TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2081 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV/ II	Time	3 hrs.

Subject: - Optical Fiber Communication *(Elective II) (EX 76501)*

- ✓ *Candidates are required to give their answers in their own words as far as practicable.*
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. What is an optical fiber? Explain on the optical communication system with its typical block diagram. [3+5]
2. What is a dispersion? Define different kinds of losses in optical fiber. [3+6]
3. Describe numerical aperture (NA) in optical communications. Derive numerical aperture formula. [3+5]
4. State Snell's law. Differentiate between metal and dielectric cable communication systems. [3+5]
5. What is a wavelength modulation? Briefly explain FM-IM modulation techniques used in optical communication system. [3+6]
6. How does an edge emitting LED function? Explain with necessary diagram. List the light emitting devices used in optical communication and briefly any two of them. [4+5]
7. Compare the optical fiber communication with wireless communication in different aspects. Write advantages and disadvantages of Optical fiber communication. [5+5]
8. Why power link budget analysis is so essential in optical fiber communication system? Explain all the aspects of link power budget and risk time budget. [5+5]
9. Write very short notes: (Any Three) [3×3]
   a) Avalanche photo diode (APD)
   b) Fusion splicing
   c) Optical couplers
   d) Photo detectors
   e) Laser Diodes

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2079 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEI, BCT,BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Optical Fiber Communication System *(Elective II) (EX 76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. Briefly explain the historical development of optical fiber communication in Nepal. [4]
2. Describe meridional ray and skew ray with figure in optical fiber. [4]
3. Derive the wave equation in cylindrical waveguide using Maxwell's equation for optical propagation. [5]
4. Define Evanescent field. Derive the relationship between phase velocity and group velocity. [1+4]
5. a) Explain the cut- off wavelength, mode- field diameter and spot size. [5]
   b) Calculate the maximum value of Δ and $\mu 2$ of a single mode fiber of core diameter 11μm and core refractive index 1.5. The fiber is coupled to the light source with a wavelength of 1.2μm and V cut off for single mode propagation is 2.405. Also calculate the acceptance angle. [4]
   c) An optical fiber has 4mW as its input power and the output power is 2μW. If the fiber is designed for an attenuation value of 0.59 dB/Km and find the length of the optical fiber. [3]
6. a) Compare and contrast between surface and edge emitting LEDS. [4]
   b) Explain the population inversion in case of four level LASAR. [4]
7. a) Explain the basic principle of light detection in p-i-n photodiode. [4]
   b) A GaAs has a band gap energy of 1.43 eV at 300 K. Determine the wavelength above which an intrinsic photo detector fabricated from this material will cause to operate. [3]
8. Briefly Explain the sub carrier Intensity Modulation (SC-IM). [4]
9. a) Explain various types of fiber cable alignment and joint losses. [4]
   b) Describe various fiber splicing techniques with their diagrams. [4]
   c) Explain fully bidirectional four port optical coupler. [4]
10. a) Explain the amplification process on Rare Earth Doped Fiber Amplifier. [4]
    b) Describe the optical switch. [3]
11. a) Explain in detail about wave Division Multiplexing technology and list out advantages. [6]
    b) A transmitter has an output of 0.1 mW. It is used with a fiber having NA = 0.25, attenuation of 6 dB/Km and length of 0.5 Km. The link contains two connector of 2 dB average loss. The receiver has a minimum acceptance power (sensitivity) of -35 dBm. The designer has allowed a 4 dB margin. Calculate the link power budget. [6]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2079 Jestha

Exam.	[redacted]		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Optical Fiber Communication System (*Elective II*)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. Briefly explain the historical development of optical fiber communication. [4]
2. Discuss the meridional ray and skew ray with figure in optical wave guide. [4]
3. Define slab waveguide and cylindrical waveguide. State Maxwell's equation for optical propagation. [4]
4. What is Evanescent field? Derive the relationship between phase velocity and group velocity. [5]
5. a) Describe multimode step index fiber and single mode step index fiber; computer the advantages and disadvantages of these two types of fiber for use as on optical channel. [5]
   b) Calculate the maximum value of Δ and μ2 of a single mode fiber of core diameter 10 μm and core refractive index 1.5.The fiber is coupled to the light source with a wavelength of 1.3 μm and V cutoff for mode propagation is 2.405. Also calculate the acceptance angle. [4]
   c) An optical fiber has 2mW as its input power and the output power is 2μW. If the fiber is designed for attenuation value of 0.49db/km and find the length of the optical fiber. [3]
6. a) Explain an internal quantum efficiency and external quantum efficiency of LED along with necessary mathematical expressions. [4]
   b) Differentiate between stimulated emission and spontaneous emission. [3]
7. a) Explain the working of Avalanche photo diode (APD). [3]
   b) Derive the relationship between detector responsivity (R) and quantum efficiency (η) in optical detector. [4]
8. Briefly Explain the Direct Intensity Modulation (D-IM). [4]
9. a) Discuss various types of misalignments in fiber cables. [3]
   b) Explain in detail about the procedure of fusion splicing. What are the advantages and disadvantages associated with fusion splicing? [3+2]
   c) Explain the optical couplers and its type. [3]
10. a) Explain the amplification process on Erbium Doped Fiber Amplifier. [4]
    b) What is integrated optics and what are its advantages over electronics circuits? [3]
11. a) Explain different components of FTTH network. What are the different standards of passive optical network? [5]
    b) Describe SONET/SDH optical network function with suitable diagram. [5]
    c) A transmitter has an output of 0.1 mW. It is used with a fiber having NA = 0.25, attenuation of 6dB/km and length of 0.5 km. The link contains two connector of 2 dB

