INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

ELECTRONICS AND COMMUNICATION ENGINEERING

TUTORIAL QUESTION BANK

Course Title	**OPTICAL COMMUNICATION**				
Course Code	**AEC018**				
Programme	B.Tech				
Semester	VIII	ECE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	-	3	-	-
Chief Coordinator	Mr. U Soma Naidu , Assistant Professor				
Course Faculty	Mr. U Soma Naidu , Assistant Professor				

COURSE OBJECTIVES:

The course should enable the students to:

S. No	Description
I.	Understand the different kind of losses, signal distortion in optical wave guides and other signal degradation factors. Design optimization of SM fibers, RI profile and cut-off wave length.
II.	Interpret various optical source materials, LED structures, quantum efficiency, Laser diodes and different fiber amplifiers.
III.	Understand fiber optical receivers such as PIN APD diodes, noise performance in photo detector, receiver operation and configuration.
IV.	Analyze fiber slicing and connectors, noise effects on system performance, operational principles WDM and solutions.

COURSE OUTCOME (COs):

CO 1	Overview Of Optical Fiber Communication, Vector Nature Of light, types of optical fibers, modal analysis.
CO 2	Understand Signal Degradation And Optical Sources, Attenuation- Absorption, Material Dispersion, Optical sources, Principles of operation.
CO 3	Understand Optical Detectors, Optical Erectors, Sensitivity And Quantum Efficiency, WDM Concepts And Components.
CO 4	Understand Optical Amplifiers, Basic concepts, semiconductor amplifier, principles of operation, intermediation effects
CO 5	Understand Optical Networks And Dispersion Compensation, Optical networks, soliton based communication system design.

COURSE LEARNING OUTCOMES (CLOs):

AEC018.01	Understand Basic principles of optical fiber Communications,
AEC018.02	Define light, propagation of light, modes, propagation of light different levels
AEC018.03	Given the propagation of light in a cylindrical dielectric rod; rays and modes types of optical fibers
AEC018.04	Given the Photonic components in optical communication systems ,
AEC018.05	Understand modal analysis of a step index fiber, linearly polarized modes, single mode fibers and graded - index fiber
AEC018.06	Understand Signal Degradation And Optical Sources, Attenuation- Absorption, scattering losses, bending losses, core
AEC018.07	Explain cladding losses, optical waveguides; Material Dispersion, Waveguide Dispersion; Optical sources
AEC018.08	Explain Semiconductor device fabrication, LED and LASER diode; Principles of operation, concepts of line width,
AEC018.09	Understand phase noise, switching and modulation characteristics
AEC018.10	Define Optical detectors: pin detector, avalanche photodiode
AEC018.11	Understand Principles of operation, concepts of responsively, sensitivity and quantum efficiency, noise in detection.
AEC018.12	Explain Multichannel Transmission Technique-Multichannel Frequency Modulation, Subcarrier multiplexing. WDM Concepts and Components
AEC018.13	Understand semiconductor amplifier, erbium-doped fiber amplifier, Raman amplifier, Brillouin amplifier
AEC018.14	Understand principles of operation, amplifier noise, signal to noise ratio, gain, gain bandwidth, gain
AEC018.15	Explain noise dependencies, inter modulation effects, saturation induced crosstalk, wavelength range of operation
AEC018.16	Design Optical networks-SONET/SDH, ATM, IP, wavelength routed networks, soliton communication system,
AEC018.17	Understand fiber soliton, soliton based communication system design, high capacity and WDM soliton.

