BE ETCE 4th Year 2nd Semester Examination 2025
Optical Fiber Communication

Time: 3 Hours **Full Marks: 100**

Answer all the parts of a question in the same place
Answer Question no. 1 and any two from each group

1. a) Explain the propagation of optical signal through a graded index optical fiber with parabolic refractive index profile.
   b) For a step index optical fiber having core refractive index 1.5 and cladding refractive index 1.45. Calculate critical angle and acceptance angle.

(6+4)

Group-A

2. a) Write the desirable characteristics of an optical source.
   b) Derive an expression for threshold current density for stimulated emission in a semiconductor LASER.
   c) The light output from a GaAs LED is coupled into a step index fiber having numerical aperture of 0.22 and core refractive index of 1.42. Calculate coupling efficiency and optical power loss in dB.

(4+7+4)

3. a) Briefly describe the working principle of an Erbium-doped fiber amplifier (EDFA).
   b) Derive the expression for power conversion efficiency and gain of an EDFA.
   c) For an erbium-doped fiber amplifier what should be the minimum pump power required to obtain 12 dBm output at 1540 nm, if the amplifier input is 0 dBm and pump wavelength is 980 nm.

(5+7+3)

4. a) With a neat diagram explain the working principle of an optical isolator.
   b) Briefly describe the working principle of an optical multiplexer.
   c) Write the common applications of optical amplifiers.

(6+5+4)

Group-B

5. a) Explain two different types of nonlinear scattering losses in an optical fiber.
   b) What do you mean by self phase modulation? How it is employed in optical solitons?
   c) A multimode graded index fiber exhibits total pulse broadening of 0.1μs over a distance of 15 km. Estimate
      i) The maximum possible bandwidth on the link assuming no inter-symbol interference.
      ii) Bandwidth length product for the fiber.

(6+6+3)

6. a) What do you mean by intramodal dispersion?
   b) Derive an expression for material dispersion.
   c) Estimate the maximum core diameter for an optical fiber with refractive index difference 1.6% and core refractive index of 1.48, in order to make it suitable for single mode operation for an operating wavelength 900 nm and V number 2.405.

(3+7+5)

7. a) Describe the loss due to bending in an optical fiber.
   b) Calculate the critical radius of curvature at which large bending losses occur in a multimode fiber with core refractive index of 1.5, relative refractive index difference of 3% and an operating wavelength of 820 nm.
   c) Explain the basic principle of polarization mode dispersion.

(7+4+4)

Group-C

8. a) Derive an expression for total system rise time of an optical fiber link.
   b) Considering following specifications, calculate the system rise time and the maximum allowable bit rate when data is encoded into NRZ format.
      i) LED source with drive circuit has a rise time 15 ns
      ii) Material dispersion related rise time degradation of 21 ns over 6 km link
      iii) Receiver has a 25 MHz electrical bandwidth
      iv) Fiber has 400 MHz.km bandwidth-distance product with q = 0.7
   c) How electrical bandwidth and optical bandwidth are related?

(8+5+2)

9. a) Draw a block schematic for an analog optical fiber system employing direct intensity modulation and explain its operation.
   b) State three types of noises in an optical receiver.
   c) What do you mean by quantum noise? Explain the effect of quantum noise in a digital optical fiber link.

(7+2+6)

10. a) With a neat block schematic explain the operation of a WDM system.
    b) Write the differences between CWDM and DWDM.
    c) A digital optical fiber communication system operating at a wavelength of 1000 nm requires a maximum bit error rate of 10^{-9}. Determine
       i) The theoretical quantum limit at the receiver in terms of quantum efficiency of the detector and the energy of an incident photon.
       ii) The minimum incident optical power in dBm is required at an ideal detector in order to achieve same performance when system is employing ideal binary signaling at 10 Mbps.

(5+3+7)