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2079 Shrawan

Exam.	Back		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Optical Fiber Communication System (Elective II) (EX7650I)

- ✓ *Candidates are required to give their answers in their own words as far as practicable.*
- ✓ *Attempt <u>All</u> questions.*
- ✓ *The figures in the margin indicate <u>Full Marks</u>.*
- ✓ *Assume suitable data if necessary.*

1. a) Briefly explain the historical development of optical fiber communication. [4]
   b) Mention the advantages if optical fiber communication. [4]
2. Provided that an optical fiber in air has an NA of 0.4. Compare the acceptance angle of meridional ray with that of skew rays which change direction of 100° at each reflection. [4]
3. Explain mode theory along with Maxiwell's equation for optical propagation. [8]
4. What is Evanescent field? Derive the relationship between phase velocity and group velocity. [2+3]
5. a) Discuss about cut-off wavelength and mode field diameter of single mode fibers. [4]
   b) When the mean optical power launched into an 8 km length of fiber is 120 μW, the mean optical power at the fiber output is 3 μW. [2+2+2]
      i) The overall signal attenuation or loss in decibels through the fiber assuming there are no connectors or splices.
      ii) The signal attenuation per kilometer for the fiber.
      iii) The overall signal attenuation for a 10 km optical link using the same fiber with splices at 1 km interval, each giving an attenuation of 1 dB.
6. a) Briefly explain Distributed feedback (DFB) laser. [3]
   b) An injection laser has an active cavity with losses of 30 cm^{-1} and the reflectivity of each cleaved laser facet is 30%. Determine the laser gain coefficient for the cavity when it has a length of 600 μm. [4]
7. a) Compare between PIN photodiode and APD considering different parameters. [4]
   b) Derive the relationship between detector responsivity (R) and quantum efficiency (η) in optical detector. [4]
8. Briefly explain subcarrier frequency modulation (Fm-IM). How is FM-IM different from Direct – IM? [4+2]
9. a) Explain various types of misalignments in fiber cables. [3]
   b) A step index fiber has a core refractive index of 1.8 and a core diameter of 55 μm. The fiber is joined with a lateral misalignment between the core axes of 5 μm. Estimate the insertion loss at the joint due to the lateral misalignment assuming a uniform distribution of power between all guided modes when: [5]
      i) There is a small air gap at the joint.
      ii) The joint is considered index matched.
10. What is integrated and what are its advantages over electronics circuits? [4+4]
11. a) Explain different components of FTTH network. [3]
    b) A transmitter has an output of 0.1 mW. It is used with a fiber having NA = 0.25, attenuation of 6 dB/km and length of 0.5 km. The link contains two connector of 2 dB

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2078 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX, BCT	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Optical Fiber Communication *(Elective II) (EX76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Explain the evolution of the Optical Communication technology. [4]
   b) What are the different types of Optical fiber used in the communication system? [4]
2. Explain the differences between meridional ray and skew ray in optical wave guide. [4]
3. Derive the wave equations of cylindrical fiber using Maxwell's equations. [8]
4. Explain the term V-number. Calculate the number of modes a step index optical fiber of diameter 40μm, will transmit as its core and cladding refractive indices are 1.5 and 1.46 respectively. Wavelength of light used is 1.5μm. [2+3]
5. a) Briefly explain types of scattering losses in optical fiber. [5]
   b) Two step index fibers exhibit the following parameters: [5]
      (i) a multimode fiber with a core refractive index of 1.500, a relative index difference of 2.5% and an operating wavelength of 0.92 μm;
      (ii) an 8.5μm core diameter single mode fiber with a core refractive index the same as (i) a relative refractive index difference of 0.4% and an operating wavelength of 1.75 μm. Estimate the critical radius of curvature at which a large bending losses occur in both cases.
6. a) Describe the operation of surface emitting LED with the diagram. [4]
   b) Derive an expression for lasing condition and hence for optical gain in LASERS. [3]
7. a) Briefly explain types of photodetector used in communication system. [3]
   b) A photodiode has a quantum efficiency of 72% when photons of energy 1.6×10^{-19} J are incident upon it. [5]
      (i) At what wavelength is the photodiode operating?
      (ii) Calculate the incident optical power required to obtain a photocurrent of 2.5 μA when the photodiode is operating as describe above.
8. What is optical modulation? Compare D-IM and Subcarrier IM. [2+4]
9. a) Differentiate between fusion splicing and mechanical splicing. [3]
   b) Explain Optical coupler and its types. How FBT Technology is used to manufacture star coupler? [5]
10. What is EDFA amplifier? Explain briefly its working principle. [3+5]
11. a) Explain the importance of link budge analysis in optical communication system. [2]
    b) An optical fiber system is to be designed to operate over an 8 km length without repeaters. The rise times of the chosen components are
       (i) Source (LED) = 8ns
       (ii) Fiber: intermodal = 5ns/km
       (iii) (pulse broadening) intramodal = 1 ns/km
       (iv) Detector (p-i-n photodiode) = 6 ns