UNIT-I OVERVIEW OF OPTICAL FIBRE COMMUNICATION				
PART-A (SHORT ANSWER QUESTIONS)				
S. No	**QUESTION**	**Blooms Taxonomy Level**	**Course Outcomes**	**Course learning Outcome**
1	What is vector nature of Light	Remember	CO 1	AEC018.01
2	How light is propagated?	Understand	CO 1	AEC018.02
3	How light is propagated in cylindrical dielectric rod?	Understand	CO 1	AEC018.03
4	How light is propagated in free Space?	Remember	CO 1	AEC018.04
5	What are motivations for Light wave Communication	Understand	CO 1	AEC018.05
6	What are the methods used to measure fiber refractive index profile?	Remember	CO 1	AEC018.01
7	Give applications of Optical Fibers	Understand	CO 1	AEC018.02
8	What are the spectral bands used for Optical Fiber Communication	Understand	CO 1	AEC018.03
9	Write the refractive index expression for graded index fiber	Understand	CO 1	AEC018.04
10	What are advances of Optical Fibers	Remember	CO 1	AEC018.05
11	Write short notes on ray optics theory.	Remember	CO 1	AEC018.01
12	What are the advantages and disadvantages of the ray optics?	Remember	CO 1	AEC018.02
13	What is meant by refractive index of the material?	Understand	CO 1	AEC018.03
14	What is the energy of the single photon of the light whose $\lambda = 1550nm$ in eV?	Remember	CO 1	AEC018.04
15	What are the conditions for total internal reflection?	Understand	CO 1	AEC018.05
16	State Snell's law.	Understand	CO 1	AEC018.01
17	Define - Numerical Aperture	Understand	CO 1	AEC018.02
18	Define – Relative Refractive Index Difference	Understand	CO 1	AEC018.03
19	Define - Acceptance angle	Understand	CO 1	AEC018.04
20	What are meridional rays?	Remember	CO 1	AEC018.05
21	State Snell's Law.	Understand	CO 1	AEC018.04
22	What is the need of Cladding?	Remember	CO 1	AEC018.05
23	Mention the advantages of Graded Index fiber.	Understand	CO 1	AEC018.04
24	Differentiate between single mode and multimode fiber.	Understand	CO 1	AEC018.04
25	What is meant by mode and index profile?	Remember	CO 1	AEC018.05
26	Define MFD?	Understand	CO 1	AEC018.04
27	Differentiate multimode and single mode fibers.	Understand	CO 1	AEC018.04
28	Explain step index and graded index fiber in detail.	Understand	CO 1	AEC018.04
29	Draw the block diagram of general communication system and fiber optics communication system	Understand	CO 1	AEC018.04
30	What are the main components of fiber optics communication system?	Remember	CO 1	AEC018.05
PART-B (LONG ANSWER QUESTIONS)				
1	A step index fiber has the normalized frequency of 26.6 at 1300nm. If the core radius is 25μm, find the numerical aperture.	Remember	CO 1	AEC018.03
2	Write a short note on single mode fiber, List out the advantages of multimode fiber over single mode fibers.	Understand	CO 1	AEC018.04
3	The relative refractive index difference (Δ) for an optical fiber is 1%. Determine the critical angle at the core cladding interface if the co rerefractive index is 1.46.	Understand	CO 1	AEC018.05
4	What are the uses of optical fibers? Draw the block diagram of an optical communication system.	Remember	CO 1	AEC018.01
5	Assume that there is glass rod of refractive index 1.5, surrounded by air. Find the critical incidence angle.	Understand	CO 1	AEC018.02
6	Why is step index single mode fiber preferred for long distance communication?	Remember	CO 1	AEC018.03
7	tate how mode- field diameter is related to the single mode fiber. What are the propagation modes in them? Draw a neat diagram and explain the ray theory behind the optical fiber communication with a special mention about the total.	Understand	CO 1	AEC018.04
8	A silica optical fiber with a large core diameter has a core refractive index of 1.5 and a cladding refractive index of 1.47.Determine the	Understand	CO 1	AEC018.05

