



**SRM VALLIAMMAI ENGINEERING COLLEGE**

(An Autonomous Institution)  
S.R.M. Nagar, Kattankulathur - 603 203.



**DEPARTMENT OF ELECTRONICS & COMMUNICAITON ENGINEERING**

**QUESTION BANK**



**Academic Year: 2025 – 2026 (Odd Semester)**

**VII SEMESTER**

**1906702 – OPTICAL COMMUNICATION**

**Regulation – 2019**

**Prepared by**

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## Syllabus

1906702

OPTICAL COMMUNICATION

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### **OBJECTIVES:**

The student should be made:

- To analyze the optical fiber modes and configuration of optical fibers.
- To understand the transmission characteristics of optical fibers.
- To learn about optical sources, detectors and transmission techniques.
- To explore the idea about optical fiber measurements and various coupling techniques.
- To enrich the knowledge about optical communication systems and networks.

### **UNIT – I: INTRODUCTION TO OPTICAL FIBERS 9**

Introduction-General optical fiber communication system- Basic optical laws and definitions  
Optical modes and configurations -Mode analysis for optical propagation through fibers modes in planar wave guide-Modes in cylindrical optical fiber-Transverse electric and transverse magnetic modes- Fiber materials-Fiber fabrication techniques-Fiber optic cables classification of optical fiber-Single mode fiber-Graded index fiber .

### **UNIT – II: TRANSMISSION CHARACTERISTIC OF OPTICAL FIBER 9**

Attenuation-Absorption-Scattering losses-Bending losses-Core and Cladding losses-Signal dispersion –Inter symbol interference and bandwidth-Intra modal dispersion-Material dispersion-Waveguide dispersion-Polarization mode dispersion-Intermodal dispersion Optimization of single mode fiber-Characteristics of single mode fiber-R-I Profile cutoff wave length-Dispersion calculation-Mode field diameter.

### **UNIT – III: OPTICAL SOURCES AND DETECTORS 9**

*Sources:* Intrinsic and extrinsic material-direct and indirect band gaps-LED-LED structures surface emitting LED-Edge emitting LED-Quantum efficiency and LED power-Light source materials-Modulation of LED-LASER diodes-Modes and threshold conditions-Rate equations-external quantum efficiency-Resonant frequencies-Structures and radiation patterns-Single mode laser-External modulation-Temperature effort.

*Detectors:* PIN photo detector-Avalanche photo diodes-Photo detector noise-Noise sources-SNR-detector response time-Avalanche multiplication noise-Temperature effects comparisons of photo detectors.

**UNIT – IV: OPTICAL RECEIVER, MEASUREMENTS AND COUPLING 9**

Fundamental receiver operation-Preamplifiers-Digital signal transmission-Error sources-Front end amplifiers-Digital receiver performance-Probability of error-Receiver sensitivity-Quantum limit. Optical power measurement-Attenuation measurement-Dispersion measurement- Fiber numerical Aperture Measurements- Fiber cut-off Wave length Measurements- Fiber diameter measurements-Source to Fiber Power Launching-Lensing Schemes for Coupling Management-Fiber to Fiber Joints-LED Coupling to Single Mode Fibers-Fiber Splicing Optical Fiber connectors.

**UNIT – V: OPTICAL COMMUNICATION SYSTEMS AND NETWORKS 9**

Elements of optical networks-SONET/SDH Optical Interfaces-SONET/SDH Rings and Networks-Optical ETHERNET-Soliton.-Optical network concepts - Optical network transmission modes, layers and protocols - Wavelength routing networks - Optical switching networks - Optical network deployment - Optical Ethernet .

**TOTAL PERIODS:45**

**OUTCOMES:**

*After studying this course, the student should be able to,*

- ❖ Examine the basic elements in optical fibers, different modes and configurations.
- ❖ Analyse the transmission characteristics associated with dispersion and polarization techniques.
- ❖ Design optical sources and detectors with their use in optical communication system.
- ❖ Construct fiber optic receiver systems, measurements and coupling techniques.
- ❖ Understand and Design communication systems and networks.

**TEXT BOOKS:**

1. P Chakrabarti, “Optical Fiber Communication”, McGraw Hill Education (India) Private Limited, 2016.
2. Gerd Keiser, “Optical Fiber Communication”, McGraw Hill Education (India) Private Limited. Fifth Edition, Reprint 2013.
3. J.Senior, “Optical Communication, Principles and Practice”, Prentice Hall of India, 3rd Edition, 2008.

**REFERENCE BOOKS:**

1. John M.Senior, “Optical fiber communication”, Pearson Education, second edition.2007.
2. Rajiv Ramaswami, “Optical Networks”, Second Edition, Elsevier, 2004.
3. J.Gower, “Optical Communication System”, Prentice Hall of India, 2001.

## UNIT – I: INTRODUCTION TO OPTICAL FIBERS

Introduction-General optical fiber communication system-Basic optical laws and definitions-Optical modes and configurations-Mode analysis for optical propagation through fibers modes in planar wave guide-Modes in cylindrical optical fiber-Transverse electric and transverse magnetic modes-Fiber materials-Fiber fabrication techniques-Fiber optic cables classification of optical fiber-Single mode fiber-Graded index fiber.