    From system rise time considerations, estimate the maximum bit rate that may be achieved on the link when using an NRZ format. [6]

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INSTITUTE OF ENGINEERING
Examination Control Division
2077 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX, BCT	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Optical Fiber Communication *(Elective II) (EX76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Draw the block diagram of optical fiber communication system and explain different components of it. [4]
   b) 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. Determine, [3]
   (i) Critical angle at the core-cladding interface.
   (ii) Numerical aperture for the fiber.
   (iii)Acceptance angle in air for the fiber.
2. What is different between phase velocity and group velocity? And explain why Maxwell equation is important in optical fiber communication. [3+3]
3. a) Explain mode coupling. [3]
   b) A multimode step index fiber with a core diameter of 80 um and a relative index difference of 1.5% is operating at a wavelength of 0.85um. If the core refractive index is 1.48, estimate: (i) The normalized frequency of the fiber, (ii) The number of guided modes. [3+2]
4. a) Differentiate between attenuation and dispersion. Explain the different types of fiber bending losses. [2+3]
   b) Differentiate between intramodal dispersion and intermodal dispersion. What are the possible ways to reduce dispersion in optical fiber communication? [2+2]
5. a) Explain any six characteristics of optical sources. [3]
   b) A radiative and nonradiative recombination lifetimes of the minority carriers in the active region of a double heterojunction LED are 60ns and 100ns respectively. Determine the total carrier recombination lifetime and the power internally generated within the device when the peak emission wavelength is 0.87 μm at a drive current of 40mA. [5]
6. Explain the detection principle of p-i-n photodiode with neat diagram. Compare it with avalanche photodiode. [5+3]
7. Why is sub carrier modulation necessary in Optical Fiber Communication? Explain the FM-IM Modulation. [2+5]
8. a) Explain the detail working mechanism of Rare Earth doped Fiber Amplifier. [4]
   b) What are the advantages of Integrated Optics over Electronics Circuits? [4]
9. Explain the process of Fusion Splicing and Mechanical Splicing in detail with required sketches. Also, state the problems associated with them. [6+3]
10. Explain rise time budget analysis in optical communication system. A transmitter has an output power of 0.1 mW. It is used with a fiber having NA of 0.25, attenuation of 6 dB/km and length 0.5km. The link contains two connectors of 2dB average loss. The receiver has a minimum acceptable power (sensitivity) of -35 dBm. The designer has allowed a 4 dB margin. Calculate the link power budget. [3+7]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2076 Bhadra

Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BCT, BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Optical Fiber Communication *(Elective II) (EX 76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. Draw and explain the electromagnetic spectrum showing the region used for optical fiber communication. [3]
2. Explain different types of Optical fibers. Derive an expression for the numerical aperture of an optical fiber. [4+3]
3. a) Explain mode coupling in optical fiber communication. [2]
   b) A graded index fiber with a parabolic profile core has a refractive index at the core axis of 1.5 and a relative index difference of 1%. Estimate the maximum possible core diameter which allows single mode-operation at a wavelength of 1.3μm. [3]
4. For a step index fiber, derive a relationship between dispersion between dispersion and the information carrying capacity of the fiber. Explain how the effect of dispersion can be reduced. [4+3]
5. A multimode step index fiber with a core diameter of 80μm and a relative index difference of 1.5% is operating at a wavelength of 0.85μm. If the core refractive index is 1.48. Determine
   a) The normalized frequency for the fiber
   b) The number of guided modes [3]
6. Explain the working principle of LASAR as a source in optical fiber communication. Differentiate between spontaneous emission and stimulated emission. [5+2]
7. Explain the working of Avalanche Photo Diode (APD). What are the drawbacks of APD? [3+2]
8. Briefly explain FM-IM modulation techniques used in optical fiber communication. [5]
9. a) Differentiate between fusion splicing and mechanical splicing. [4]
   b) Why do we need connectors and couplers in optical fiber communication? [3]
   c) Explain semi-transparent mirroring method for coupling. [4]
10. a) What is integrated optics and what are its advantages over electronic circuits? [3]
    b) Differentiate between PDH, SDH, and SONET. [3]
11. What is the difference between Optical network terminal (ONT) and Optical Network Unit (ONU)? What are the different standards of Passive Optical Network? [4+3]
12. a) What is fiber link power budget? Why is power margin needed in link design? [3+3]
    b) A datacenter requires to setup a link with it's client to cater a data traffic of 40Gbps. The estimated link length of the optical system is 80km. The network consists of an optical transmitter having output power +3dBm. The minimum detectable power of the optical detector is -26dBm. There are total 6 connectors each having a loss of 0.2dB, 5 splices each having a loss of 0.1 dB. As per the fiber specification, fiber loss is 0.3 dB/km. Designer has recommended to install an optical amplifier EDFA in the link at 50Km distance. Determine using power budget calculation whether the EDFA needs to be installed or not? If yes what should be the gain of EDFA? [8]