	acceptance angle in air for the fiber.			
9	Compare the optical link with that of the satellite link .Explain the differences between meridional and skew rays. In detail.	Understand	CO 1	AEC018.01
10	Draw the block diagram of general communication system and fiber optics communication system? Explain in detail.	Understand	CO 1	AEC018.05
11	What is the structure of optical fiber? Give the advantage of optical fiber over metallic cables	Remember	CO 1	AEC018.03
12	Differentiate between step index and Graded index fiber. How the rays do propagates in graded index fiber?	Understand	CO 1	AEC018.05
13	Explain in brief the propagation characteristics of single and multimode fibers.	Understand	CO 1	AEC018.01
14	Sketch the block diagram of optical fiber communication system	Understand	CO 1	AEC018.01
15	List out various advantages of optical fiber communication system over the conventional electrical communication system.	Understand	CO 1	AEC018.02
16	Compare step index & graded index fiber?	Understand	CO 1	AEC018.05
17	Illustrate about the propagation modes in multi mode fibers?	Understand	CO 1	AEC018.04
18	Illustrate about the propagation modes in single mode fibers?	Understand	CO 1	AEC018.04
19	List the advantages of optical communication?	Understand	CO 1	AEC018.04
20	Explain the Elements of an optical fiber Transmission link.	Understand	CO 1	AEC018.04
	PART C			
1	A step index fiber has the normalized frequency of 26.6 at 1300 nm. If the core radius is 25 m, find the numerical aperture.	Remember	CO 1	AEC018.02
2	A silica optical fiber with a large core diameter has a core refractive index of 1.5 and a Cladding refractive index of 1.47. Determine the acceptance angle in air for the fiber.	Remember	CO 1	AEC018.03
3	Assume that there is a glass rod of refractive index 1.5 surrounded by air.Find the critical incidence angle.	Understand	CO 1	AEC018.04
4	For n1 = 1.55 and n2 = 1.52. calculate the critical angle and numerical aperture.	Remember	CO 1	AEC018.05
5	calculate the cut off wavelength of a single mode fibre with core radius of 4 m and index difference= 0.003	Remember	CO 1	AEC018.01
6	For a fiber with core refractive index of 1.54 and fractional refractive index difference of 0.01. Calculate its numerical aperture	Understand	CO 1	AEC018.02
7	The relative refractive index difference for an optical fiber is 1%.Determine the critical angle at the core cladding interface if the core refractive index is 1.46.	Remember	CO 1	AEC018.03
8	The relative refractive index difference between the core and the cladding of a graded index fiber is 0.7% when the refractive index at the core axis is 1.45.Estimate values for the numerical aperture of the fiber along the axis when the index profile is assumed to be triangular	Remember	CO 1	AEC018.01
9	Calculate the numerical aperture, cut-off parameter and number of modes supported by a fiber having μ1(core) = 1.54, μ2(cladding) = 1.5, core radius 25μm and operating wavelength 1300nm.	Understand	CO 1	AEC018.02
10	Calculate NA of silica fiber with its core refractive index (n1) of 1.48 and cladding refractive index of 1.46. What should be the new value of 'n' in order to change the NA to 0.23?	Remember	CO 1	AEC018.03

UNIT-II
SIGNAL DEGRADATION AND OPTICAL SOURCES

PART-A (Long Answer Questions)

S. No	QUESTION	Blooms Taxonomy Level	Course Outcomes	Course learning Outcome
1	List out the advantages of multimode fiber over single mode fibers. The advantages of multimode fiber are:	Understand	CO 2	AEC018.06

2	List the advantages and disadvantages of monomode fiber. The advantages of single mode fiber are:	Remember	CO 2	AEC018.07
3	Define – Mode Field Diameter	Understand	CO 2	AEC018.08
4	What is meant by attenuation coefficient of a fiber?	Remember	CO 2	AEC018.09
5	What are the types of material absorption losses in silica glass fibers?	Understand	CO 2	AEC018.06
6	What is meant by intrinsic absorption in optical fibers?	Remember	CO 2	AEC018.07
7	What is meant by extrinsic absorption in optical fibers?	Understand	CO 2	AEC018.08
8	Differentiate linear scattering from nonlinear scattering.	Remember	CO 2	AEC018.09
9	What are the types of linear scattering losses?	Understand	CO 2	AEC018.06
10	What are the types of nonlinear scattering losses?	Remember	CO 2	AEC018.07
11	What is meant by Fresnel Reflection?	Understand	CO 2	AEC018.08
12	What is meant by linear scattering?	Remember	CO 2	AEC018.09
13	What are the factors that cause Rayleigh scattering in optical fibers?	Understand	CO 2	AEC018.06
14	What are the factors that cause Mie scattering in optical fibers?	Remember	CO 2	AEC018.07
15	What are the ways to reduce macro bending losses?	Understand	CO 2	AEC018.08
16	Explain population inversion in case of three level LASER	Remember	CO 2	AEC018.06
17	Explain population inversion in case of four level LASER	Understand	CO 2	AEC018.07
18	Explain stimulated emission in p-n junction with the help of energy band Diagrams.	Remember	CO 2	AEC018.08
19	Write a short note on DH LASER	Understand	CO 2	AEC018.09
20	Give the advantages of LED over LASER	Remember	CO 2	AEC018.06
21	Derive the equation of coupling efficiency of LED	Understand	CO 2	AEC018.07
22	Write a short note on DH LED	Remember	CO 2	AEC018.08
23	Write a short note on SLED.	Understand	CO 2	AEC018.09
24	Write a short note on ELED.	Remember	CO 2	AEC018.06
25	List extrinsic absorption loss	Understand	CO 2	AEC018.07
26	Write a short note on Rayleigh scattering	Remember	CO 2	AEC018.08
27	Write a short note on Mie scattering	Understand	CO 2	AEC018.09
28	What are the types of linear scattering loss	Remember	CO 2	AEC018.06
29	What are the types of non linear scattering loss	Understand	CO 2	AEC018.07
30	What are the requirements of optical sources	Remember	CO 2	AEC018.08
PART-B (Long Answer Questions)				
1	What is meant by heterojunction? List out the advantages of heterojunction. Distinguish between direct and indirect band gap Materials	Understand	CO 2	AEC018.06
2	Why is silicon not used to fabricate LED or Laser diode? What are the advantages of LED?	Remember	CO 2	AEC018.07
3	What is the principle of operation of LASER? , Write the three modes of the cavity of LASER diode.	Understand	CO 2	AEC018.08
4	What is a DFB Laser? Differentiate DFB LASER from other types of LASER. What is population inversion?	Remember	CO 2	AEC018.09
5	Compare LED and ILD sources. Write the three key processes of laser action.	Understand	CO 2	AEC018.06
6	What are the advantages of Quantum Well Lasers? Define – Internal Quantum Efficiency	Remember	CO 2	AEC018.07
7	Define – External Quantum Efficiency	Understand	CO 2	AEC018.08
8	What are the factors that produce dispersion in optical fibers? What are the methods used to measure fiber dispersion?	Remember	CO 2	AEC018.09
9	Discuss in detail the intermodal dispersion with relevant expressions and Diagrams	Understand	CO 2	AEC018.06
10	Explain the effects of signal distortion in optical waveguide	Remember	CO 2	AEC018.07
11	Explain briefly various types of losses in optical fiber cable.	Understand	CO 2	AEC018.06
12	With the aid of suitable diagram, briefly discuss the following in the case opticalfiber transmission	Understand	CO 2	AEC018.08

