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Subject: Fiber Optics Communications
EC-404

Time: 3 Hrs **Max. Marks: 60**

Note: All sections carry equal marks **(20 marks each)**.
Sections-A carry only **one (1)** question of 10 parts of 2 mark each and all parts are **compulsory**.
Section-B contains **five (5)** questions of 5 marks each and any **four (4)** are to be attempted.
Section-C consists of **three (3)** questions of ten (10) marks each and any **two (2)** are to be attempted.

Section-A [Two marks each (2)]

1.

i. Low-order and high-order modes propagate along an optical fiber. How are modes determined to be low-order or high-order modes?The index of refraction measures the speed of light in an optical fiber. Will light travel faster in an optically dense material or in one that is less dense?
ii. As the core and cladding modes travel along the fiber, mode coupling occurs. What is mode coupling?
iii. A light ray incident on the optical fiber core is propagated along the fiber. Is the angle of incidence of the light ray entering the fiber larger or smaller than the acceptance angle?
iv. Two methods describe how light propagates along an optical fiber. These methods define two theories of light propagation. What do we call these two theories?
v. A refracted wave occurs when a wave passes from one medium into another medium. What determines the angle of refraction?
vi. The fiber's normalized frequency (V) determines how many modes a fiber can support. As the value of V increases, will the number of modes supported by the fiber increase or decrease?
vii. Light transmission along an optical fiber is described by two theories. Which theory is used to approximate the light acceptance and guiding properties of an optical fiber?
viii. A wavefront undergoes a phase change as it travels along the fiber. If the wavefront transverses the fiber twice and is reflected twice and the total phase change is equal to $1/2\pi$ will the wavefront disappear? If yes, why?
ix. A light wave can be represented as a plane wave. What three properties of light propagation describe a plane wave?
x. What condition causes a light ray to be totally reflected back into its medium of propagation?

Section-B [Five marks each (5)]

2. Explain the relationship between the transmission time delay and dispersion and explain what is meant by the sign of the dispersion. Describe how waveguide dispersion is used to achieve dispersion shifting. Explain the principle of dispersion compensation and indicate how fibres are used to achieve this effect.
3. Two fibres are spliced with ideal angular and lateral alignment. Cut-off wavelengths for the two fibres are λ_{c1}= 0.75μm and λ_{c2}= 1.5μm. Refractive index difference is the same in both fibres. Calculate the splicing loss in decibels.
4. Find the amount of pulse spreading in pure silica for an LED operating at 820 nm and having 20 nm spectral width. The path is 10 km long. Repeat for operational wavelength of 1500 nm and spectral width of 50 nm. Dispersion at 820 nm is around - 110 ps/nm/km.
5. Define responsivity and quantum efficiency of a photodetector. Describe three communication windows and give some typical values of loss for standard single mode fibre.
6. For a fibre link operating at 1.55μm at 2.5Gbit/s using standard single mode fibre construct a typical power budget for a receiver sensitivity of –41dBm. Determine a suitable launch power for a 150 km long link.

Section-C [Ten Marks each (10)]

7. a. Define and explain the terms: Numerical aperture, critical angle, total internal reflection, propagating modes and micro bends in context of an optical fiber.

b. For a single-mode step-index fiber, what are the limits on the V parameter? What determines these limits?

8. a. A 700μm long InGaAs laser (refractive index 3.6) has a bandgap of 0.8 eV. Calculate the wavelength of optical emission and calculate the number of modes within the 2 nm linewidth of the laser.
   b. Fiber Non-linearties degrades the optical communication system performance. Justify your answer.
9. Write short article on
   a. WDM optical systems and networks.
   b. PIN photodiodes and their applications.

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