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25 G TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2075 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX, BCT	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Optical Fiber Communication *(Elective II) (EX7650I)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Outline the advantages of optical fiber communication system and it's applications. Explain the evolution of the Optical Communication technology. [2+2+3]
   b) What are the different types of Optical fiber used in the communication system? [4]
2. a) Explain Goos Haenchen Shift. Derivation and explain the significance of the wave equation for a Dielectric slab waveguide of infinite depth consisting of a slab of dielectric material of width 'd' of refractive index, η_1 embedded in a material having refractive index, η_2. [2+6]
   b) Calculate the normalized frequency at 820 nm for a step-index fibre having 25 μm core radius, n_1 equal to 1.48 and n_2 equal to 1.46.
      (i) How many modes propagate in this fibre at 820 nm?
      (ii) How many modes propagate in this fibre at 1320 nm?
      (iii) What percentage of this optical power flows in the cladding in each case? [3]
3. a) What is the significance of profile parameter in graded index fiber? [2]
   b) Derive and explain the relation between bandwidth and numerical aperture in a Multi mode step index fiber due to dispersion. [4]
4. a) What is optical modulation? Compare D-IM and Subcarrier IM. [2+4]
   b) Estimate the external power efficiency of a GaAs planar LED when the transmission factor of the GaAs-air interface is 0.68 and the internally generated optical power is 30% of the electric power supplied. The refractive index of GaAs may be taken as 3.6. [4]
5. a) Explain Optical Couplers and it's types? How FBT Technology is used to manufacture Star Coupler? [3+3]
   b) A step index fiber with a 200μm core diameter is butt jointed. The joint which is index matched has a lateral offset of 10μm but no longitudinal or angular misalignment. Determine the loss due to this type of misalignment. [3]
   c) What are the performance parameters of a good optical detectors. [3]
6. a) For Silica the fictive tempersature (T_f) is 1400K, the isothermal compressibility (β_T) is $6.8*10^{-11}m^2/N$, and the photo-elastic coefficient is 0.286. Estimate the scattering loss at 1.3μm wavelength where n = 1.45. [3]
   b) What is Optical Amplifiers? Explain the working principle of EDFA. Using energy level diagram explain the significance of metastable level. [2+5]

7. a) Explain the working principal of Distributed feedback Laser. Why it is preferred by the telecom companies? [3+2]

   b) Explain the importance of link budget analysis in optical communication system. Define Dispersion penalty. [2+2]

8. a) Find the total system loss and excess margin where 9 splices and 2 connectors are used.

Fiber Cable Loss	Splice Loss	Connector Loss	Safety Margin
3-dB/km	0.3 dB/ splice	1 dB/connector	7 dB

   A typical operating power budget over 8-km of multimode graded index fiber at wavelength of 0.85-μm, mean power launched from laser transmitter is -4.5dB and APD receiver sensitivity is -48 dBm. [6]

   b) Explain different components of FTTH network. What are the different standards of Passive Optical Network? [3+2]

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35G TRIBHUVAN UNIVERSITY
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2074 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Optical Fiber Communication *(Elective II) (EX76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Explain different components of optical fiber communication system with block diagram and list the advantages of optical fiber communication. [2+2]
   b) Explain in detail about cutoff wavelength and normalized frequency? Also write the significance of each. [2+2]
2. a) What is the difference between phase velocity and group velocity? Elaborate with examples. [4]
   b) Find the maximum diameter of a signal mode fiber designed to carry a signal of wavelength 1.3 μ m if the index of refraction of the core of the fiber is 1.55 and the index of refraction of the cladding of the fiber is 1.52. [3]
3. a) Describe the major causes of attenuation in optical fiber. Illustrate the transparent windows in optical fiber with major peak transparent wavelength in fiber. Describe its impact in transmission systems. [3+2+2]
   b) Compare meridional rays and skew rays with necessary sketch. [4]
4. a) Explain Modulation bandwidth in terms of electrical and optical bandwidth. [4]
   b) Explain quantum efficiency and responsively along with their mathematical relationship. [6]
5. a) What are the property of light which are used in optical modulation? Explain in detail about direct intensity modulation. [2+5]
   b) Explain in detail about the procedure of fusion splicing? What are the advantages and disadvantages associated with fusion splicing? [4+2]
6. a) Write the difference between linear and non-linear scattering. Also explain its type. [5]
   b) A glass fiber has the material dispersion parameter value 98.1 $psnm^{-1}km^{-1}$. Estimate the pulse broadening per kilometer for the fiber operating at 0.85 μm wave length given that relative spectral width of injection laser ($6\lambda/\lambda$) is 0.0012. [4]
7. a) Explain in detail about Dense Wave Division Multiplexing technology. Write the advantages. [6]
   b) A 15 km optical fiber link uses fiber with a loss of 1.5dB km^{-1}. The fiber is jointed every kilometer with connectors which give an attenuation of 0.8dB each. Determine the minimum mean optical power which must be launched into the fiber in order to maintain a mean optical power level of 0.3μw at detector. [4]
8. An optical fiber system is to operate at 622 Mbps over a distance of 65 km without repeaters. Fiber with a loss of 0.23 dB/km and a dispersion of 5.5 ps/km is available in maximum lengths of 1 km. The fusion spice loss is 0.035dB/splice and repair power margin is 5 dB. If the receiver sensitivity is -28 dBm and the transmitter output power is +1dBm, determine the maximum allowable attenuation which can be tolerated during installation. If a system upgrade to operation at 1.2 Gbits/sec is required, is the fiber link acceptable? [12]