	i.Fiber bend losses ; ii.Dispersion shifted fibers.			
13	Discuss the following terms for optical fiber: (i) Absorption (ii) Scattering losses.	Understand	CO 2	AEC018.08
14	Difference in LED and Laser.	Understand	CO 2	AEC018.08
15	Explain the principal of LASER diode	Understand	CO 2	AEC018.08
16	Mention the losses responsible for attenuation in optical fibers	Understand	CO 2	AEC018.06
17	Enlist the advantage & Disadvantages of LASER & LED.	Understand	CO 2	AEC018.06
18	Explain the characteristics of LED.	Understand	CO 2	AEC018.06
19	With the suitable diagram give the mechanism of light from an LED and its use in optical source for communication.	Understand	CO 2	AEC018.06
20	Explain briefly various types of losses in optical fiber cable.	Understand	CO 2	AEC018.06
PART-C (PROBLEM SOLVIING AND CRITICAL THINKING ANSWER QUESTIONS)				
1	A 30 km long optical fiber has an attenuation of 0.8 dB/km. If 7 dBm of optical power is launched into the fiber, determine the output optical power in dBm.	Remember	CO 2	AEC018.06
2	When an LED has 2V applied to its terminals, it draws 100mA and produces 2mW of optical power. Determine conversion efficiency of the LED from electrical to optical power.	Understand	CO 2	AEC018.07
3	An LED has radiative and nonradiative recombination times of 30 and 100 ns respectively. Determine the internal quantum efficiency	Remember	CO 2	AEC018.06
4	Calculate the external differential quantum efficiency of a laser diode operating at 1.33µm.The slope of the straight line portion of the emitted optical power P versus drive current I is given by 15 mW/mA.	Understand	CO 2	AEC018.07
5	An LED operating at 850 nm has a spectral width of 45 nm, what is the pulse spreading in ns/km due to material dispersion? What is the pulse spreading when a laser diode having a 2nm spectral width is used? The material dispersion is 90ps/nm.km.	Remember	CO 2	AEC018.08
6	An LED has radiative and non- radiative recombination times of 30 and 100 ns respectively. Determine the internal quantum efficiency	Understand	CO 2	AEC018.09
7	When a LED has 2V applied to its terminals, it draws 100 mA and produces 2 mW of optical power. Determine the conversion efficiency of the LED from electrical to optical power.	Remember	CO 2	AEC018.06
8	Calculate the external differential quantum efficiency of a LASER diode operating at 1.33 m, the slope of the straight line portion of the emitted optical power P versus drive current I is given by 15 mW/ ma.	Understand	CO 2	AEC018.07
9	Discuss the following terms for optical fiber: (i) Absorption (ii) Scattering losses.	Remember	CO 2	AEC018.08
10	What is the requirement for optical sources to feed into a fiber? Enlist the advantage & Disadvantages of LASER & LED.	Remember	CO 2	AEC018.08

