NEW YORK CITY COLLEGE OF TECHNOLOGY
The City University of New York

DEPARTMENT: Electrical and Telecommunications Engineering Technology

SUBJECT CODE AND TITLE: TCET 4152/TC 730 Optical Network Components

COURSE DESCRIPTION: This course is concentrated on components for optical networks such as multimode and single mode optical fibers, transmitters, receivers, passive components, and active components. The main focus of this course is teaching the students to understand technical documentation through the prism of scientific and engineering foundation of the discussed components. The course pays special attention to the new trends-expansion of the components functionality by making use of tunable devices and the increase of the level of component integration.

PREREQUISITE: TCET 3202/TC 620

PRE OR COREQUISITE: TCET 4162/TC 760

TEXTBOOK: Djafar K. Mynbaev and Lowell L. Scheiner, *Fiber-Optic Communications Technology*, Prentice Hall, 2001, ISBN 0-13-962069-9.
Course notes prepared by Professor Djafar Mynbaev, New York City College of Technology, Fall 2005.

COURSE OBJECTIVES/ COURSE OUTCOMES: Upon completion of this course students will posses the ability to:

1. Understand the main characteristics of and requirements to an optical fiber as a transmission medium (ABET Criteria 2a, 2b, 2d, 2g).
2. Understand the general principles of light propagation in multimode (MMF) and single mode (SMF) optical fibers (ABET Criteria 2a, 2b, 2d, 2f).
3. Describe attenuation in MMF and SMF (ABET Criteria 2a, 2b, 2d, 2f).
4. Explain dispersion, including modal, spectral and polarization-mode dispersions in MMF and SMF. Also, describe the main measures to cope with all types of dispersion (ABET Criteria 2a, 2b, 2c, 2d, 2e, 2f, 2k).
5. Study the structure of fiber-optic cable and describe splicing (ABET Criteria 2a, 2b, 2d, 2f).

6. Understand the principle of operation and know the main parameters of VCSEL, DFB and other types of laser diodes (ABET Criteria 2a, 2b, 2d, 2f).
7. Analyze the characteristics and evaluate the performance of transmitter modules (ABET Criteria 2a, 2b, 2d, 2f, 2k).
8. Describe the principle of operation and main parameters of photodiodes and analyze the characteristics and evaluate the performance of receiver modules (ABET Criteria 2a, 2b, 2c, 2d, 2e, 2f, 2k).
9. Explain the principle of operation and parameters of optical amplifiers and regenerators (ABET Criteria 2a, 2b, 2d, 2f).
10. Explain the principle of operation, implementation and main parameters of passive components, such as splitters, multiplexers, interleavers, attenuators and filters (ABET Criteria 2a, 2b, 2d, 2f).
11. Describe the principle of operation of the main types of optical switches (ABET Criteria 2a, 2b, 2d, 2f).
12. Understand and use technical documentation of all the discussed devices (ABET Criteria 2a, 2b, 2d, 2f, 2g, 2k).

TOPICS: Topics include introduction to fiber-optic communications, optical fiber as a transmission medium, modes and modal dispersion in optical fiber, fiber optic cables, laser diodes, optical fibers, passive and active components, photonic switches.

CLASS HOURS: 2

Lab Hours 3

CREDITS: 3

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Descriptive details for laboratory coursework:

Laboratory exercises include measuring attenuation in plastic optical fibers and silica fibers at various wavelengths, signal distortion in silica fibers, CD compensation and management with VPI system, and connection losses in fiber-optic cable. The students will also measure and analyze input-output characteristics of VCSEL diode, VCSEL modulation, spectral characteristics of a photo diode, gain & bandwidth of EDFA and SOA, and characteristics of splitters, attenuators, WDM, MUXs, MEMS switches.