35G TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2074 Magh

Exam.	Back		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Optical Fiber Communication *(Elective II) (EX76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Describe the optical fiber communication system? [3]
   b) Describe the structure of optical fiber? How light propagates on it? [3+2]
2. a) Define meridional and skew ray with figure in optical wave guide? [4]
   b) An 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. Determine: (a) The critical angle at the core-cladding interface; (b) The NA for the fiber; (c) The acceptance angle in air for the fiber? [4]
3. a) Describe multimode step index fiber and single-mode step index fiber; compare the advantages and disadvantages of these two types of fiber for use as an optical channel. [5]
   b) A multimode graded index fiber has an acceptance angle in air of 8°. Estimate the relative refractive index difference between the core axis and the cladding when the refractive index at the core axis is 1.52. [3]
4. Describe the mechanism of intermodal dispersion in a multimode step index fiber. Show that the total broadening of a light pulse δ_T due to intermodal dispersion in a multimode step index fiber is: $\delta_T = L\frac{(NA)^2}{2n_1C}$ [8]

   Where, L is the fiber length, NA is the numerical aperture of the fiber, n_1 is the core refractive index and c is the velocity of light in a vaccum.
5. a) Briefly discuss the evanescent field in optical fiber transmission with suitable diagrams? [4]
   b) A fiber link has following data: [4]

Component	BW	Rise time
Transmitter	200MHz	1.75 ns
LED (850 nm)	100 MHz	3.50 ns
Fiber cable	90 MHz	3.89 ns
PIN detector	350 MHz	1.00 n
Receiver	180 MHz	1.94 ns

6. a) Briefly explain the reasons for pulse broadening due to material dispersion in optical fibers. [3]
   b) A multimode step index fiber has a numerical aperture of 0.2 and a core refractive index of 1.47. Estimate the bandwidth length product for the fiber assuming only intermodal dispersion and a return to zero code when: (a) There is no mode coupling between the guided modes: (b) Mode coupling between the guided [5]

7. a) Explain what is meant by the critical bending radius for an optical fiber? [4]

   b) A multimode graded index fiber has a refractive index at the core axis of 1.46 with a cladding refractive index of 1.45. The critical radius of curvature which allows large bending losses to occur is 84 μm when the fiber is transmitting light of a particular wavelength. Determine the wavelength of the transmitted light. [4]

8. a) Define the mechanism for light generation in Optical Source? [4]

   b) Briefly outline the advantages and drawback of the LED in comparison with the laser for use as a source in optical fiber communications. [4]

9. Define network topology? A transmitter has an output power of 0.1 mW. It is used with a fiber having NA = 0.25, attenuation of 6 dB/km and length 0.5 km. The link contains two connectors of 2 dB average loss. The receiver has a minimum acceptance power (sensitivity) of -35 dBm. The designer has allowed a 4 dB margin. Calculate the link power budget. [2+6]