### PART-A

Q. No	Questions	CO	BT Level	Domain
1.	Draw the basic block diagram of an optical fiber communication system.	CO1	BTL 2	Understanding
2.	What are the advantages of optical fiber?	CO1	BTL 1	Remembering
3.	State the reasons to opt for Optical fiber communication.	CO1	BTL 1	Remembering
4.	What are the conditions for light to be propagation inside a fiber?	CO1	BTL 1	Remembering
5.	Define Numerical Aperture.	CO1	BTL 1	Remembering
6.	State Snell's law.	CO1	BTL 1	Remembering
7.	Why partial reflection of light is occurring in optical fiber?	CO1	BTL 1	Remembering
8.	What is total internal reflection in a fiber?	CO1	BTL 1	Remembering
9.	The refractive indices of the core and cladding of a silica fiber are 1.48 and 1.47 respectively. Find the Numerical Aperture (NA) of the fiber.	CO1	BTL 1	Remembering
10.	Outline the concept of Meridional rays.	CO1	BTL 2	Understanding
11.	Compare Single mode and Multimode fibers.	CO1	BTL 2	Understanding
12.	What is planar wave guide in an optical fiber?	CO1	BTL 1	Remembering
13.	What is the necessity of cladding for an optical fiber?	CO1	BTL 1	Remembering
14.	Assume that there is a glass rod of refractive index 1.5, surrounded by air. Identify the critical incident angle.	CO1	BTL 2	Understanding
15.	Summarize the raw materials used for glass fiber.	CO1	BTL 2	Understanding
16.	Outline the advantages of this fiber over plastic fiber.	CO1	BTL 2	Understanding
17.	Mention the characteristics of preform with its typical length and diameter.	CO1	BTL 2	Understanding
18.	Why sintering is not needed in plasma chemical vapor deposition?	CO1	BTL 1	Remembering
19.	Interpret the term modes.	CO1	BTL 2	Understanding
20.	A SI fiber with silica core refractive index of 1.458, $V=75$ and $NA=0.3$ is to be operated at 820 nm. Identify its core size.	CO1	BTL 2	Understanding

21.	Classify the fibers based on index of refraction and modes.	CO1	BTL 2	Understanding
22.	A manufacturing Engineer wants to make an optical fiber that has a core index of 1.480 and cladding index of 1.478. Identify the core size for single mode operation at 1550 nm.	CO1	BTL 2	Understanding
23.	Summarize the characteristics of graded index fiber.	CO1	BTL 2	Understanding
24.	Why should we prefer step index single mode fiber for long distance communication?	CO1	BTL 1	Remembering
<b>PART-B</b>				
1.	With a neat block diagram, examine the blocks of a practical optical fiber communication system. (13)	CO1	BTL 3	Applying
2.	Draw a neat diagrams determine the ray theory behind the optical fiber communication with a special mention about total internal reflection, Acceptance angle and Numerical aperture. (13)	CO1	BTL 3	Applying
3.	Illustrate the following fiber configurations with neat index profile diagrams. (i). Step-Index (SI) fiber (7) (ii). Graded Index (GI) (6)	CO1	BTL 3	Applying
4.	Inspect the following with the aid of simple ray diagrams. (i). Single mode step index fibers (6) (ii). Multimode step index fibers (7)	CO1	BTL 4	Analyzing
5.	A step-index silica fiber with a core radius much longer than the operating wavelength of light has a core refractive index of 1.50 and a cladding refractive index of 1.48. Evaluate the values of a) Numerical aperture of the fiber. b) Maximum acceptance angle in air. c) Maximum acceptance angle in water having a refractive index of 1.33. (13)	CO1	BTL 4	Analyzing
6.	Illustrate the ray theory transmission in optical communication with neat	CO1	BTL 3	Applying

	diagrams. (13)			
7.	Identify the advantages and disadvantages of step index and graded index, single mode propagation and multimode propagation. (13)	CO1	BTL 3	Applying
8.	(i) Examine the modes in a planar waveguide with well-ordered diagrams. (10) (ii) Determine the concepts of leaky modes in cylindrical optical fibers. (3)	CO1	BTL 3	Applying
9.	(i) A multimode step index fiber with a core diameter of $80\ \mu\text{m}$ and a relative index difference of 1.5% is operating at a wavelength of $0.85\ \mu\text{m}$ . If the core refractive index is 1.48, calculate (a) the normalized frequency for the fiber; (b) the number of guided modes. (7) (ii) A graded index fiber has a core with a parabolic refractive index profile which has a diameter of $50\ \mu\text{m}$ . The fiber has a numerical aperture of 0.2. Calculate the total number of guided modes propagating in the fiber when it is operating at a wavelength of $1\ \mu\text{m}$ . (6)	CO1	BTL 4	Analyzing
10.	(i) A step-index fiber has an acceptance angle of $18^\circ$ in air. The fiber has a relative refractive index of 2.5%. Evaluate the value of the critical angle at the core-cladding interface of the fiber and also the numerical aperture of the fiber. (8) (ii) A silica optical fiber with a 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. Calculate (a) the critical angle at the core-cladding interface; (b) the $NA$ for the fiber; (c) the acceptance angle in air for the fiber. (5)	CO1	BTL 4	Analyzing
11.	Illustrate the following: (i) Glass fibers. (6) (ii) Fluoride fibers. (7)	CO1	BTL 3	Applying

12.	Examine the following fiber materials. (i) Active glass fibers. (6) (ii) Chalcogenide glass fibers. (7)	CO1	BTL 4	Analyzing
13.	Predict the performance of the following fiber materials. (i) Plastic Optical Fiber (7) (iii) Plastic Clad Silica (PCS) fiber. (6)	CO1	BTL 4	Analyzing
14.	Inspect the fabrication process of preform and also explain about how fiber is pulled from a preform. (13)	CO1	BTL 4	Analyzing
15.	Determine the Outside Vapor Deposition (OVD) with proper diagrams. (13)	CO1	BTL 4	Analyzing
16.	Illustrate the fiber fabrication techniques with neat diagrams. (i) Vapor Phase Axial Deposition (VAD). (7) (ii) Modified Chemical Vapor Deposition (MCVD) (6)	CO1	BTL 3	Applying
17.	Classify the types of optical fiber cables and explain each in brief with neat diagrams. (13)	CO1	BTL 4	Analyzing
<b>PART-C</b>				
1.	Determine the mode analysis for optical propagation through fibers with significant illustration and expressions. (15)	CO1	BTL 4	Analyzing
2.	Examine the following of modes in cylindrical optical fibers (i) Relationship between number of modes and V-number. (5) (ii) Linearly Polarized Modes. (10)	CO1	BTL 4	Analyzing

3.	Inspect the Transverse Electric (TE) and Transverse Magnetic (TM) modes in cylindrical optical fibers with necessary diagram. (15)	CO1	BTL 4	Analyzing
4.	Interpret the following fiber fabrication techniques with suitable figures. (i) Fiber pulling from a preform. (7) (ii) Fabrication of fiber preforms. (3) (iii) Modified Chemical Vapour Deposition (MCVD). (5)	CO1	BTL 3	Applying
5.	(i) Illustrate the fiber fabrication method without involving preforms. (7) (ii) Write the advantages of optical fiber communication in detail. (8)	CO1	BTL 3	Applying

### UNIT - II: TRANSMISSION CHARACTERISTIC OF OPTICAL FIBER

Attenuation-absorption-scattering losses-bending losses-core and cladding losses-signal dispersion –inter symbol interference and bandwidth-intra modal dispersion-material dispersion- waveguide dispersion-polarization mode dispersion-intermodal dispersion, dispersion optimization of single mode fiber-characteristics of single mode fiber-R-I Profile- cutoff wave length-dispersion calculation-mode field diameter.

