Optical Communication

BECE1-668

Question Bank

Section A

1) Describe the function of core and cladding in optical fiber.
2) What is acceptance angle? Why do we need to know this angle?
3) Draw a block diagram of fiber optic communication system and describe the function of each component
4) Why the R.I. of core and cladding are different? Which one has greater R.I. and why?
5) Why is it necessary to meet the total reflection requirement inside an optical fiber?
6) What is meant by the term critical propagation angle?
7) What are the advantages and disadvantages of fiber optic communications?
8) Define Numerical aperture of the fiber. Why it can't be made very large?
9) Derive the relationship between n1, n2 &a .
10) Differentiate between step index and Graded index fiber.
11) Differentiate between single mode and multimode fiber.
12) Among Microwaves and light waves which have high bit rate distance product? Why?
13) Mention the three advantages of optical fiber as waveguide over conventional metallic waveguide?
14) What is meant by mode and index profile?
15) Mention the advantages of Graded Index fiber.
16) Write the expression for the refractive index in Graded index fiber.
17) Give the expression of the effective number of modes that are guided by a curved multimode fiber of radius ' a'.
18) State Snell's Law.
19) Define TIR?
20) What is the need of Cladding?
21) What are leaky modes in optical fibers?
22) Define External reflection of light rays?
23) Define V number?
24) What is relation between V number and power flow in cladding?
25) What is the fundamental parameter of SM fiber?
26) Give the relation between rays and modes?
27) What are the advantages and disadvantages of SM fiber and MM fiber?
28) Define skew rays and merdional rays?
29) Define cutoff conditions?
30) What is meant by Degenerate modes?
31) What is meant by linearly polarized modes?
32) Define MFD?
33) A point source of light is 12cm below the surface of a large body of water (n=1.33). What

is the radius of the largest circle on the water surface through which the lights can emerge?

Section B

1. Draw a block diagram of fiber optic communication system and describe the function of each component
2. What is the structure of optical fiber? Give the advantage of optical fiber over metallic cables.
3. Differentiate between step index and Graded index fiber. How the rays do propagates in graded index fiber?
4. What is the difference between acceptance angle, critical angle and numerical aperture? A step index fiber has a core and cladding refractive index of 1.50 and 1.46 resp. what is the value of NA and acceptance angle of the fiber?
5. Differentiate between Meridional Rays and Skew Rays. Explain the nature of light.
6. What is the group velocity and phase velocity? An optical signal of wavelength λ propagates
in a medium of refractive e index n1. What is the value of phase velocity and Group velocity?
7. Explain the following:
1. Normalized propagation constant
2. Mode field Theory
3. Explain what is meant by critical bending radius for an optical fiber.
4. Discuss the linear scattering losses in optical fibers w.r.t
1. Rayleigh Scattering
2. Mie Scattering
3. What do you mean by mode coupling? Explain the various irregularities in the fiber of its causes.
4. Explain Modal birefringence and beat length in single mode fibers,
5. Explain intrinsic and extrinsic absorption in optical fiber material.
6. Write a note on polarization maintain fiber.
7. Explain the dispersion mechanism in optical fibers.
8. What is the population Inversion? Explain the mechanism of Population inversion for three level &four level energy state system.
9. What is the requirement for optical sources to feed into a fiber? Enlist the advantage & Disadvantages of LASER & LED.
10. Explain the necessity of carrier confinement in semiconductor laser.
11. Differentiate the different geometries of LASER
12. Explain the various structure of LED.
13. Derive the expression for the threshold value of gain for LASER oscillations.
14. Difference in LED and Laser.
15. Explain the characteristics of LED.
16. Explain the principal of LASER diode. What are the pumping techniques of LASER diode?
Give the structure of FP cavity LASER and how it is better than FP LASER.
17. What do you understand by the term external quantum efficiency and internal quantum efficiency?

18. What do you understand by optical detector? Discuss its various types of optical detector and parameters of photo detectors
19. Discuss the impact ionization in avalanche photodiode. Explain the multiplication factor and photo multiplication factors also.
20. Explain the various measures of efficiency in PIN photodiode & briefly explain the working principle of Schottky barrier photodiodes.
21. Explain the working of p-i-n photodiode. Also explain the factors that limit the speed of response of photodiode.
22. How is RAPD operated? How does it differ from p-i-n photodiode? What are the advantage & disadvantage of RAPD photo detector?
23. Mention the criteria for choosing the photo detectors for optical communication. How does a reverse bias p-n diode act as a detector?
Draw the block diagram of optical fiber communication system. Enlist the advantages of optical communication.
24. What do you mean by acceptance angle of an optical fiber, show how it is related to refractive index of the fiber core, cladding and medium where fiber is placed ?
25. Explain following :
(i) Normalized Propagation constant.
(ii) Mode field diameter.
26. A graded index fiber has a core with a parabolic refractive index profile and diameter 40 μm. Numerical aperture is 0.2. Estimate the total number of guided modes for a wavelength of 1 μm.
27. What do you understand by Attenuation? Describe its various types with expressions.
28. Differentiate between meridional and skew rays. An optical fiber in air has NA 0.4 ; compare the acceptance angle for skew rays which changes direction by 100° at each reflection.
29. What do you understand by lnter Symbol Interference (ISI) ? A multimode graded index fiber exhibits total pulse broadening of 0.1 μs over a distance of 15km.
Estimate : (i) The maximum possible bandwidth without ISI.
(iii) Pulse dispersion per unit length.
30. Discuss the vapour-phase oxidation technique in preparation of low-loss optical fiber.
31. What do you understand by scattering loss ? Describe its types with expressions.
32. Discuss various dispersion mechanisms.

