of 1.5 and a cladding refractive index of 1.46. Its numerical aperture is _____.

(xv) Unit of responsivity of photo detector is _____.

Group - B

2. (a) What are the homojunction and heterojunction type semiconductor? *[(CO3)(Remember/LOCQ)]*

(b) Analyze direct and indirect bandgap type semiconductor (GaAs) with the help of E-K diagram. How it will change from one to another? *[(CO2)(Analyze/IOCQ)]*

(c) If a LED is forward biased with a current of 120 mA and a voltage 1.5V and emitted photon posses energy Eph =1.43eV. Evaluate (i) the internal power efficiency of the device (ii) the external power efficiency of the device, if it is emitting in the air. Assume that the refractive indices of the core and cladding of the optical fiber are 1.5 and 1.48, respectively. *[(CO3)(Evaluate/HOCQ)]*

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

3. (a) What do you meant by quantum efficiency and responsivity of a photo detector? *[(CO4)(Remember/LOCQ)]*

(b) Calculate the wavelength at which quantum efficiency and responsivity are equal. *[(CO4) (Remember/LOCQ)]*

(c) A photo diode has quantum efficiency of 50% at 0.90 μm. Calculate responsivity and received optical power if mean photo current is 10μA. *[(CO4) (Evaluate/IOCQ)]*

4 + 6 + 2 = 12

Group - C

4. (a) Make a comparative analysis of different type's optical fiber concerning their refractive index profile, number of mode propagation through optical fiber, and application. *[(CO1)(Remember/LOCQ)]*

(b) The axial refractive index of the core, n, of a graded-index fiber is 1.50, and the maximum relative index difference is 1%. Evaluate the relative index of the cladding? *[(CO1)(Evaluate/IOCQ)]*

(c) Two compatible multimode SI fibers are joint with small air gap. The fiber axes and end faces are perfectly aligned. Evaluate the refractive index of fiber core if the joint is showing the loss of 0.47 dB. *[(CO1)(Evaluate/HOCQ)]*

4 + 4 + 4 = 12

5. (a) What are the major losses in optical fiber communication? *[(CO1)(Remember/LOCQ)]*

(b) Graphically analyze effect index profile parameter in different types of fiber. *[(CO1) (Analyze/IOCQ)]*

(c) The mean optical power at the fiber output is 3 μm when the mean optical power launched into an 8km length of fiber is 120 μw.
Evaluate
(i) The overall signal attenuation or loss in dB through the fiber.
(ii) Overall signal attenuation for 10km optical link using the same fiber with splices at 1km intervals, each giving an attenuation of 1dB.
[(CO1)(Evaluate/HOCQ)]

4 + 4 + 4 = 12

Group - D

6. (a) What is meant by optical and electrical confinement in a semiconductor laser? *[(CO3)(Understand/LOCQ)]*

(b) Graphically and mathematically analyze the optical output response of a semiconductor laser with the temperature variation. (Temperature change from 20 °C to 30 °C). *[(CO3)(Analyze/IOCQ)]*

(c) An injection laser has GaAs active region with band gap energy 1.43eV. Evaluate the wavelength of optical emission. *[(CO3)(Evaluate/IOCQ)]*

4 + 4 + 4 = 12

7. (a) Derive the relation between the different Einstein coefficient A_{ij} and B_{ij} for the two layer laser diode. *[(CO3)(Remember/LOCQ)]*

(b) What do you mean by population inversion? *[(CO3)(Analyze/IOCQ)]*

(c) A double heterojunction In GaAsP LED operating at 1310nm has radiative and non-radiative recombination times of 30 and 100 ns respectively. The injected current is 40mA. Calculate: (i) recombination life time (ii) internal quantum efficiency (iii) internal power level. *[(CO3)(Evaluate/IOCQ)]*

6 + 3 + 3 = 12

Group - E

8. (a) How are fiber-optic sensors classified? Determine the expressions of coupling efficiencies in case of Intensity Modulated Sensors. *[(CO6)(Remember/LOCQ)]*

(b) In case of a fiber-optic based temperature sensor, show that the phase change 'ΔΦ' per unit length in the sensing arm due to change in temperature ΔT is given approximately by, $\frac{\Delta\emptyset}{L\Delta T} = \frac{2\pi}{\lambda}[\frac{n}{L}\frac{\Delta L}{\Delta T} + \frac{\Delta n}{\Delta T}]$, Where symbols are standard meaning. *[(CO6)(Apply/IOCQ)]*

(2 + 4) + 6 = 12

9. (a) What do you mean by intrinsic and extrinsic fiber optic sensor?

[(CO6)(Understand/LOCQ)]

(b) In case of a fiber-optic based temperature sensor, show that the phase change 'ΔΦ' per unit length in the sensing arm due to change in temperature ΔP is given approximately by, $\frac{\Delta \emptyset}{L \Delta P} = \frac{2\pi}{\lambda}\left[\frac{n}{L}\frac{\Delta L}{\Delta P} + \frac{\Delta n}{\Delta P}\right]$, Where symbols are standard meaning.

[(CO6) (Evaluate/IOCQ)]

(c) What is electro-optic effect? *[(CO6) (Understand/LOCQ)]*

4 + 4 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	47.9	39.5	12.5