UNIT-III

OPTICAL DETECTORS

PART – A (SHORT ANSWER QUESTIONS)

S. No	QUESTION	Blooms Taxonomy Level	Course Outcomes	Course learning Outcome
1	Define – Quantum efficiency of a photo detector	Remember	CO 3	AEC018.10
2	What are the necessary features of a photo detector?	Understand	CO 3	AEC018.11
3	Define – Responsively of a photo detector	Understand	CO 3	AEC018.12
4	Compare the performance of APD with PIN diode.	Understand	CO 3	AEC018.10
5	What are the drawbacks of Avalanche photo diode?	Understand	CO 3	AEC018.11
6	Define response time and list the factors that influence the response time of a photo diode.	Remember	CO 3	AEC018.12
7	Define multiplication M.	Remember	CO 3	AEC018.10

8	Give the advantages of pin photodiodes	Remember	CO 3	AEC018.11
9	Define sensitivity or minimum detectable optical power of a photo detector.	Remember	CO 3	AEC018.12
10	What are the conditions for a high signal- to- noise ratio in a Photo detector?	Remember	CO 3	AEC018.10
11	Define ionization rate.	Understand	CO 3	AEC018.11
12	What is reach- through structure?	Remember	CO 3	AEC018.12
13	Define avalanche effect.	Remember	CO 3	AEC018.10
14	Define impact ionization	Remember	CO 3	AEC018.11
	CIE-II			
15	Define quantum efficiency of a detector.	Understand	CO 3	AEC018.12
16	Define long wavelength cut off related to photodiode	Remember	CO 3	AEC018.10
17	Define responsively	Understand	CO 3	AEC018.11
18	Define photocurrent.	Remember	CO 3	AEC018.12
19	Define photo carriers	Remember	CO 3	AEC018.10
20	What is the significance of intrinsic layer in PIN diodes?	Remember	CO 3	AEC018.1
21	What are the advantages of photodiodes?	Understand	CO 3	AEC018.12
22	What are the types of photodiodes?	Remember	CO 3	AEC018.10
23	Define – Quantum Limit	Remember	CO 3	AEC018.10
24	What is meant by (1/f) noise corner frequency?	Understand	CO 3	AEC018.11
25	Why silicon is preferred to make fiber optical receivers?	Remember	CO 3	AEC018.12
26	Define – Responsively of a photo detector	Remember	CO 3	AEC018.10
27	Define – Bit Error Rate	Understand	CO 3	AEC018.11
28	Define – Extinction ratio	Remember	CO 3	AEC018.12
29	List the advantages of preamplifiers	Remember	CO 3	AEC018.10
30	How does dark current arise?	Understand	CO 3	AEC018.11
	PART – B (LONG ANSWER QUESTIONS)			
1	List out the operating wavelengths and responsivities of Si, Ge, and In GaAs photodiodes. List the benefits and drawbacks of avalanche Photo diodes.	Remember	CO 3	AEC018.10
2	What are the requirements of a photo detector? Give different types of photo detectors.	Understand	CO 3	AEC018.11
3	Draw the injection laser diode structure and explain lasing in it	Understand	CO 3	AEC018.12
4	Draw the structures of PIN and APD photo detectors and explain their Operations	Remember	CO 3	AEC018.10
5	Derive the expressions for the SNS of both PIN and APD by incorporating all noise sources	Understand	CO 3	AEC018.11
6	Draw and compare the construction and characteristics of PIN and avalanche photo diode	Understand	CO 3	AEC018.12
7	What are the desired features of a photo detector?	Remember	CO 3	AEC018.10
8	Compare the performance of APD and PIN diode.	Remember	CO 3	AEC018.11
	CIE-II			
9	Mention the benefits and drawbacks of APD	Remember	CO 3	AEC018.12
10	Why semiconductors based photo detectors preferred to other types of photo detectors.	Understand	CO 3	AEC018.10
11	What are the types of preamplifiers, What is inter symbol interference?	Remember	CO 3	AEC018.11
12	List the benefits and drawbacks of avalanche photodiodes.	Remember	CO 3	AEC018.12
13	Draw and explain the operation of APD	Remember	CO 3	AEC018.10