**PART-A**

<b>Q.No</b>	<b>Questions</b>	<b>CO</b>	<b>BT Level</b>	<b>Domain</b>
1.	What is meant by attenuation of an optical fiber?	CO2	BTL 1	Remembering
2.	A fiber has an attenuation of 0.5 dB/Km at 1500nm. If 1500nm. If 0.5mW of optical power is initially launched into the fiber, find the power level after 25Km?	CO2	BTL 1	Remembering
3.	List the different mechanisms which cause absorption.	CO2	BTL 1	Remembering
4.	How does the scattering loss occur?	CO2	BTL 1	Remembering
5.	Define fictive temperature.	CO2	BTL 1	Remembering
6.	Light is launched from an injection laser diode operating at 1.55 $\mu$ m to an 8/(125 $\mu$ m) single mode fiber. The bandwidth of the laser source is 500MHz. The single mode fiber offers an average loss of 0.3 $\frac{dB}{km}$ . Identify the values of threshold optical power for the cases of stimulated Brillouin scattering.	CO2	BTL 2	Understanding
7.	How to reduce the Mie scattering?	CO2	BTL 1	Remembering
8.	Why scattering losses occurs more in multimode fibers?	CO2	BTL 1	Remembering
9.	Infer the term bending losses and classify its types.	CO2	BTL 2	Understanding
10.	Show and label the significance of microscopic bending.	CO2	BTL 2	Understanding
11.	Summarize the causes of dispersion.	CO2	BTL 2	Understanding
12.	Identify the bandwidth of RZ and NRZ in a fiber.	CO2	BTL 2	Understanding
13.	Outline the characteristics of chromatic dispersion.	CO2	BTL 2	Understanding
14.	Outline the concept of zero-material dispersion.	CO2	BTL 2	Understanding
15.	What is meant by waveguide dispersion?	CO2	BTL 1	Remembering
16.	Mention the polarization mode dispersion and write the expression for it.	CO2	BTL 2	Understanding
17.	Write the expression for the delay difference responsible for intermodal dispersion.	CO2	BTL 1	Remembering
18.	Identify the parameters used in the design optimization of single mode fiber.	CO2	BTL 2	Understanding
19.	List the attributes of single mode fibers.	CO2	BTL 1	Remembering
20.	Brief about the depressed cladding fibers.	CO2	BTL 1	Remembering

21.	What is effective cut off wavelength in a fiber?	CO2	BTL 1	Remembering
22.	Summarize the features of the dispersion shifted fiber.	CO2	BTL 2	Understanding
23.	What is large effective core area fibers?	CO2	BTL 2	Understanding
24.	Interpret the term mode field diameter.	CO2	BTL 2	Understanding
<b>PART-B</b>				
1.	Examine the following: (i) Attenuation. (4) (ii) Absorption loss by Intrinsic Absorption. (9)	CO2	BTL 3	Applying
2.	Illustrate the absorption loss by extrinsic absorption. (13)	CO2	BTL 3	Applying
3.	Determine in detail about the linear scattering losses that occur in an optical fiber with relevant diagrams and expressions. (13)	CO2	BTL 3	Applying
4.	Inspect the non-linear scattering losses in a fiber and write the about Stimulated Brillouin Scattering and Stimulated Raman Scattering. (13)	CO2	BTL 4	Analyzing
5.	Analyze the bending losses of an optical fiber with neat diagrams. (13)	CO2	BTL 4	Analyzing
6.	(i) Choose the suitable expressions to point out the Core-Cladding Loss. (5) (ii) Two step index fibers exhibit the following parameters: (a) A multimode fiber with a core refractive index of 1.500, a relative refractive index difference of 3% and an operating wavelength of 0.82 $\mu\text{m}$ ; (b) An 8 $\mu\text{m}$ core diameter single-mode fiber with a core refractive index the same as (a), a relative refractive index difference of 0.3% and an operating wavelength of 1.55 $\mu\text{m}$ . Estimate the critical radius of curvature at which large bending losses occur in both cases. (8)	CO2	BTL 3	Applying
7.	Examine the relationship between Inter Symbol Interference (ISI) and Bandwidth in an optical fiber. (13)	CO2	BTL 4	Analyzing
8.	(i) Illustrate the Intramodal Dispersion. (4) (ii) A 20 km long optical fiber exhibits <i>nrms</i> pulse broadening of 20 ns due to material dispersion alone, when the power is launched from an LED operating at 850 nm with a spectral width of 30nm. Calculate the material	CO2	BTL 3	Applying

