*Total number of printed pages:* **Programme (UG) 8th Semester/UECE811A**

**2023**

# Optical Communication

*Full Marks : 100*

Time : Three hours

***The figures in the margin indicate full marks for the questions.***

*Answer **any five** questions.*

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| 1 | (a) | With neat sketch describe the basic structure of an optical fiber and explain the functions of each part. | 2+3 |
| | (b) | What are the different modes of electromagnetic waves commonly propagating in optical fiber? Explain each of them with suitable sketch | 2+6 |
| | (c) | What are single mode and multi-mode optical fiber? | 3 |
| | (d) | Briefly describe the refractive index profile and basic characteristics for step index and graded index fiber | 4 |
| 2 | (a) | Define the critical angle, acceptance angle and numerical aperture of an optical fiber. Establish relation between acceptance angle and numerical aperture of an optical fiber for meridional ray. | 3+5 |
| | (b) | What is skew ray? Derive an expression for the acceptance angle for skew ray which changes direction by an angle $2\delta$ at each reflection in a step index fiber in terms of numerical aperture and $\delta$; also show that the maximum acceptance angle for the meridional ray is the minimum acceptance angle for the skew ray. It may be assumed that the ray theory holds good for the fiber. | 2+4+2 |
| | (c) | A silica optical fiber with core diameter large enough to be considered by ray theory analysis has a core refractive index of 1.50 and a cladding refractive index of 1.47. Determine the critical angle, numerical aperture and acceptance angle in air for the fiber. | 4 |
| 3 | (a) | What is dispersion? Discuss the different types of dispersions present in optical fiber and their origination. | 2+8 |
| | (b) | What is link power budget and rise time budget? Discuss each of them | 5+5 |
| 4 | (a) | What is photo detector? What are the different steps involved in the photo detection process? What are the basic criteria required for a good photo detector? | 2+3+3 |

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| | (b) | Define quantum efficiency and responsivity of a photo detector with expressions. With suitable schematic illustrates the variation of the responsivity of ideal and real photodiode. Explain the reasons for higher and lower cut-off wavelength in the responsivity of a real photo detector. | 4+5+3 |
| 5 | (a) | What is LASER? What are the different types of radiation processes in LASER? Discuss? With suitable energy state diagram discus the absorption and radiation processes of LASER. | 2+2+6 |
| | (b) | Deduce the Einstein's relation (i) $B_{12} = \frac{g_2}{g_1} B_{21}$ (ii) $\frac{A_{21}}{B_{21}} = \frac{8\pi h f^3}{c^3}$ where $B_{12}$ is the Einstein's coefficient of absorption , $B_{21}$ is the Einstein's coefficient of stimulated emission, $A_{21}$ is the Einstein's coefficient of spontaneous emission, $g_1$and $g_2$ are the degeneracy of the lower and higher energy state. Other symbols are their usual meanings. | 10 |
| 6 | (a) | Derive the expressions for the coupling efficiency of SIF and GIF for light source with lambertian beam profile $B(\theta, \Phi) = B_0 Cos\theta$ for $a > r_s$ *and* $a < r_s$ where $a$ *and* $r_s$ are the radiuses of optical fiber and the light source. | 12 |
| | (b) | Deriving the necessary expressions discuss how the coupling efficiency can be increased by using non lambertian source with beam profile $B(\theta, \Phi) = B_0 Cos^n\theta, (n > 1)$. | 8 |
| 7 | (a) | What are the key features of WDM? | 4 |
| | (b) | Derive the expression of total loss of the $N \times N$ star coupler using $2 \times 2$ coupler in terms of N | 2+2 |
| | (c ) | With the neat sketch discuss the operating principle of $2 \times 2$ Mach-Zehnder interferometer. | 5 |
| | (d) | Derive the expressions of throughput and coupled power in terms of incident powers also prove that for getting the whole power in the coupled port the length difference should be $\Delta L = [2n_{eff}\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right)]^{-1}$ where $\lambda_1 and\ \lambda_2$ are the wavelengths in input ports and $n_{eff}$ is the effective refractive index of the fiber | 7 |