10. Write short notes on :(any two) [4+4]

    a) SONET
    b) Rayleigh scattering
    c) Optical fiber joints

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35 G TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCT, BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Optical Fiber Communication *(Elective II) (EX76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt All questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. What are the advantage of optical fiber communication over other medium? [4]
2. The velocity of the light in the core of step index fiber is 2.01×10^8 ms^{-1} and the critical angle at the core- cladding interface is 80°. Determine the NA and the acceptance angle for the fiber in air, assuming it has a core diameter suitable for consideration by ray analysis. The velocity of light in vacuum is 2.998×10^8ms^{-1}. [4]
3. State Maxwell's equation for optical propagation. [2]
4. What is Evanescent Field in optical fiber communication? [2]
5. A multimode step index fiber has a relative refractive index difference of 1% and core refractive index of 1.5. The number of modes propagating at a wavelength of 1.3 μm is 1100. Estimate the diameter of the fiber core. [5]
6. What is a fiber dispersion? Explain it. [4]
7. A multimode graded index fiber has a refractive index at the core axis of 1.46 with a cladding refractive index of 1.45. The critical radius of curvature which allows large bending losses to occur is 84 μm when the fiber is transmitted light of a particular wavelength. Determine the wavelength of the transmitted light. [5]
8. Explain an internal Quantum efficiency and external Quantum efficiency of LED along with necessary mathematical expressions. [4]
9. The power generated internally within a double hetero junction LED is 28.4-m W at a drive current of 60-mA. Determine the peak emission wavelength from the device when the radiative and non radiative recombination lifetimes of the minority carriers in the active region are equal. [3]
10. Explain the optical detection principle of p-n photodiode. [4]
11. A given silicon avalanche photodiode 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 factor. [3]
12. Briefly explain a Direct-Intensity modulation (D-IM). [5]
13. Compare between an optical splice and connector. [5]
14. Briefly explain structure and principle of operation for the fiber fused biconical taper coupler. [6]
15. Explain with principle of different types of optoelectronic integration. [7]

16. Explain with principle and neat diagram of digital fiber optic transmission. [8]

17. A D-IM analog optical fiber link of length 2 km employs an LED which launches mean optical power of -10 dBm in to multimode optical fiber. The fiber cable exhibits a loss of 3.5 db km^{-1} with splice losses calculated at 0.7 db km^{-1}. In addition there is a connector loss at the receiver of 1.6 db. The p-i-n photodiode receiver has a sensitivity of -25 dBm for an SNR of 50 dB and with a modulation index of 0.5. Estimated that a safety margin of 4dB is required. Assuming there is no dispersion equalization penalty.

a) Perform an optical power budget for the system operating under the above conditions and as certain its velocity.

b) Estimate any possible increase in link length which may be achieved using an injection laser source which launches mean optical power of 0 dBm in to the fiber cable. In this case the safety margin must be increased to 7 dB. [9]

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35 G TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 Magh

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BCT, BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Optical Fiber Communication *(Elective II) (EX76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. Explain different components of an optical fiber communication system with a block diagram. [3]
2. What is a material absorption loss? What are the causes of absorption of light in optical fiber? [1+2]
3. Explain Goos-Haenchen shift. For a TE mode wave propagation, derive the wave equation for a Dielectric slab waveguide of infinite depth consisting of a slab of dielectric material of width 'd' of refractive index, η_1 embedded in a material having refractive index, η_2. [2+7]
4. A multimode step index fiber with a core diameter of 80 μm and a relative index difference of 1.5% is operating at a wavelength of 0.85 μm. If the core refractive index is 1.48. Determine [2]
   a) The normalized frequency for the fiber
   b) The number of guided modes
5. With a suitable example explain the effect of dispersion during optical signal propagation and how it can be reduced? [6]
6. Derive the expression of Numerical Aperture of meridional-ray in terms of refractive index of core and cladding. [4]
7. Explain a subcarrier intensity modulation. [5]
8. What is a Misalignment Loss? Explain the causes of misalignment loss. [1+2]
9. In which condition mode LED act as laser? Explain it. [3]
10. What are the types of LED? Which types of LED used in optical fiber communication? Explain it briefly. [4]
11. Explain about benefit and drawback of an avalanche photodiode. [3]
12. A photodiode has a quantum efficiency of 65% when photons of energy 1.5×10^{-19} J are incident upon it.
    a) At what wavelength is the photodiode operating? [2]
    b) Calculate the incident optical power required to obtain a photo current of 2.5μA when the photo diode is operating as described above. [2]
13. Explain the causes of the insertion loss. What are the problems associated with fusion splicing? [3+2]

14. 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 dB at the joint (due to Fresnel reflection) when there is a small air gap between the fiber end faces. [3]

15. The LED in a silica optical fiber link has arise time of 8ns and a spectral width of 40nm at an operating wavelength of 840nm. The PIN photo detector has a rise time of 10ns. For silica D = 95.2 ps/(nm.km). For a 2.5 Km link, the intermodal dispersion of graded index fiber is 3.5 ns/Km. Calculate the system rise time and data rate that the system can support for NRZ coding and RZ coding.
Also Calculate data rate for NRZ and RZ coding when Single mode fiber with D = 95.2 ps/(nm.km) and LASER having spectral width 1 nm and a rise time of 8ns is used in the same system. [4+3]

16. Explain the amplification process based on stimulated emission. What are the advantages of Erbium Doped Fiber Amplifier? [3+2]

17. Three clients traffic: STM-16 from SDH equipment, 10 Gbps internet traffic from router and 1 Gbps voice traffic from MSC needs to be carried from Kathmandu to Biratnagar. Only one pair of optical fiber is available between these cities. Explain how the traffic can be carried in the given scenario using DWDM technology with necessary block diagram. Assume the channel value having channel spacing of 100 GHz. [7]