	dispersion parameter of the fiber. (4) (iii) A silica fiber operating at 650 nm has a core refractive index of 1.46. The photo elastic coefficient and isothermal compressibility of the silica glass are 0.3 and $7 \times 10^{-11} m^2/N$ respectively. Identify the loss due to Rayleigh scattering in the fiber assuming the fictive temperature of glass to be 1400 K. (5)			
9.	Illustrate the material dispersion mechanism with necessary mathematical expressions. (13)	CO2	BTL 4	Analyzing
10.	Examine the waveguide dispersion mechanism with suitable mathematical expressions. (13)	CO2	BTL 4	Analyzing
11.	Inspect the waveguide dispersion in a single mode fiber in detail. (13)	CO2	BTL 4	Analyzing
12.	Determine the Polarization mode dispersion with suitable diagram. (13)	CO2	BTL 4	Analyzing
13.	Illustrate the Intermodal Dispersion and Pulse broadening in a multimode Step-Index Fiber with necessary equations. (13)	CO2	BTL 3	Applying
14.	Examine the following. (i) RMS Pulse Broadening. (10) (ii) Intermodal Dispersion in a Multimode Graded-Index Fiber. (3)	CO2	BTL 3	Applying
15.	Analyze the functional characteristics of the following with respect to single mode fiber: (i) Refractive-Index profiles. (5) (ii) Cutoff Wavelength. (3) (iii) Dispersion calculation. (5)	CO2	BTL 4	Analyzing
16.	(i) Describe the dispersion optimization of single mode fibers. (3) (ii) Determine the dispersion-shifted and dispersion-flattened fibers. (10)	CO2	BTL 4	Analyzing
17.	(i) A 50 km long optical fiber link operating at 850 nm offers an average attenuation of 0.5 dB / km. An optical power of 100 $\mu$ W is launched into the fiber at the input. What is the value of optical power at a distance of 30 km from the input? Also express the power in $\mu$ W and in dBm. Calculate	CO2	BTL 3	Applying

	<p>the output power at the end of the link? (7)</p> <p>(ii) Consider a 10 km optical fiber link using a multimode step-index fiber with the following parameters: Core refractive index, <math>n_1 = 1.458</math>; Relative index deviation <math>\Delta = 0.002</math>. Estimate the delay time difference between the axial ray and the most oblique ray. What is the value of rms pulse broadening due to intermodal dispersion? Estimate the bandwidth and the maximum bit-rate of transmission assuming RZ formatting and neglecting intramodal dispersion.</p> <p>(6)</p>			
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**PART - C**

1.	<p>(i) Illustrate about attenuation and formulate the attenuation units in an optical fiber. (3)</p> <p>(ii) When the mean optical power launched into an <math>8km</math> length of fiber is <math>120 \mu W</math>, the mean optical power at the fiber output is <math>3 \mu W</math>. Estimate:</p> <ol style="list-style-type: none"> <li>a) The overall signal attenuation or loss in decibels through the fiber assuming there are no connectors or splices.</li> <li>b) The signal attenuation per kilometre for the fiber.</li> <li>c) The overall signal attenuation for a <math>10 km</math> optical link using the same fiber with splices at <math>1km</math> intervals, each giving an attenuation of <math>1dB</math>.</li> <li>d) The numerical input and output power ratio in (c).</li> </ol> <p>(8)</p> <p>(iii) <math>150 \mu W</math> Optical power is launched at the input of a <math>10 km</math> long optical fiber link operating at <math>850 nm</math>. The output power available is <math>5\mu W</math>. Estimate the total attenuation in <math>dB</math> over the link length neglecting all connector and splice losses. Calculate the average attenuation per <math>k</math> <math>m</math> <math>?</math></p> <p style="text-align: right;">(4)</p>	CO2	BTL 3	Applying
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2.	<p>(i) A <math>\frac{50}{125}</math>mm GI fiber with a parabolic index profile has a core refractive index of 1.458 at the centre of the core and a relative index deviation of <math>\Delta = 0.01</math>. Estimate the number of modes supported by the fiber at 850 nm. The fiber is now uniformly bent with a radius of curvature of 2cm. Estimate the expected number of modes to be radiated out due to bending of the fiber. (10)</p> <p>(ii) A <math>\frac{62.5}{125}</math>mm step-index fiber has a core and cladding refractive index values of 1.50 and 1.48 respectively at a wavelength of operation of 1330 nm. Calculate the value of the critical radius of curvature from the view point of macro-bending loss. (5)</p>	CO2	BTL 3	Applying
3.	<p>Analyze the various design techniques for tailoring the dispersion optimization of single mode fibers.</p> <p>(i) Dispersion-flattened Fiber (DFF) (9)</p> <p>(ii) Polarization Maintaining Fibers. (6)</p>	CO2	BTL 4	Analyzing
4.	<p>(i) A multimode step-index fiber has a numerical aperture of 0.22 and a core refractive index of 1.458. The fiber exhibits an overall intramodal dispersion of <math>200 \text{ ps km}^{-1}</math>. Compute overall value of the rms pulse broadening per kilometre of the fiber when the LED source operating at 850nm has an rms spectral width of 40nm. Estimate the bandwidth of a <math>n_1 = 10 \text{ km}</math> link based on this fiber. (5)</p> <p>(ii) Illustrate the Mode-Field Diameter with necessary diagrams and expressions. (10)</p>	CO2	BTL 3	Applying
5.	<p>Analyze the optimum refractive-index profile of a graded-index fiber with relevant mathematical expressions. (15)</p>	CO2	BTL 4	Analyzing

**UNIT – III: OPTICAL SOURCES AND DETECTORS**

*Sources:* Intrinsic and extrinsic material-direct and indirect band gaps-LED-LED structures surface emitting LED-Edge emitting LED-Quantum efficiency and LED power-Light source materials-Modulation of LED-LASER diodes-Modes and threshold conditions-Rate equations-external quantum efficiency-Resonant Frequencies-Structures and radiation patterns-Single mode laser-External Modulation-Temperature effect.

*Detectors:* PIN photo detector-Avalanche photo diodes-Photo detector noise-Noise sources-SNR-detector response time-Avalanche multiplication noise-Temperature effects comparisons of photo detectors.

