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) A photo conducting detector can be constructed from
(a) An intrinsic semiconductor (b) An extrinsic semiconductor
(c) Polycrystalline material (d) all of these

(ii) 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

(iii) The quantum efficiency (η) of a photodetector is defined as:
(a) Ratio of output electrical power to input optical power
(b) Number of electron-hole pairs generated per incident photon
(c) Ratio of absorbed photons to incident photons
(d) Ratio of incident photons to emitted photons

(iv) Total internal reflection will happen due to
(a) Refractive index of the core is less than cladding
(b) Refractive index of the core is greater than cladding
(c) Refractive index of the core is equal to cladding
(d) All of these

(v) Light is guided within the core of a step index fiber by
(a) Refraction at the core –air interface
(b) Total internal reflection at the core cladding interface
(c) Total internal reflection at the outer surface of the cladding
(d) Change in speed of light within the core

(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) Population inversion in LASER happens when
(a) $N_2 > N_1$ (b) $N_2 < N_1$ (c) $N_2 = N_1$ (d) None of these

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

(ix) In Q-switching of a laser, the main purpose is:
(a) To increase output wavelength
(b) To generate very short, high-power laser pulses
(c) To improve beam divergence
(d) To reduce threshold current

(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) What is the cut-off wavelength of a step index single mode fiber with core diameter of 8.2 μm and NA = 0.12, _____.

(xii) 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 _____.

(xiii) Write full form of LASER _____.

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

(xv) Full form of RAPD is _____.

Group - B

2. (a) What are the basic requirement of photo detector to generate current. *[(CO4)(Remember/LOCQ)]*

(b) Define quantum efficiency and responsivity of photodiode. Analyze it quantitatively and qualitatively. *[(CO4)(analyze/IOCQ)]*

(c) The responsivity of photodiode is 0.85 A/W and the input power saturation is 1.5mW. Evaluate the Photo current if the incident light power is 1mW? *[(CO4)(Evaluate/HOCQ)]*

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

3. (a) What do you mean by indirect and direct band gap materials. *[(CO2)(Remember/LOCQ)]*

(b) Prove that the internal efficiency of a LED be expressed as
$\eta_{int} = r_r / [r_r + r_{nr}]$. *[(CO3)(Analyze/IOCQ)]*

(c) The radiative and non-radiative recombination lifetimes of the minority carriers in the active region of a double heterojunction LED are 50nS and 90nS respectively. Determine the total carrier recombination lifetime and the power internally generated within the device when the peak emission wavelength is 0.87μm at a drive current of 40 mA. *[(CO3)(Analyze/IOCQ)]*

4 + 4 + 4 = 12

Group - C

4. (a) Analyze the effect of source fiber coupling mismatch. *[(CO1)(Analyze/IOCQ)]*
   (b) Analysis different type of optical fiber connector and splices with respect to maintenance of the fiber. *[(CO1)(Analyze/IOCQ)]*
   (c) A step index fiber is operating at a wavelength of 1.3 μm with the refractive indices of core and claddings are 1.450 and 1.447. Evaluate the Maximum acceptance angle. *[(CO1)(Evaluate/IOCQ)]*

4 + 4 + 4 = 12

5. (a) Why refractive index of the core is more than cladding in the optical fiber? What is the acceptance angle? *[(CO1)(Remember/LOCQ)]*
   (b) Explain multipath time dispersion and material dispersion. How can these be minimized? *[(CO1)(Understand/LOCQ)]*
   (c) An optical fiber has a NA of 0.20 and a cladding refractive index of 1.59. Determine the acceptance angle for fiber in water, which has a refractive index of 1.33. *[(CO1)(Evaluate/HOCQ)]*

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

Group - D

6. (a) Derive an 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 + 2 + 4 = 12

7. (a) Define differential external quantum efficiency, internal quantum efficiency, of a semiconductor laser. *[(CO3)(Remember/LOCQ)]*
   (b) What is the difference between spontaneous and stimulated emission? How is the light amplified in the laser? *[(CO3)(Understand/LOCQ))]*
   (c) An injection laser has GaAs active region with band-gap energy 1.43ev. Evaluate the wavelength of optical emission and determine the line width in hertz if measured spectral width is 0.1 nm. *[(CO3)(Evaluate/HOCQ)]*

4 + 6 + 2 = 12

Group - E

8. (a) Explain the use of micro bending in Fiber optic sensor. *[(CO6)(Understand/LOCQ)]*
   (b) A fiber optic cable of a length of 5 km is attached to an apparatus to measure loss. The detector has then sensed output of 5 V for 5 km length. When the fiber is cut back to leave a 2 m length voltage increases to 10 V. Determine the attenuation per km. *[(CO6)(Evaluate/IOCQ)]*

(c) Choose a suitable technique to measure the temperature using Fiber optic sensor. Explain in detail with mathematical relation, and block diagram.

[(CO6)(Evaluate/HOCQ)]

2 + 4 + 6 = 12

9. (a) Explain the working principle of a fiber optic sensor. Discuss the advantages of fiber optic sensors over conventional electrical sensors. *[(CO6)(Remember/LOCQ)]*

(b) Analyze the basic components of a fiber optic instrumentation system and explain the function of each block with a block diagram. *[(CO6)(Understand/LOCQ)]*

(c) A fiber optic sensor receives an optical power of 50 μW. If the photodetector responsivity is 0.8 A/W, calculate the photocurrent generated. *[(Analyze/IOCQ)]*

2 + 4 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	41.66	43.75	14.58