18. What are the advantages and enhanced management capabilities of Synchronous Digital Hierarchy? [4]

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(17)

35F TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Ashwin

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX, BCT	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Optical Fiber Communication *(Elective II) (EX76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. Explain the historical development of optical fiber communication? List the advantage and disadvantages of optical fiber communication. [3+1]
2. Find the acceptance angle and numerical aperture of a fiber with a core index of reflection of 1.57 and a cladding index of refraction of 1.51. [2+2]
3. Define slab waveguide and cylindrical waveguide? Using Maxwell's equation, drive wave equation for cylindrical waveguide. [2+2]
4. Distinguish between phase velocity and group velocity. Discuss modes in a planar optical guide. [3+2]
5. A multimode step index fiber with a core diameter of 80 μm and a relative index difference of 1.5% is operating at a wavelength of 0.85 μm. If the core refractive index is 1.48, estimate: (i) The normalized frequency for the fiber, (ii) the number of guided modes. [2+2]
6. Explain the main causes of chromatic dispersion. How can dispersion be minimized in the optical fiber communication. [2+3]
7. What are the types of optical light source? Draw energy state diagram and light output current characteristics of an ideal semiconductor laser indicating absorption and emission of radiation. Also draw light output as a function of frequency. [2+3+2]
8. Define quantum efficiency of optical detector. A photodiode has a quantum efficiency of 65% when photons of energy 1.5×10^{-19} J are incident upon it. (i) At what wavelength is the photodiode operating? (ii) Calculate the incident optical power required to obtain a photocurrent of 2.5 μA when the photodiode is operating as describe above. Describe the working mechanism of Distributed Bragg Reflector (DBR) laser. [1+3+3]
9. Why the high capacity optical fiber communication systems used digital system using intensity modulation of the optical source. What is an Eye pattern in binary digital transmission? [3+2]
10. What are optical Couplers and their types? Explain the fabrication method of fused Star Coupler. Write short notes on Fresnel loss in fiber joint. [3+4+4]
11. Consider an EDFA being pumped at 980-nm with a 30-mW pump power. If the gain at 1550-nm is 20dB, what are the maximum input and output power? What is Integrated optics and what are its advantages over electronic circuit. [4+1+2]

12. Write short notes on PON and FTTH. A 622 Mbps optical transmission system is to operate at a wavelength of 1550 nm. Apart from the transmitter and receiver, the optical links contains an optical amplifier with 7 dB gain at 45 km of the links. The transmitter available has a minimum coupled output power of +3 dBm. While the receiver has a worst case sensitivity of -27 dBm. Two types of fiber with different specifications are available as shown in the table below. Four connectors are to be used in the system with a loss of 0.15 dB each, while the splice loss for both fiber types is 0.05 dB maximum. Calculate the dispersion penalty associated with the use of each fiber. Prepare a power budget for each system and decide which fiber type should be used and why? Assume transmitter and receiver are situated at Kathmandu and Pokhara, respectively. [5+12]

Fiber type	Total Dispersion	Attenuation	Maximum distance between splices
X	5 ps/km	0.3 dB/km	0.7 km
Y	7 ps/km	0.4 dB/km	0.6 km

Fiber type	Total Dispersion	Attenuation	Attenuation standard deviation
A	7 ps/km	0.36 dB/km	0.05 dB/km
B	9.5 ps/km	0.33 dB/km	0.04 dB/km

Joint type	Avg. attenuation	Attenuation standard deviation
Fusion splice	0.03 dB	0.012 dB
Connector	0.25 dB	0.04 dB

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35A TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Bhadra

Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BEX, BCT	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Optical Fiber Communication *(Elective II) (EX76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. (a) A multimode step index fiber with a core diameter of 80 μm and a relative index difference of 1.5% is operating at a wavelength of 0.85 μm. If the core refractive index is 1.48. Determine **(2+2)**
   i) The normalized frequency for the fiber
   ii) The number of guided modes
   (b) With respect to attenuation window curve explain the nature of attenuation for different operating wavelength in optical communication? **(5)**

2. Describe the operation of EDFA (Erbium Doped Fiber Amplifier) and explain the significance of metastable level. What are the advantages and disadvantages of EDFA? **(8)**

3. Derive the wave equation and its solution for a slab waveguide having dielectric slab of refractive index η_1 embedded in a material having refractive index, η_2. Show it's signification with respect to normalized frequency, V. **(8)**

4. What are the different types of misalignment losses associated with optical fiber joints? What are the causes of insertion loss? **(4+3)**

5. When an input to the optical fiber communication system with step index fiber is an impulse response, explain how bandwidth of the system is affected by dispersion and how it can be minimized. **(6)**

6. The 10–90% rise times for possible components to be used in a D–IM analog optical fiber link are specified below: **(5)**
   Source (LED) =10 ns ; Fiber cable: intermodal =9 ns km−1 ; Chromatic= 2 ns km−1 ; Detector (APD)= 3 ns. The desired link length without repeaters is 5 km and the required optical bandwidth is 6 MHz.
   Determine whether above combination of components gives an adequate temporal response.