SECTION C

Very Short Questions. (2 Marks)
1) Write the expression for the refractive index in graded index fibers.
2) Define Numerical aperture of a step index fiber.
3) Define Mode-field diameter.
4) What is the necessity of cladding for an optical fiber?
5) What are step index and graded index fibers?
6) What are meridional rays?
7) What is Intra Modal Dispersion?

8) What is group velocity?
9) Define depression shifted fiber.
10) What is Rayleigh scattering?
11) Mention the losses responsible for attenuation in optical fibers.
12) What are the advantages of optical communication?
13) What are the three requirements of Laser action?
14) Define external quantum efficiency.
15) Differentiate LEDs and Laserdiodes.
16) A given APD has a quantum efficiency of 65% at a wavelength of 900 nm. If 0.5μW of optical power produces a multiplied photocurrent of 10μA, find the multiplication M.
17) Explain briefly about link power budget analysis?
18) What is the necessity of cladding for an optical fiber?
19) What are the factors to be considered in link power budget?
20) What is WDM? Define.
21. Explain the principle , constraction, Characteristics and working of semiconductor Injection laser.
22. The radiative and non radiative recombination lifetimes of the minority carriers in the active region of double heterostructure LED are 50 ns and 100 ns respectively. Determine the total carrier recombination life time and the power internally generated within the device when the peak emission wavelength is 0.87μm at a drive current of 40 mA.
23. Explain the working principle of LED. How the quantum efficiency of a LED is defined ? List out various parameters which are needed to be optimized for getting maximum output power from the LED.
24. Derive an expression for the coupling efficiency of a surface emitting LED into a step index fiber, assuming the device to have a lambertian output. Also write the difference between Edge and Surface emitting LED.
25. A p-i-n photodiode on average generate one electron hole pair per three incident photons at a wavelength of 0.8 μm. Assuming all the electrons are collected, calculate:
(i)The quantum efficiency of the device
(ii)The maximum possible bandgap energy.
26. Explain the principle, construction and working of APD.
27. Write Short Notes on:
(a) Population Inversion (b) Optical Detection Principle
28. Explain what is meant by : (a) Model birefringence (b) The beat length in single mode fibers.
29. The beat length in a single-mode optical fiber is 9 cm when light from an injection laser with a spectral linewidth of 1 nm and a peak wavelength of 0.9 μmis launched into it. Determine the modal birefringence and estimate the coherence length in this situation. In addition calculate the difference between the propagation constants for the two orthogonal modes and check the result.
30. a 32x32 port multimode coupler (fiber transmissive star coupler) has 1 mW of official power launched to a single input port. The average optical power measured for each

output port is 14 µW. Evaluate the total loss incurred through the device and average insertion loss.
31. a continuous 12 km long optical fiber link has a loss of 1.5 dB/km.
32. What is the minimum optical power level that must be launched into the fiber to maintain an optical power level of 0.3 µm at the receiving end ?
33. What is the required input power if the fiber has a loss of 2.5 dB/km2 ?
34. What is the significance of intrinsic layer in PIN diode ? What is the principle of working of PIN diode ?
35. Explain a digital signal transmission setup suitable for fiber optic communication.
36. Explain the physical principle of APD. What is the temperature effect on avalanche gain ? Describe automatic gain control using Op-amp.
37. Explain the detection process in p-n photodiode. Compare this device with the p-i-n photodiode.
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SECTION D

Short Questions. (10 Marks)
1) Determine the refractive indices of the core and the cladding material of a fiber if numerical aperture is 0.22 and refractive index difference Δ=0.012.
2) Find the maximum diameter allowed for a fiber having core refractive index 0.153 and cladding refractive index 1.50. The fiber is supporting only one mode of a wavelength of 1200 nm.
4) Find the maximum diameter of a core for a single mode optical fiber operating at 1.55 µm with n1=1.55 and n2=1.48.
5)Briefly explain the reason for pulse broadening due to material dispersion in optical fibers.
6) Explain overall fiber dispersion in single mode fiber.
7) Explain linear and non-linear scattering losses.
8) What is the difference between step index fiber and graded index fiber? How does the ray of light propagate in a graded index fiber?
9) What is the difference between phase velocity
and group velocity? An optical signal of wavelength *Ie* propagates in a medium of refractive index nl What is the value of phase velocity , group velocity and group refractive index?
10) Explain intrinsic and extrinsic absorption In optical fiber material.
11) Explain intramodal and intermodal dispersion in graded index fiber.
12) What is modal noise? Explain the working of dispersion shifted fiber.
13) Write a note on polarization maintaining fiber.
14) What is internal quantum efficiency, differential
quantum efficiency and total efficiency of semiconductor
laser? A GaAs injection laser with refractive index 3.6 has a cavity length of 500 j.! m and loss coefficient 20 cm-]. The measured differential quantum efficiency is 45 %. Calculate the internal quantum efficiency of semiconductor laser.
15) What is meant by acceptance angle of an optical fiber? Show how it is related to the refractive indices of the fiber core and cladding and the medium where the fiber is placed.
16) What is normalized frequency and cut-off normalized frequency. A graded index fiber has normalized frequency of 30.0 has refractive index profile ex = 2. What is the total number