14	Discuss the different noise sources and disturbances in the optical pulse detection mechanism	Remember	CO 3	AEC018.11
15	Draw the circuit diagram of high impedance pre-amplifier and explain its operation.	Understand	CO 3	AEC018.12
16	Discuss with necessary expressions that different types of noise that affect the performance of a photo detector	Remember	CO 3	AEC018.10
PART - C (PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS)				
1	In a 100ns pulse, 6 × 106 photons at wavelength of 1300 nm fall on an InGaAs photo detector on the average, 5.4 × 106 electron-hole pairs are generated. Find the quantum efficiency.	Understand	CO 3	AEC018.10
2	Photons of energy 1.53×10-19 J are incident on a photodiode that has the responsivity of 0.65Amps/W. If the optical power level is 10µW, find the photo current generated.	Remember	CO 3	AEC018.11
3	Ga As has band gap energy of 1.43ev at 300k. Determine the wavelength above which an intrinsic photo detector fabricated from this material will cease to operate.	Remember	CO 3	AEC018.12
CIE-II				
4	A silicon p- i-n photodiode incorporated into an optical receiver has a quantum efficiency of 60% at a wavelength of 0.9 µm. The dark current is 3nA and load resistance is 4 KΩ. The incident optical power is 200nw and the receiver bandwidth is 5Mhz. Determine (1) mean square quantum noise current, (2) mean square dark current and (3) mean square thermal noise current at a temperature of 20◦C.	Remember	CO 3	AEC018.10
5	The quantum efficiency of a particular silicion RAPD is 80% for the detection of radiation at a wavelength of 0.9 µm, when the incident optical power is 0.5 µW. The output current from the device(after avalanche gain) is 11µA.Determine the multiplication factor of the photodiode under these conditions.	Remember	CO 3	AEC018.11
6	When 3 $\times 10^{11}$ photons each with a wavelength of 0.85µm is incident on the photodiode, on the average 1.2×10^{11} electrons are collected at the terminals of the device. Determine the quantum efficiency and responsivity of the photodiode at 0.85µm	Understand	CO 3	AEC018.12

UNIT-IV
OPTICAL AMPLIFIERS

PART – A (SHORT ANSWER QUESTIONS)

S. No	QUESTION	Blooms Taxonomy Level	Course Outcomes	Course learning Outcome
1	Define Stimulated Raman scattering.	Remember	CO 4	AEC018.13
2	Define Stimulated Brillouin scattering.	Understand	CO 4	AEC018.14
3	Define Cross-phase modulation.	Understand	CO 4	AEC018.15
4	Define Self-phase modulation.	Understand	CO 4	AEC018.13
5	Define power penalty.	Understand	CO 4	AEC018.14
6	What are the most important non-linear effects of optical fiber communication?	Remember	CO 4	AEC018.15
7	What are the advantages of a trans-impedance amplifier	Remember	CO 4	AEC018.13
8	What is meant by bit error rate?	Remember	CO 4	AEC018.14
9	What is a preamplifier? Give the classifications of preamplifiers.	Remember	CO 4	AEC018.15