7. What are the performance & compatibility requirement for an optical detector? Explain the basic operation principle of a p-n photodiode. **(3+4)**

8. An optical fiber system is to operate at 622 Mbps over a distance of 65 km without repeaters. Fiber with a loss of 0.23 dB/km and a dispersion of 5.5 ps/km is available in maximum lengths of 1 km. The fusion splice loss is 0.035dB/splice and repair power margin is 5 dB. If the receiver sensitivity is -28 dBm and the transmitter output power is +1dBm, determine the maximum allowable attenuation which can be tolerated during installation. If a system upgrade to operation at 1.2 Gbits/ sec is required, is the fiber link acceptable? **(8)**

9. Explain the mechanism for the operation of LASER. What is the responsivity of an optical detector? **(5+2)**

10. Write short notes on **any three** **(3*5)**
    a) Phase velocity and Group velocity
    b) Direct intensity Modulation
    c) Goos-Haenchen effec.
    d) SONET

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20970

45A TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Optical Fiber Communication *(Elective II) (EX76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Provide a clear and clean sketch of a general optical fiber communication system, and describe the various parts of the system. List at least 5 areas of application of optical fiber communication. [2+2]
   b) With the assistance of a suitable sketch, provide a detailed description of the optical fiber structure. An optical fiber in air has a numerical aperture of 0.4. Compare the acceptance angle for meridional rays with that for skew rays, which change direction by 100^0 at each reflection. [2+2]

2. a) Define a dielectric slab waveguide. Using Maxwell's equations derive the eigenvalue equations for transverse electric modes in a symmetric dielectric slab waveguide. [1+3]
   b) Define the Goos-Haenchen shift. Consider a fiber with a 25-μm core radius, a core index of 1.48 and index difference of 0.01. If the wavelength is 1320 nm, what is the value of the normalized frequency parameter, how many modes propagate in the fiber, and what percent of the optical power flows in the cladding? [1+3]

3. a) Describe the major causes of attenuation in optical fiber. Provide a clear sketch of the attenuation versus wavelength curve for optical fibers; indicate the windows of transmission and their respective operating wavelengths. [3+1]
   b) Define dispersion and describe the types of dispersion present in optical fibers. A step index fiber has a core refractive index of 1.5, an index difference of 3% and an operating wavelength of 0.82-μm; estimate the critical radius of curvature at which large bending losses occur. [3+2]

4. a) Describe the working principle of the hetero-junction LED. A LED emitting at a peak wavelength of 1310 nm has radiative and non-radiative recombination lifetimes of 30 ns and 100 ns, respectively, with 40 mA of drive current. Find the total recombination lifetime, the internal quantum efficiency, and the internal power level. [2+2]
   b) Describe the working mechanism of the distributed feedback laser and how does it differ from the distributed Bragg reflector laser? [3]

5. a) Describe in detail the working mechanism of the APD. A Silicon APD has a quantum efficiency of 65% at a wavelength of 900 nm. Suppose 0.5-μW of optical power produces a multiplied photocurrent of 10-μA. What is the multiplication factor? [4+3]
   b) Describe in detail the working mechanism of EDFA, and point out its advantages. [7]

6. a) Define an optical modulation. Why is intensity modulation preferred over field modulation in optical fiber communication systems? [1+2]
   b) Describe direct intensity modulation and subcarrier multiplexing. [3]

7. a) Describe the manufacturing process of the FBT coupler. [6]
   b) A four-port multimode fiber FBT coupler has 60-μW optical power launched into port 1. The measured output powers at ports 2, 3, 4 are 0.004-μW, 26-μW and 27.5-μW respectively. Determine the excess loss, the insertion losses between the input and output ports, the crosstalk and the split ratio for the device. [5]

8. a) Differentiate between PDH and SDH. [4]
   b) After a number of years of service an existing single mode fiber is to be upgraded to a bit rate of 622 Mb/s at 1550 nm, using a new transmitter and receiver. The fiber span is 81 km and the fiber has a loss of 0.24 dB per km at 1550 nm and a dimensionless material dispersion coefficient Y equal to 0.007. The fiber was originally operated at 1330 nm, where the fiber loss was 0.7 dB. The fiber was installed in lengths 700 m long and the maximum splice loss was 0.05 dB. The original repair margin was 6 dB, but no repairs have been required. Two connectors were used with a loss of 0.2 dB each. Two different types of transmitter are available for the upgrade. Transmitter A has an output power of +3dBm and a RMS spectral width of 0.35 nm. Transmitter B has an output power of +4 dBm and a RMS spectral width of 0.47 nm. Both transmitters are capable of operating at 622 Mb/s. The receiver availeble for the upgrade has a worst-case sensitivity of -32 dBm. Complete a power budget for the upgraded system using each of the transmitters in turn to determine which transmitter should be chosen on the basis of the highest repair margin. State all of your assumptions clearly. [13]

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