GRADING POLICY: TCET 4152/TC 730

Laboratory part	30%
Quizzes	30%
Research paper	10%
Final Exam	30%

Letter Grade	Numerical Grade Ranges	Quality
A	93-100	4.0
A-	90-92.9	3.7
B+	87-89.9	3.3
B	83-86.9	3.0
B-	80.82.9	2.7
C+	77-79.9	2.3
C	70-76.9	2.0
D	60-69.9	1.0
F	59.9 and below	0.0

Class policy:

1. Students are required to attend all regularly scheduled class meetings.
2. Students are required to be on time for all class meetings.
3. Students are responsible for all material covered by the instructor in class whether they are present or not. If a student must be absent, it is their responsibility to find out what was missed from either the instructor or a fellow student.
4. Students are expected and encouraged to see the instructor for extra help outside of class as soon as difficulty in understanding the material is encountered. Students who do not grasp the material the material from a given day's class will not be able to understand the material in subsequent classes.
5. Students are expected and encouraged to use online options, such as Blackboard and e-mail, for additional help and advice
6. Students are expected to work all homework and test problems.
7. Students are expected to keep a class notebook.
8. Students require submitting a laboratory report next week after the experiment is conducted.
9. Research paper is due the week before the final examination.
10. No food or drink is allowed in the classroom at any time.

Assessment

The following assessment techniques are correlated to the course objectives as follows: In addition, each assessment technique incorporates one or more of the following ABET Criteria 2 outcomes (2a, 2b, 2c, 2d, 2f, 2k).

COURSE OBJECTIVES	ASSESSSMENT
For the successful completion of this course, the students should be able to:	Evaluation Methods and Criteria: Students will exhibit skills in class discussion, homework assignments, laboratory exercises, quizzes, exams, and course projects.
1. Understand the main characteristics of and requirements to an optical fiber as a transmission medium.	1. Define attenuation and bandwidth of an optical fiber and state the requirements to an optical fiber as a transmission medium.
2. Understand the general principles of light propagation in multimode (MMF) and single mode (SMF) optical fibers.	2. Compute critical propagation angle and numerical aperture, which will demonstrate the students' understanding total internal reflection as a necessary condition for light propagation in multimode (MMF) and single mode (SMF) optical fibers.
3. Describe attenuation in MMF and SMF.	3. List the main sources of losses, describe their mechanisms and calculate attenuation of MMF and SMF.
4. Explain dispersion, including modal, spectral and polarization-mode dispersions in MMF and SMF. Also, describe the main measures to cope with all types of dispersion.	4. Analyze the mechanism of dispersion, including modal, spectral and polarization-mode dispersions in MMF and SMF and describe how dispersion translates into restriction of MMF and SMF bandwidth. Also, describe the devices and systems to use in coping with all types of dispersion.
5. Study the structure of fiber-optic cable and describe splicing.	5. List the main components of a fiber-optic cable, describe mechanical and fusion splicing and analyze application of cables and splicing.
6. Understand the principle of operation and know the main parameters of VCSEL, DFB and other types of laser diodes.	6. Compute main characteristics (input/output, modulation bandwidth and spectral) of VCSEL, DFB and other main types of laser diodes based on the results of experiments. Simulate their performance. Analyze the manufacturers' data sheets.
7. Analyze the characteristics and evaluate the performance of transmitter modules.	7. Sketch the block diagram of a transmitter and demonstrate the use of eye diagram for evaluation of performance of transmitter modules.

8. Describe the principle of operation and main parameters of photodiodes and analyze the characteristics and evaluate the performance of receiver modules.	8. Compute the main parameters of photodiodes (responsivity, modulation bandwidth and spectral bandwidth). Use eye diagram and bit-error-rate (BER) figures for evaluation of performance of receiver modules.
9. Explain the principle of operation and parameters of optical amplifiers and regenerators.	9. Analyze the difference between optical amplifiers and regenerators, list the main—EDFA, SOA and Raman—types of optical amplifiers, and demonstrate the knowledge of their principles of operation, main characteristics and applications. Compute gain and noise figure of each type of OA.
10. Explain the principle of operation, implementation and main parameters of passive components, such as splitters, multiplexers, interleavers, attenuators and filters.	10. Calculate the main characteristics of passive components, such as splitters, multiplexers, interleavers, attenuators and filters and present the results in tabulated and graphical formats.
11. Describe the principle of operation of the main types of optical switches.	11. List the main types of optical switches, analyze the principle of operation and list the characteristics of the main types of optical switches. Simulate their operation.
12. Understand and use technical documentation of all the discussed devices.	12. Analyze technical documentation of all the discussed devices.

