OPTICAL INSTRUMENTATION
(AEIE 4126)

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

(ii) Light is guided within the core of a step index fiber by
(a) refraction at 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 the speed of light within the core.

(iii) The material for making an efficient LED should be
(a) an indirect band gap type semiconductor
(b) a direct band gap type semiconductor
(c) metal
(d) insulator.

(iv) 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.

(v) Which of the following detectors give amplified output?
(a) p-n photodiode (b) p-i-n photodiode
(c) Avalanche photodiode (d) Photo voltaic detector.

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

(vii) What are the three parts of an optical data link?
(a) Transmitter, optical fiber, receiver
(b) Transmitter ,optical fiber, optical connectors
(c) Optical fiber, optical connectors, receiver
(d) Optical fiber, optical connectors, optical splices.

(viii) Population inversion in a laser occurs due to
(a) spontaneous emission of atoms
(b) stimulated emission of atoms
(c) both for the spontaneous emission and stimulated emission of atoms
(d) spontaneous absorption of atoms.

(ix) Laser is not used in
(a) optical communications (b) entertainment electronics
(c) illumination purposes (d) bloodless surgery.

(x) Optical fiber sensors are electrically _____ .
(a) active (b) active as well as passive
(c) passive (d) cannot be determined

Group- B

2. (a) What do you meant by quantum efficiency and responsivity of a photo detector? Calculate the wavelength at which quantum efficiency and responsivity are equal. [(CO4) (Remember/LOCQ)]
(b) Write down the relation between photo current and width of the absorption region. How this current can be maximized? [(CO4) (Analyse/IOCQ)]
(c) Determine the responsivity of an InGaAs photodiode if its quantum efficiency is equal to 60%. The energy gap of InGaAs is 0.75eV. [(CO4) (Evaluate/IOCQ)]
(2 + 2) + (2 + 2) + 4 = 12

3. (a) How to increase output from the semiconductor LED? [(CO2)(Remember/LOCQ)]
(b) Analyze the different characteristics of LED,
(i) i-v and i-p characteristics
(ii) temperature dependence of optical output. [(CO3)(Analyse/IOCQ)]
(c) Comparative analysis of semiconductor LED materials with respect to generation of colour of light, wavelength, band gap energy and application. [(CO3)(Analyse/IOCQ)]
2 + (4 + 2) + 4 = 12

Group - C

4. (a) If a meridional ray passing through an optical fiber with an acceptance angle α_m, critical angle φ_c. Hence draw the ray diagram and derive NA, and $\Delta T/L$ (all are standard symbols). [(CO1)(Remember/LOCQ)]
(b) A silica optical fiber with a core diameter large enough to consider by ray theory analysis has core refractive index of 1.50 and cladding refractive index 1.47. Determine
(i) critical angle (ii) NA for the silica optical fiber (iii) acceptance angle.
[(CO1)(Understand/IOCQ)]
(c) For the design point of view of an optical system, what will the problem due to coupling between optical fiber and optoelectronics sources? [(CO1)(Design/HOCQ)]
(3 + 3) + (2 + 2) + 2 = 12

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

(b) Graphically analyse effect index profile parameter in different types of fiber. [(CO1)(Analyse/IOCQ)]

(c) The mean optical power at the fiber output is 5 μm when the mean optical power launched into a 10 km length of fiber is 150 μw.
Evaluate
(i) The overall signal attenuation or loss in dB through the fiber.
(ii) Overall signal attenuation for 10 km optical link using the same fiber with splices at 1 km intervals, each giving an attenuation of 1 dB. [(CO1)(Evaluate/IOCQ)]

2 + 6 + (2 + 2) = 12

Group - D

6. (a) Explain semiconductor injection laser. Find its internal quantum efficiency and show how it is related to differential external quantum efficiency. [(CO5)(Understand/LOCQ)]

(b) Temperature controlling system to be attached with laser system design in medical application. Why? [(CO5)(Design/HOCQ)]

(c) A GaAs laser with refractive index 3.6 has a cavity of length $20cm^{-1}$. The measured differential quantum efficiency is 45%. Calculate the internal quantum efficiency of semiconductor laser. [(CO5)(Evaluate/IOCQ)]

(2 + 3) + 3 + 4 = 12

7. (a) Derive an expression of Einstein's relation for the injection laser diode. [(CO5)(Remember/LOCQ)]

(b) Comparative analysis between longitudinal modes and transverse modes in the laser resonator. [(CO5)(Analyze/IOCQ)]

(c) A GaAs injection laser with refractive index 3.6 has a cavity of length of 500 μm and loss efficiency 20/cm. The measured differential quantum efficiency is 45%. Evaluate the internal quantum efficiency of semiconductor laser. [(CO5)(Evaluate/IOCQ)]

3 + (3 + 3) + 3 = 12

Group - E

8. (a) A simple 2×2 coupler consist of two input ports and two output ports. Hence write down the formula in dB (i) coupling ratio (ii) insertion loss (iii) excess loss. [(CO6)(Remember/LOCQ)]

(b) Define Pockels and Kerr effect. [(CO6)(Understand/LOCQ)]

(c) Design an electro optic amplitude modulator (draw the block diagram). Hence show the output response of the each block. [(CO6)(Design/HOCQ)]

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

9. (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/HOCQ)]

(c) Choose a suitable technique to measure the temperature using Fiber optic sensor. [(CO6)(Evaluate/HOCQ)]

3 + 4 + 5 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	54.10	36.11	19.79

Course Outcome (CO):

After the completion of the course students will be able to

1. Learn the techniques of communications using optical fiber.
2. Learn the difference between direct and indirect band gap semiconductors.
3. Characterize structures and performance of LEDs and lasers.
4. Learn the structures and performance of photo detectors (like photo diode, PIN diode, APD etc).
5. Explain the techniques of measurement of distance, length, velocity, acceleration, current, voltage using laser. Formulate the structure of generalized measurement system.
6. Acquire the knowledge of different types of Optical Fiber sensors and their applications.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question