of modes in fiber?
17) An optical signal has lost 55% of its power after travelling 3.5 km of fiber. What is the loss in dB/km of the fiber?
18) Explain the principle of operation of optical detectors. An intrinsic photodetector in fabricated from GaAs whose band gap energy is 1.43 eV at
300°K. Determine the wavelength above which the photo detector will cease to operate.
19) What is excess noise factor with reference to an APD? What material exhibits lesser excess noise and why ?
20) Explain the following terms with reference to a photo detector .
(i) Quantum Noise
(ii) Dark Current Noise
21. Briefly discuss the possible source of noise in optical fiber receivers. Describe the quantum noise in detail.
22. Sketch the full equivalent circuit for a digital optical fiber receiver. Briefly explain its various parts.

SECTION E

Long Questions. (10 Marks)
1) What are the two major requirement of a pre-amplifier in optical receiver? Explain how these are achieved in a trans impedance amplifier.
2) An optical fiber system at 1300 nm has -13 dBm power coupled into the fiber. The PIN diode detector sensitivity is - 38 dBm. The fiber attenuation is 1.5 dB/km with connector loss of 1 dB/km connector at each end. If a safety margin of 6 dB is required, find the maximum attenuation limited transmission distance.
3) What are the advantages of a coherent optical communication system? Explain the principle of heterodyne detection used in optical systems.
4) With the suitable diagram give the mechanism of light from an LED and its use in optical source for communication.
5) How does silicon RAPD operated? How does it differ from p-i-n photodiode? What are the advantage and disadvantage?
6. Write short notes on any TWO of the following :
(a) The optical power meter
(b) OTDR
(c) Wavelength division multiplexing.
7. Attempt any two parts of the following :
(i) Multichannel transmission techniques.
(ii) WDM
8. With the help of a neat block diagram, explain the principle of working of point to point digital link.
9. Explain briefly various types of losses in optical fiber cable.
10. What are all the possibilities for WDM system?
11. A step index fiber has an acceptance angle in air of 20 degree and a relative refractive index difference of 3 %. Find (i) Numerical aperture (ii) Critical angle at core-cladding interface (iii) Solid acceptance angle.

12. Describe techniques employed to provide dispersion shifted single mode fibers.
13. Using simple ray theory, describe the mechanism of the transmission of light within an optical fiber.
14. Explain in brief the propagation characteristics of single and multimode fibers.
15. Sketch the block diagram of optical fiber communication system.
16. List out various advantages of optical fiber communication system over the conventional electrical communication system.
17. Explain the concept of acceptance angle in optical fiber with the help of proper diagram. How it is related to the numerical aperture of optical fiber ?
18. With the suitable ray diagram, explain the propagation of skew rays in the optical waveguide and compare it with meridional ray.
19. Mention any two materials system used in the fabrication of optical fibers. Explain the vapor-phase deposition techniques to produce silica rich glasses of highest transparency.
20. With the aid of suitable diagram, briefly discuss the following in the case optical fiber transmission.
(i) Fiber bend losses ;
(ii) Dispersion shifted fibers.
21. Describe the mechanism of intermodal dispersion in a multimode step index fiber, Show that the total broadening of a light pulse ΔT_s due to intermodal dispersion in a multimode step index fiber may be given by :

$$\Delta Ts = \frac{L(NA)}{2n\,c}$$

Where L is the length of the fiber , NA is the numerical aperture of the fiber , n_1 is the core refractive index and c is the velocity of light in vacuum.
22. Explain what is meant by : (i) Modal birefringence
(Ii) The beat length in single mode fibers.
The difference between the propagation constants for the two orthogonal modes in a single mode fiber is 250. It is illuminated with light of peak wavelength 1.55 μm from an injection laser source with a spectral line width of 0.8 nm. Estimate the coherence length within the fiber.
23. What is Total Internal Reflection ? Explain Snell's law.
24. Write a short note on fabrication process of optical fiber.
25. Write a short note on Dispersion Shifted Fiber (DSF).
26. Differentiate between intramodal and intermodal dispersion for step and graded index fibers.
27. Explain the working of a Heterodyne detection technique suitable for optical fiber communication.
28. Enlist the polarization maintaining fibers. Two fibers having same polarization and operating at a wavelength of 0.8 μm have beat lengths of 0.5mm and 75m. Find the modal birefringence in each case.
29. Discuss the following terms for optical fiber:

(i) Absorption
(ii) Scattering losses.