Week	Topics	Reading assignments	Homework problems and laboratory exercises
1	Introduction to fiber-optic communications: major components of a fiber-optic communications systems, technology and optical networks. Physics of light: quantum view, wave view, ray view. Total internal reflection. .	Pp. 1-13, 18-25, 28-41. Course notes (CN).	Pr. 1.1-1.10, 1.12-1.20, 2.1-2.11. Demo 1 – fabrication of fiber and cable. Demo 2 –computer simulation of fiber-optic com. system.
2	Optical fiber as a transmission medium: Signal distortion in amplitude and width. Attenuation and bandwidth (transmission capacity). Attenuation: absorption, scattering and bending losses. Launching light into optical fiber: numerical aperture.	Pp. 42-56, CN. **Quiz #1 – Light**	Pr. 3.1-3.26. Lab 1: Measuring attenuation in plastic optical fibers at various wavelengths.
3	Modes in optical fibers. Attenuation in multimode (MMF) and single mode (CMF) fibers.	Pp. 57-69, CN.	Pr. 3.27-3.44. Lab 2: Measuring attenuation in silica fibers according to industry standards.
4	Modal dispersion. Chromatic dispersion (CD). Polarization-mode dispersion (PMD). Bandwidth and bit rate. Reading the data sheets of MMF and SMF. Bandwidth and bit rate. Reading data sheets of MMF and SMF.	Pp. 71-77, 195-204, CN. **Quiz #2 – optical fiber**	Pr. 3.45-3.51, 6.16, 6.17, 6.19. Lab 3: Signal distortion in silica fibers.
5	Coping with transmission impairments in optical fibers: Attenuation and bandwidth; nonlinear effects (FWM, XPM, SPM, and SBS). Dispersion management: CD and PMD compensation and management.	Pp. 66-69, 122-135, 147-160. CN	Pr. 4.45-4.57, 5.13-5.19. Lab 4: CD compensation and management with VPI system.
6	Fiber-optic cables. Splicing: procedure and losses. Connectors and adapters.	Pp. 220-244, 248-270. CN.	Pr. 7.6-7.8, 7.12, 8.1-8.16. Demo: Fusion splicers. Lab 5: Connection losses.
7	Laser diodes (LDs): Principle of operation and basic characteristics. VCSELs: reading the data sheet.	Pp. 332-359. CN. **Quiz # 3 – Optical fiber and cables.**	Pr. 9.25-9.35. Lab 6: Input-output characteristic of VCSEL diode.
8	Distributed feedback (DFB) laser diodes: principle of operation and basic characteristics. Modulation of laser diodes: internal and external modulation. Chirp and noise. Transmitter modules. Tunable LDs.	Pp. 347-354. CN Pp. 386-416. CN.	Pr. 9.36-9-51. Lab 7: VCSEL modulation. Pr. 10.27-10.45. Demo: Tunable laser diode.
9	Receivers: principle of operation and characteristics. Reading a receiver data	Pp. 434-459. CN.	Pr. 11.1-11.45, 11.91. Lab 8: Spectral

	sheet.	**Quiz # 4 – Laser diodes.**	characteristics of a photodiode.
10	Optical amplifiers (OAs). Regenerators and amplifiers. Erbium-doped fiber amplifier (EDFA). Raman amplification.	Pp. 542-578. CN.	Pr. 12.19-12.25, 12.39-12.42. Lab 9: EDFA: Gain and bandwidth.
11	Semiconductor and linear optical amplifiers (SOAs and LOAs): operation and applications.	Pp. 523-541. CN.	Pr. 12.43-12.64. Lab 10: SOA: gain, bandwidth and noise figure.
12	Passive and active components: Couplers/splitters, WDM MUXs and DEMUXs, interleavers, filters, attenuators, wavelength converters.	Pp. 586-634. CN. Quiz # 5 – Receivers and optical amplifiers.	Pr. 13.1-13.34. Lab 11: Measuring characteristics of splitters, attenuators and WDM MUXs.
13	Photonic switches: configuration, required characteristics and applications. Technologies of optical switches.	Pp. 637-646. CN.	Pr. 13.35-13.43. Lab 12: Measuring characteristics of MEMS switches.
14	Switching systems: optical add/drop multiplexers (OADMs) and optical cross-connects (OXCs). Burst switching and packet switching. Review for final examination.	Pp. 643-636. CN.	Pr. Instructor assignment. Lab 13; Make-up session.
15	**Final examination**		