**PART-A**

<b>Q. No</b>	<b>Questions</b>	<b>CO</b>	<b>BT Level</b>	<b>Domain</b>
1.	Why indirect band gap material is preferred for optical sources?	CO 3	BTL 1	Remembering
2.	Draw the energy level diagram of P & N type semiconductor.	CO 3	BTL 1	Remembering
3.	Find the peak emission wavelength of an LED that uses Al <sub>0.11</sub> Ga <sub>0.89</sub> AS as active region.	CO 3	BTL 1	Remembering
4.	Define internal quantum efficiency of LED.	CO 3	BTL 1	Remembering
5.	What is meant by hetero junction? Write its advantages.	CO 3	BTL 1	Remembering
6.	The carrier recombination lifetime for an LED is 10ns. Find the optical bandwidth of the LED.	CO 3	BTL 1	Remembering
7.	Why silicon is not used to fabricate LED or laser diodes?	CO 3	BTL 1	Remembering
8.	Summarize the types of LED structures.	CO 3	BTL 2	Understanding
9.	What are the several drawbacks of LED when compared to the injection lasers?	CO 3	BTL 1	Remembering
10.	State the mechanisms behind the lasing action.	CO 3	BTL 1	Remembering
11.	Identify the expression for the laser diode rate equation.	CO 3	BTL 2	Understanding
12.	Choose the reflectivity's of the mirror, if a Fabry-Perot cavity resonator has uncoated facets working as mirrors. The cavity refractive index is 3.7 and the surrounding medium is air.	CO 3	BTL 1	Remembering

13.	Compare the optical sources LED with Laser.			CO 3	BTL 2	Understanding	
14.	Summarize the stimulated absorption.			CO 3	BTL 2	Understanding	
15.	A FP injection laser diode operates at 850 nm and has a cavity 20 $\mu$ m. Find the divergence angle of emitted beam in lateral and transverse direction of the cavity assuming the thickness of active region is 2 $\mu$ m.			CO 3	BTL 2	Understanding	
16.	Classify the types of laser structures.			CO 3	BTL 2	Understanding	
17.	List the advantages of pin photodiodes.			CO 3	BTL 1	Remembering	
18.	Outline the drawbacks of avalanche photodiode.			CO 3	BTL 2	Understanding	
19.	Interpret the modes of cavity.			CO 3	BTL 2	Understanding	
20.	Name the factors that determine the response time of the photodiode.			CO 3	BTL 1	Remembering	
21.	Summarize the noise sources in photodiode.			CO 3	BTL 2	Understanding	
22.	Identify the photo generated current. The photons of energy $1.53 \times 10^{-19}$ J are incident on a photodiode which has the responsivity of 0.65 A/W, if the optical power level is 10 $\mu$ W.			CO 3	BTL 2	Understanding	
23.	Outline the responsivity and quantum efficiency of photodiode.			CO 3	BTL 2	Understanding	
24.	Compare any two parameters of Si, Ge, InGaAs pin and avalanche photodiodes.			CO 3	BTL 2	Understanding	
<b>PART-B</b>							
1.	(i)	Identify the direct band gap and indirect band gap semiconductors and examine it with necessary diagrams.	(7)	CO 3	BTL 3	Applying	
	(ii)	Choose the appropriate materials used for the preparation of LED.	(6)				
2.	Determine the N-type semiconductor and P-type semiconductor with relevant diagrams.			(13)	CO 3	BTL 4	Analyzing
3.	(i)	Construct the diagram of a surface emitting LED and examine it.	(10)	CO 3	BTL 3	Applying	
	(ii)	Interpret the term emission response time.	(3)				
4.	Analyze the working principle of Edge emitting LED with necessary diagrams.			(13)	CO 3	BTL 4	Analyzing
5.	(i)	Evaluate the expression of internal quantum efficiency and the internal power generated in the LED.	(7)	CO 3	BTL 4	Analyzing	

	(ii)	A double hetero junction InGaAsP LED emitting at a peak wavelength of 1310 nm has radiative and non-radiative recombination times of 30 and 100 ns resp. The drive current of 40mA. Calculate the bulk recombination time, internal quantum efficiency and internal power level.	(6)			
6.		Estimate the external quantum efficiency and the external power generated in the LED with necessary equations.	(13)	CO 3	BTL 3	Applying
7.	(i)	Determine the concept of modulation in an LED.	(3)	CO 3	BTL 3	Applying
	(ii)	The minority carrier recombination life time for an LED is 5ns.when a constant d.c current is applied to the device the optical power is 300μW. Calculate the optical output power when the device is modulated with an rms drive current corresponding to the d.c drive current at frequencies of (a) 20 MHz (b) 100MHz.  Further determine the 3dB optical bandwidth for the device and estimate the 3dB electrical bandwidth assuming Gaussian response	(10)			
8.	(i)	Construct the Fabry-Perot resonator cavity laser diode with necessary diagram also derive the threshold condition for lasing.	(8)	CO 3	BTL 3	Applying
	(ii)	A Fabry-Perot laser diode with a 400μm long cavity uses GaAs as the material in the active region with uncoated facets. The cavity offers an average loss of 1000 m <sup>-1</sup> at the operating wavelength. Calculate the value of the threshold gain assuming the refractive index of GaAs to be 3.6.	(5)			
9.	(i)	Determine the expression for Laser diode rate equation.	(8)	CO 3	BTL 3	Applying
	(ii)	A given GaAlAs laser diode has an optical cavity length of 300μm and 100μm width. At a normal operating temperature, the gain factor $\beta = 21 \times 10^{-3} \text{ A cm}^3$ and loss coefficient $\alpha = 10 \text{ cm}^{-1}$ . Assume the reflectivity is $R_1 = R_2 = R = 0.32$ for each end face. Calculate the threshold	(5)			