10	What is meant by excess noise factor?	Remember	CO 4	AEC018.13
11	What is meant by inter symbol interference (ISI)?	Understand	CO 4	AEC018.14
12	What do you mean by thermal noise?	Remember	CO 4	AEC018.15
13	Define surface dark current	Remember	CO 4	AEC018.13
14	Define bulk dark current.	Remember	CO 4	AEC018.14
15	Define dark current noise	Understand	CO 4	AEC018.15
16	Define quantum noise.	Remember	CO 4	AEC018.13
17	List out the various error sources.	Understand	CO 4	AEC018.14
18	What is Fiber refractive index profile measurement?	Remember	CO 4	AEC018.15
19	What is Fiber cutoff wavelength measurement?	Remember	CO 4	AEC018.13
20	Draw the optical receiver	Remember	CO 4	AEC018.14
21	Explain about the front end optical amplifiers.	Understand	CO 4	AEC018.15
22	Define – Quantum Limit	Remember	CO 4	AEC018.13
23	What is meant by (1/f) noise corner frequency?	Understand	CO 4	AEC018.14
24	Why silicon is preferred to make fiber optical receivers?	Understand	CO 4	AEC018.15
25	What are the advantages of preamplifiers?	Remember	CO 4	AEC018.13
26	Explain preamplifiers?	Understand	CO 4	AEC018.14
27	How does dark current arise?	Understand	CO 4	AEC018.15
28	What is inter symbol interference?	Remember	CO 4	AEC018.13
29	What are the error sources of receiver?	Understand	CO 4	AEC018.14
30	How to measure fiber refractive index profile	Remember	CO 4	AEC018.13
PART – B (LONG ANSWER QUESTIONS)				
1	Analyze the front end optical amplifiers and explain.	Remember	CO 4	AEC018.13
2	Construct power launching and coupling in optical fiber amplifiers	Understand	CO 4	AEC018.14
3	Explain in detail about source to Fiber power launching.	Understand	CO 4	AEC018.15
4	Illustrate the three factors that decides the response time of	Remember	CO 4	AEC018.13
5	Generalize the error sources of receiver.	Understand	CO 4	AEC018.14
6	Explain Photodiodes in detail with neat sketches	Understand	CO 4	AEC018.15
7	Justify the Use of silicon is preferred to make optical receivers.	Remember	CO 4	AEC018.13
8	Point out the advantages of preamplifiers.	Remember	CO 4	AEC018.14
9	Categorize the types of preamplifiers?	Remember	CO 4	AEC018.15
10	Examine the standard fiber measurement techniques?	Understand	CO 4	AEC018.13
11	Determine Bend attenuation	Remember	CO 4	AEC018.14
12	Why the attenuation limit curve slopes towards to the right?	Remember	CO 4	AEC018.15
13	Develop the measures to avoid modal noise	Remember	CO 4	AEC018.13
14	Propose the range of system margin in link power budget.	Remember	CO 4	AEC018.14
15	Draw the block diagram of fundamental optical receiver. Write about each block	Understand	CO 4	AEC018.15
16	Explain any two types of pre amplifiers used in a receiver	Understand	CO 4	AEC018.13
PART - C (PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS)				
1	Calculate the number of independent signals that can be sent on a single fiber in the 1525-1565 nm bands. Assume the spectral spacing as per ITU-T recommendation G.692.	Understand	CO 4	AEC018.13
2	A link of 400 km length, in which an amplifier is used. The gain of the amplifier is 40 dB and its output saturation power is Pout,sat = 100 mW. The sensitivity of the receiver for the bit rate used for the transmissions is equal to PRec,dBm = –40 dBm. The attenuation coefficient of the fiber is	Understand	CO 4	AEC018.14

	α = 0.2 dB/km, Calculate the power coupling percentage on the power budget as losses in dB values.		CO 4	
3	The quantum efficiency of a particular silicon RAPD is 80% for the detection of radiation at a wavelength of 0.9μm, when the incident optical power is 0.5μW.The output current from the device (after avalanche gain) is 11μA.Determine the multiplication factor of the photodiode under these conditions.	Remember	CO 4	AEC018.15
4	A silicon p- i-n photodiode incorporated into an optical receiver has a quantum efficiency of 60% when operating at a wavelength of 0.9mm. The dark current is 3 nA and the load resistance is 4 KΩ. The incident optical power is 200 nW and the post detection bandwidth of the receiver is 5 MHZ. Calculate the root mean square (rms) shot noise and thermal noise currents generated.	Remember	CO 4	AEC018.13
5	GaAs has band gap energy of 1.43 eV at 300 k. Determine the wavelength above which an intrinsic photo detector fabricated from this material will cease to operate ?	Remember	CO 4	AEC018.14

UNIT-V
OPTICAL NETWORKS AND DISPERSION COMPENSATION

PART-A (Short Answer Questions)

