(b) Discuss the principle of a coherent lightwave system. Derive an expression for the current in the receiver in terms of the optical signal power, local oscillator power, phases of the optical signal and the local oscillator signal and the receiver sensitivity for a homodyne receiver system. Which of the two systems namely homodyne and heterodyne receivers have better SNR?

6 + 6 = 12

7. (a) Discuss the implementation of a typical WDM network containing various types of optical amplifiers.

(b) Draw the variation of attenuation (dB/km) with wavelength in O and C band of an optical glass fibre. The ITU -T G.692 standard for WDM specifies channels with 100 GHz spacing. Discuss how many channels are possible in O band of fibre.

6 + (4 + 2) = 12

Group - E

8. (a) Draw and explain the basic structure for an STS-1 SONET (Synchronous optical network) frame and STM-1 SDH (Synchronous Digital Hierarchy) frame.

(b) Draw a generic two fiber unidirectional path switched ring (UPSR) with a counter rotating protection path. Explain the flow of primary and protection traffic from one node to another.

(3 + 3) +(2 + 4) = 12

9. (a) Draw a block schematic of the generic configuration of a large SONET or SDH network consisting of linear chains and various types of interconnected rings. Explain the operating principles.

(b) Explain what do you understand by the term "Soliton". A typical Soliton pulse has FWHM pulse width = 19 ps. The pulse propagates through a dispersion shifted fiber having D = 0.52 ps/nm.km at 1550 nm. Find the dispersion length in units of km.

6 + 6 = 12

PHOTONICS & OPTICAL COMMUNICATION
(ECEN 5201)

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 suitable for fabrication of a semiconductor laser?
(a) Silicon   (b) Germanium
(c) Gallium Arsenide   (d) Gallium Phosphide.

(ii) An APD for detection of optical signal of 550 nm can be constructed using
(a) CdS   (b) Ge
(c) AIAs   (d) GaAs.

(iii) The no. of modes M in a multimode step index fibre with modified frequency parameter V is given by
(a) $M = V/2$ (b) $M = V^2/2$
(c) $M = V^2/3$ (d) $M = V^2/4$.

(iv) For a single mode fiber, the modified frequency parameter (V number) should be
(a) below 2.405
(b) between 2.405 to 5.00
(c) between 5.00 and 7.50
(d) between 7.50 and 10.00.

(v) In a step index fiber, the core refractive index in 1.48 and the cladding refractive index is 1.45. The numerical aperture of the fiber is
(a) 0.244   (b) 0.256
(c) 0.296   (d) 0.344.

(vi) The figure of merit of a dispersion compensating fibre with loss α and dispersion D is expressed as
(a) D/α (b) $|D|/\alpha$
(c) $(D/\alpha)^{1/2}$ (d) $D^2/2\alpha$.

(vii) The best value of sensitivity of a synchronous coherent receiver is obtained for
(a) ASK heterodyne
(b) PSK homodyne
(c) Intensity modulation/ Direct detection
(d) PSK heterodyne

(viii) The channel spacing (in GHz) specified by the ITU-T recommendation G.692 is
(a) 25   (b) 50
(c) 100   (d) 200.

(ix) A tunable optical filter used in WDM has a typical value of tuning range of
(a) 0.01 nm   (b) 0.1 nm
(c) 4 nm   (d) 40 nm.

(x) The maximum wave length of photons that can be detected by a photo diode made of a semiconductor of band gap 2 eV is about
(a) 620 nm   (b) 700 nm
(c) 740 nm   (d) 1240 nm.

Group - B

2. (a) For (a lattice matched) $In_{1-x}Ga_x As_yP_{1-y}$ semiconductor laser system the energy band gap is given by $Eg = 1.35 - 0.72 y + 0.12y^2$ with $y = 2.2x$ (x and y being alloy compositions).Find the maximum and minimum values of the wavelengths obtainable using the lattice matched $In_{1-x}Ga_x As_yP_{1-y}$ system.

(b) Draw the cross sectional diagram of an AlGaAs Double Hetero structure (DH) laser system and discuss its principles of operation. Discuss the importance of "Optical confinement", "Carrier confinement" and "Reabsorption" with reference to DH laser operation.

6 + 6 = 12

3. (a) Draw the variation of refractive index profile in the core of a single mode dispersion shifted optical fibre.

(b) A step index filter with a core diameter of 100 μm has a cladding refractive index of 1.46 and core refractive index 1.48. Find the numerical aperture (NA) and pulse broadening per unit length due to multipath dispersion.

6 + (3 + 3) = 12

Group - C

4. (a) Draw a block schematic diagram for an analog optical link comprising an optical transmitter, optical fiber channel, optical amplifier and the optical receiver. Discuss the factors that contribute to noise in such a system.

(b) An InGaAsP laser is employed in the transmitter of an analog optical link. If the relative intensivity noise (RIN) of the laser is −148 dB/Hz and if the average optical output power is 3mW and that if the photodetector is a p-i-n detector with responsivity of 0.65 A/W and a BW of 95 MHz find the root mean square (r.m.s.) noise current due to the laser RIN.

6 + 6 = 12

5. (a) Calculate the possible transmission distance for a cable with an attenuation α = 3.5 dB/km allowing 29 dB power loss between the source and the photodetector including a 6 db system margin. Assume that, a 1dB loss occurs when the fibre flylead is connected to the cable and another 1dB connector loss occurs at the cable-photo detector interface.

(b) Calculate the value of carrier to noise ratio (CNR) of a link having modulation index, m = 0.25, receiver bandwidth = 10 MHz and laser RIN = -150 dB/Hz, considering the reflection noise dominant.

6 + 6 = 12

Group - D

6. (a) Draw a neat sketch showing the modulation formats for PSK, FSK and ASK for bit pattern 11000111.