		current density and threshold current for the device?				
10.		Examine the various structures of laser diode and its radiation pattern with neat diagram.	(13)	CO 3	BTL 3	Applying
11.	(i)	Illustrate the nature of double heterostructure laser diode with energy band diagram and refractive index profile.	(8)	CO 3	BTL 3	Applying
	(ii)	A double heterostructure laser diode operating at $0.87\mu\text{m}$ has an active layer thickness of $0.2\mu\text{m}$ . The refractive index of active region is 3.59 and that the confining region is 3.25. Estimate the optical confining factor.	(5)			
12.	(i)	Analyze the expression for resonant frequency in laser diode.	(8)	CO 3	BTL 4	Analyzing
	(ii)	A GaAs laser operating at $850\text{nm}$ has a $500\mu\text{m}$ length and refractive index $n=3.7$ . Examine the following a) Frequency spacing b) Wavelength spacing c) Number of modes	(5)			
13.	(i)	Inspect how lasing occurs in lasers with the help of population inversion and optical feedback?	(6)	CO 3	BTL 4	Analyzing
	(ii)	Compare the DFB, DBR and DR laser structures with built in frequency selective resonator gratings.	(7)			
14.	(i)	Examine the working principle of p-i-n photodiode with a neat diagram.	(10)	CO 3	BTL 4	Analyzing
	(ii)	Calculate the responsivity of p-i-n photodiode if the quantum efficiency is around 90 percent and operating wavelength is $1300\text{nm}$ .	(3)			
15.	(i)	Determine the working principle of Avalanche photodiode	(10)	CO 3	BTL 4	Analyzing
	(ii)	A silicon avalanche photodiode has a quantum efficiency of 65 percent at a wavelength of $900\text{ nm}$ . Suppose $0.5\mu\text{W}$ of optical power produces a multiplied photocurrent of $10\mu\text{A}$ .	(3)			

		Calculate the multiplication M.				
16.		Analyze the excess noise in APD and derive the expression for excess noise factor.	(13)	CO 3	BTL 4	Analyzing
17.		Examine the characteristics of a general photo detector.	(13)	CO 3	BTL 4	Analyzing
<b>PART-C</b>						
1.		Demonstrate the types of LED structures with neat diagrams.	(15)	CO 3	BTL 3	Applying
2.	(i)	Determine electro optic phase modulator and electro absorption modulator.	(7)	CO 3	BTL 4	Analyzing
	(ii)	The threshold current of AlGaAs laser diode at 20°C is 3100mA. The threshold temperature of the device is $T_0=180K$ . Evaluate the percentage change in threshold current when the temperature of the device is increased to 60°C.	(8)			
3.	(i)	Describe the signal-to-noise ratio of p-i-n photo diode.	(8)	CO 3	BTL 3	Applying
	(ii)	An InGaAs pin photo diode has the following parameters at a wavelength of 1300 nm. $I_D=4nA$ , $\eta=0.90$ , $R_L=1000 \Omega$ and the surface leakage current is negligible. The incident optical power is 300nW and the receiver bandwidth is 20MHz. Calculate the various noise terms of the receiver.	(7)			
4.	(i)	Analyze the different factors that determine the response time of photo detector.	(8)	CO 3	BTL 4	Analyzing
	(ii)	In Si P-i-n photo detector, the width of i-region is $5\mu m$ and a device area is $0.5 \times 10^{-7} m^2$ . The load resistance and input resistance of the amplifier are $1k\Omega$ and $3k\Omega$ resp. The input capacitance of the amplifier is 5pF. The relative permittivity of Si is 11.9 and the saturation velocity of the carriers in Si is $10^5 m/s$ . Calculate junction capacitance, bandwidth of photo detector, total resistance and capacitance and bandwidth of photo detector in absence of circuit elements.	(7)			

5.	Illustrate the concept of photo detector and compare the photo detectors by their generic operating parameters of Si, Ge and InGaAs.	(15)	CO 3	BTL 4	Analyzing
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**UNIT – IV: OPTICAL RECEIVER, MEASUREMENTS AND COUPLING**

Fundamental receiver operation-Preamplifiers-Digital signal transmission-Error Sources-Front end amplifiers-Digital receiver performance-Probability of error-Receiver sensitivity-Quantum limit. Optical power measurement-Attenuation Measurement-Dispersion measurement- Fiber numerical Aperture Measurements- Fiber cut-off Wave length Measurements- Fiber diameter measurements-Source to Fiber Power Launching-Lensing Schemes for Coupling Management-Fiber to Fiber Joints-LED Coupling to Single Mode Fibers-Fiber Splicing Optical Fiber connectors.

**PART-A**

<b>Q.No</b>	<b>Questions</b>	<b>CO</b>	<b>BT Level</b>	<b>Domain</b>
1.	What is bit period $T_b$ ?	CO 4	BTL 1	Remembering
2.	Define threshold level.	CO 4	BTL 1	Remembering
3.	List the error sources associated with fiber optic receiver section.	CO 4	BTL 1	Remembering
4.	Summarize the term 'Quantum limit'.	CO 4	BTL 2	Understanding
5.	Interpret the term 'bit error rate'.	CO 4	BTL 2	Understanding
6.	List out the different types of preamplifiers.	CO 4	BTL 1	Remembering
7.	Summarize the advantages of trans-impedance amplifier.	CO 4	BTL 2	Understanding
8.	What is meant by receiver sensitivity?	CO 4	BTL 1	Remembering
9.	Name the methods employed for measuring dispersion in optical fiber.	CO 4	BTL 1	Remembering
10.	Interpret the significance of maintaining the fiber outer diameter constant.	CO 4	BTL 2	Understanding
11.	Mention the principle of cutback technique.	CO 4	BTL 2	Understanding
12.	Identify some dispersion measurement techniques for optical fiber.	CO 4	BTL 2	Understanding
13.	What type of power measured in digital transmission and reception?	CO 4	BTL 1	Remembering