S. No	QUESTION	Blooms Taxonomy Level	Course Outcomes	Course learning Outcome
1	What is SONET/SDH?	Remember	CO 5	AEC018.16
2	Draw the frame format of SONET.	Understand	CO 5	AEC018.17
3	What are solitons?	Understand	CO 5	AEC018.16
4	What is chirping?	Remember	CO 5	AEC018.17
5	What are the advantages of using soliton signals through fiber?	Understand	CO 5	AEC018.16
6	Distinguish between fundamental and higher order soliton.	Remember	CO 5	AEC018.17
7	What are the advantages of WDM?	Understand	CO 5	AEC018.16
8	What is the purpose of rise-time budget analysis?	Understand	CO 5	AEC018.17
9	What is EDFA?	Understand	CO 5	AEC018.16
10	Define – WDM	Remember	CO 5	AEC018.17
11	Define wavelength-routed WDM network.	Remember	CO 5	AEC018.16
12	What are the three topologies used for fiber optical network?	Remember	CO 5	AEC018.17
13	What are the drawbacks of broadcast and select networks for wide area network applications?	Understand	CO 5	AEC018.16
14	Define Broadcast-and-select WDM network.	Remember	CO 5	AEC018.16
15	Mention the key features of WDM?	Understand	CO 5	AEC018.17
16	What is meant by bidirectional WDM?	Understand	CO 5	AEC018.16
17	What are the basic performance criteria of the WDM?	Understand	CO 5	AEC018.17
18	Discuss the concepts of SONET/SDH.	Understand	CO 5	AEC018.16
19	Mention the four common topologies used for fiber optic networks.	Understand	CO 5	AEC018.17
20	What are the different network layers?	Remember	CO 5	AEC018.16
21	What do you mean by solitons?	Understand	CO 5	AEC018.17
22	Distinguish fundamental and higher order solitons.	Remember	CO 5	AEC018.16
23	What are the different layers in SONET/SDH?	Remember	CO 5	AEC018.17
24	What are the drawbacks of broadcast and select networks for wide area network applications?	Understand	CO 5	AEC018.16
25	Define – Bend Attenuation	Understand	CO 5	AEC018.17
26	What is the technique used for measuring the total fiber attenuation?	Understand	CO 5	AEC018.16
27	What are the factors that produce dispersion in optical fibers?	Understand	CO 5	AEC018.17
28	What are the methods used to measure fiber dispersion?	Remember	CO 5	AEC018.16
29	What are the methods used to measure fiber refractive index profile?	Understand	CO 5	AEC018.17
30	What are the three topologies used for fiber optical network?	Remember	CO 5	AEC018.16

PART-B (Long Answer Questions)

1	Calculate the number of independent signals that can be sent on a single fiber in the 1525-1565 nm bands. Assume the spectral spacing as per ITU-T recommendation G.692.	Remember	CO 5	AEC018.16
2	Define Interchannel and Interchannel crosstalk that occur in WDM systems.	Understand	CO 5	AEC018.17
3	List out the benefits of SONET over PDH networks.	Understand	CO 5	AEC018.16
4	What were the problems associated with PDH networks?	Remember	CO 5	AEC018.17
5	Define a network. List the different network categories.	Understand	CO 5	AEC018.16
6	Enumerate the various SONET / SDH layers?	Remember	CO 5	AEC018.17
7	What are the drawbacks of broadcast and select networks for wide area network applications?	Understand	CO 5	AEC018.16
8	What is the purpose of rise-time budget analysis?	Understand	CO 5	AEC018.17
9	Distinguish between fundamental and higher order soliton?	Understand	CO 5	AEC018.16
10	What are the advantages of using soliton signals through fiber?	Remember	CO 5	AEC018.17
11	What are the advantages of WDM?	Remember	CO 5	AEC018.16
12	What are the standard fiber measurement techniques?	Remember	CO 5	AEC018.17
13	Write the concept of link power budget	Understand	CO 5	AEC018.16
14	Write the basic concept of soliton generation.	Understand	CO 5	AEC018.17
15	Draw the frame format of SONET, What are the basic performance criteria of WDM technique?	Understand	CO 5	AEC018.16
16	What are the main parameters used for characterizing the performance of optical amplifiers in a communication system?	Understand	CO 5	AEC018.17
17	Give the significance of solitons	Understand	CO 5	AEC018.16
PART-C (Analytical Questions)				
1	Explain the principle of solitons and discuss the soliton parameters with necessary expressions and diagrams	Remember	CO 5	AEC018.16
2	What is a ‘four-fiber BLSR ring in a SONET? Explain the reconfiguration of the same during node or fiber failure	Remember	CO 5	AEC018.17
3	Explain the following requirements for the design of an optically amplified WDM link: i) Link Bandwidth ii) Optical power requirements for a specific BER	Understand	CO 5	AEC018.16
4	Write short notes with necessary diagrams on: (i) Optical CDMA. (ii) WDM and EDFA system performance.	Remember	CO 5	AEC018.17
5	Summarize the transmission bit rate of the basic SONET frame in Mbps	Understand	CO 5	AEC018.16
6	Outline interchannel cross talk that occurs in a WDM system	Remember	CO 5	AEC018.17
7	List the benefits of SONET over PDH networks.	Understand	CO 5	AEC018.16
8	Express the various SONET/SDH layers.	Remember	CO 5	AEC018.17
9	Demonstrate a model of EDFA	Understand	CO 5	AEC018.16
10	Classify the important features of time slotted optical TDM network.	Remember	CO 5	AEC018.17

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