14.	An OTDR is used to measure the attenuation of a long length of fiber. If the optical power level measured by the OTDR at 8-km point is 0.5 of the measured value at the 3-km point, what is the fiber attenuation?		CO 4	BTL 2	Understanding
15.	Define radiance and write down the expression for Lambertian source.		CO 4	BTL 1	Remembering
16.	Summarize the principal requirements of a good connector.		CO 4	BTL 2	Understanding
17.	Categorize the lensing scheme to improve optical source to fiber coupling efficiency.		CO 4	BTL 2	Understanding
18.	Write about the 3-dB optical bandwidth.		CO 4	BTL 1	Remembering
19.	Classify some common end face defects happen in fiber.		CO 4	BTL 2	Understanding
20.	An optical source with circular output pattern is closely coupled to step-index fiber that has a numerical aperture of 0.22. if the source radius $R_s = 50\mu\text{m}$ and fiber core radius $a=25\mu\text{m}$ , Find the maximum coupling efficiency from the source into the fiber.		CO 4	BTL 1	Remembering
21.	An engineer makes a joint between two identical step-index fibers. Each fiber has a core diameter of $50\mu\text{m}$ . If the two fibers have an axial or lateral misalignment of $5\mu\text{m}$ , Identify the insertion loss at the joint.		CO 4	BTL 2	Understanding
22.	Two identical step index fibers each have a $25\mu\text{m}$ core radius and an acceptance angle of $14^\circ$ . Assume the two fibers are perfectly axially and angularly. Infer the insertion loss for a longitudinal separation of $0.025\text{mm}$ .		CO 4	BTL 2	Understanding
23.	Suppose two identical graded index fibers are misaligned with an axial offset of $d= 0.3$ . What is the power coupling loss between these two fibers?		CO 4	BTL 1	Remembering
24.	Write the formula for the angular coupling efficiency formula.		CO 4	BTL 1	Remembering
<b>PART-B</b>					
1.	Describe the block diagram of fundamental optical receiver and determine each block with the intermediate signals at each stage.	(13)	CO 4	BTL 3	Applying
2.	Identify the various error sources associated with the receiver system.	(13)	CO 4	BTL 3	Applying
3.	Inspect the front-end amplifiers with neat diagrams.	(13)	CO 4	BTL 3	Applying

4.	Analyze the performance measures of a digital receiver and derive the expression for bit error rate of a digital receiver.		(13)	CO 4	BTL 4	Analyzing
5.	(i)	Determine the receiver sensitivity in detail.	(8)	CO 4	BTL 4	Analyzing
	(ii)	Examine the term 'Quantum limit' and derive the expression for receiver sensitivity of an digital receiver.	(5)			
6.	(i)	Illustrate the cutback technique for finding the attenuation of an optical fiber.	(8)	CO 4	BTL 3	Applying
	(ii)	An engineer wants to find the attenuation at 1310 nm of a 4.95-km long fiber. The only available instrument is a photo detector, which gives an output reading in volts. Using this device in a cutback-attenuation setup, the engineer measures an output of 2.21 V from the photodiode at the far end of the fiber, after cutting the fiber 2m from the source, the output voltage from the photo detector now reads 6.58 V. Calculate the attenuation of the fiber in dB/km.	(5)			
7.	Summarize the following			CO 4	BTL 3	Applying
	(i)	Power launching and coupling.	(4)			
	(ii)	Source output pattern.	(4)			
	(iii)	Power coupling calculations.	(5)			
8.	(i)	In what way the insertion loss method is better to measure the attenuation of cables?	(8)	CO 4	BTL 4	Analyzing
	(ii)	Find the insertion loss of the device, when the power at the photo detector prior to inserting filter is $P_1=0.51\text{mW}$ and power level with the optical filter in the link $P_2=0.43\text{mW}$ .	(5)			
9.	Elaborate the cut off wavelength measurements of a fiber with suitable diagrams.		(13)	CO 4	BTL 4	Analyzing
10.	(i)	Describe the typical experimental arrangement and brief the measurement process of diameter of the fiber.	(8)	CO 4	BTL 3	Applying
	(ii)	The shadow method is used for the on-line measurement of the outer diameter of an optical fiber. The apparatus	(5)			

		employs a rotating mirror with an angular velocity of $4 \text{ rad s}^{-1}$ which is located 10 cm from the photo detector. At a particular instant in time a shadow pulse of width $300\mu\text{s}$ is registered by the photo detector. Estimate the outer diameter of the optical fiber in $\mu\text{m}$ at this instant in time.				
11.	(i)	Analyze the numerical aperture measurement of an optical fiber with neat diagram.	(10)	CO 4	BTL 4	Analyzing
	(ii)	The trigonometrical measurement is performed in order to determine the numerical aperture of the step index fiber. The screen is positioned 10.0 cm from the fiber end face. When illuminated from a wide-angled visible source the measured output pattern size is 6.2 cm. Estimate the approximate numerical aperture of the fiber.	(3)			
12.		Compare the different types of lensing schemes used to improve the coupling efficiency and also derive the expression for it.	(13)	CO 4	BTL 4	Analyzing
13.	(i)	Classify the fiber related losses that occurs in joining two fibers and also calculate the coupling loss if the refractive index profiles of receiving and emitting fiber are 1.98 and 2.20 respectively.	(10)	CO 4	BTL 3	Applying
	(ii)	Consider two step index fibers that are perfectly aligned. Calculate the coupling loss if the numerical aperture of receiving fiber and emitting fiber is 0.20 and 0.22 respectively.	(3)			
14.		Distinguish various splicing techniques with necessary diagrams and also give the expression for various losses when splicing single mode fibers.	(13)	CO 4	BTL 4	Analyzing
15.		Classify the connector types and compare the six popular fiber optic connectors with their features and applications.	(13)	CO 4	BTL 4	Analyzing
16.	(i)	Illustrate the process of fiber end face preparation.	(7)	CO 4	BTL 3	Applying

	(ii)	Estimate the coupling efficiency of LED power to SM fiber.	(6)			
17.	(i)	Categorize the fiber related losses in detail.	(9)	CO 4	BTL 4	Analyzing
	(ii)	List the features of MU connector.	(4)			
<b>PART-C</b>						
1.		Determine the probability of error in digital data transmission and reception.	(15)	CO 4	BTL 3	Applying
2.		Analyze the methods of dispersion measurements in optical fiber.	(15)	CO 4	BTL 4	Analyzing
3.		Compare the different mechanical misalignments in fiber coupling also derive the loss expression for those misalignments.	(15)	CO 4	BTL 3	Applying
4.		Determine the expression for power coupling from LED to step index and graded index fibers.	(15)	CO 4	BTL 4	Analyzing
5.	(i)	An optical fiber has a core refractive index of 1.5. Two lengths of the fiber with smooth and perpendicular (to the core axes) end faces are butted together. Assuming the fiber axes are perfectly aligned, calculate the optical loss in decibels at the joint (due to Fresnel reflection) when there is a small air gap between the fiber end faces.	(4)	CO 4	BTL 4	Analyzing
	(ii)	A graded index fiber has a parabolic refractive index profile ( $\alpha = 2$ ) and a core diameter of 50 $\mu\text{m}$ . Evaluate the insertion loss due to a 3 $\mu\text{m}$ lateral misalignment at a fiber joint when there is index matching and assuming:				
		(a) there is uniform illumination of all guided modes only. (b) there is uniform illumination of all guided and leaky modes.	(3) (3)			
(iii)	Two single-mode fibers with mode-field diameters of 9.2 $\mu\text{m}$ and 8.4 $\mu\text{m}$ are to be connected together. Assuming no extrinsic losses, predict the loss at the	(5)				

		connection due to the mode-field diameter mismatch.				
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### UNIT V - OPTICAL COMMUNICATION SYSTEMS AND NETWORKS

Elements of optical networks-SONET/SDH Optical Interfaces-SONET/SDH Rings and Networks-Optical ETHERNET-Soliton. Optical network concepts - Optical network transmission modes, layers and protocols - Wavelength routing networks - Optical switching networks - Optical network deployment - Optical Ethernet.

#### PART - A

Q.No	Questions	CO	BT Level	Competence
1.	Define optical network.	CO5	BTL 1	Remembering
2.	Identify the advantages of an optical network.	CO5	BTL 1	Remembering
3.	What is meant by connection?	CO5	BTL 1	Remembering
4.	List out the different layers in SONET architecture.	CO5	BTL 1	Remembering
5.	Interpret the function of photonic layer.	CO5	BTL 2	Understanding
6.	How STS-1 frame is organized?	CO5	BTL 1	Remembering
7.	Outline the types of topologies available in SONET architecture.	CO5	BTL 2	Understanding
8.	Summarize the applications of SONET/SDH.	CO5	BTL 2	Understanding
9.	Define soliton.	CO5	BTL 1	Remembering
10.	Mention the characteristics of higher order solitons.	CO5	BTL 2	Understanding
11.	Outline the principle of modularity.	CO5	BTL 2	Understanding
12.	Define scalability.	CO5	BTL 1	Remembering
13.	Identify the functions of OADM.	CO5	BTL 2	Understanding
14.	Summarize the layers in OSI reference model.	CO5	BTL 2	Understanding
15.	Summarize the nature of fixed wavelength nodes.	CO5	BTL 2	Understanding
16.	What is optical circuit switched networks?	CO5	BTL 1	Remembering
17.	Define optical packet switched networks.	CO5	BTL 1	Remembering
18.	Interpret about the multiprotocol label switching.	CO5	BTL 2	Understanding

19.	Compare reverse limited duration and reverse fixed duration.		CO5	BTL 2	Understanding
20.	List the functions of DWDM.		CO5	BTL 1	Remembering
21.	Compare WDM and DWDM.		CO5	BTL 2	Understanding
22.	Outline the concept of optical ethernet.		CO5	BTL 2	Understanding
23.	What is the basic principle behind the virtual concatenation?		CO5	BTL 1	Remembering
24.	Draw the ethernet frame format structure.		CO5	BTL 1	Remembering
<b>PART - B</b>					
1.	Draw and explain the elements of optical networks with neat diagrams.	(13)	CO5	BTL 3	Applying
2.	Determine the following		CO5	BTL 4	Analyzing
(i)	Why SONET/SDH is needed in optical networks?	(4)			
(ii)	Transmission formats and speeds.	(5)			
(iii)	SONET and SDH transmissions rates.	(4)			
3.	Analyze the layers of SONET with neat sketches.	(13)	CO5	BTL 4	Analyzing
4.	Identify the basic concepts of SONET/SDH network and write it in detail.	(13)	CO5	BTL 3	Applying
5.	Analyze the optical network concepts with necessary diagrams.	(13)	CO5	BTL 4	Analyzing
6.	Illustrate the following in Optical networking terminology		CO5	BTL 4	Analyzing
(i)	Network topology	(3)			
(ii)	Network architecture	(4)			
(iii)	Networking modes	(3)			
(iv)	Network switching modes	(3)			
7.	Summarize the concepts of the virtual circuits, networking routing, modularity and scalability in optical network.	(13)	CO5	BTL 3	Applying
8.	Elaborate the performance of optical network node and switching elements in optical network with suitable diagrams.	(13)	CO5	BTL 4	Analyzing
9.	Describe the concept of wavelength dependent interconnection in wavelength routing networks.	(13)	CO5	BTL 3	Applying

10.	Describe the wavelength convertible routing network architectures with neat diagrams.		(13)	CO5	BTL 3	Applying
11.	Examine the routing and wavelength assignment with diagrams.		(13)	CO5	BTL 4	Analyzing
12.	Illustrate the concept of optical circuit switched networks.		(13)	CO5	BTL 4	Analyzing
13.	Elaborate the functions of optical packet switched networks with neat diagrams.		(13)	CO5	BTL 4	Analyzing
14.	Analyze the multiprotocol label switching.		(13)	CO5	BTL 4	Analyzing
15.	Describe the optical burst switching networks with suitable diagrams.		(13)	CO5	BTL 3	Applying
16.	Explain the following			CO5	BTL 3	Applying
	(i)	Long haul networks	(6)			
	(ii)	Metropolitan area networks	(7)			
17.	Illustrate the concepts of an optical ethernet with relevant diagrams.		(13)	CO5	BTL 3	Applying

**PART – C**

1.	(i)	Construct the SONET frame structure and illustrate it in detail.	(8)	CO5	BTL 3	Applying
	(ii)	Examine in detail about the waveband switching network architecture employing a multigranular optical cross-connect with diagrams.	(7)			
2.	Classify the types of SONET/SDH rings and networks with necessary diagrams.		(15)	CO5	BTL 3	Applying
3.	Analyze the salient features of solitons using relevant expressions and diagrams.		(15)	CO5	BTL 4	Analyzing
4.	Illustrate the optical network transmission modes, layers and protocols with suitable diagrams.		(15)	CO5	BTL 4	Analyzing
5.	Inspect the access networks and local area networks in an optical network deployment with neat diagrams.		(15)	CO5	BTL 4	Analyzing