ECE 7850 Fiber and Integrated Optics
Syllabus
Winter 2016
5:30 – 7:20 M W 0243 Manoogian

No: ECE 7850

Title: Fiber and Integrated Optics. Cr. 4

Course Description:

Fiber- and integrated-optical devices used in optical systems for applications in communication, signal processing, data storage, and sensing. Optical waveguides, couplers, filters, modulators, (de)multiplexers, light sources and detectors, amplifiers. Physics of device operation, working characteristics, compatibility of devices in optical systems.

Coordinator: Ivan Avrutsky, Associate Professor of Electrical and Computer Engineering

Instructor: Ivan Avrutsky, Associate Professor of Electrical and Computer Engineering

Office hours: 4:30 –5:30 p.m. Mondays, Wednesdays

Office location: 3142, Engineering Building

Phone: (313) 577 4801

Email: ivan.avrutsky@wayne.edu

Web page: http://www.ece.eng.wayne.edu/~avrutsky/

Course Meeting Time: Mondays, Wednesdays, 5:30 p. m. – 7:20 p. m.

Course Meeting Location: 0243 Manoogian

Goals:

The goal of this course is to develop critical understanding of fiber-based and integrated-optical device used in modern optical systems for applications in communication, signal processing, data storage, and sensing. This includes, among others, optical waveguides such as fibers, planar and channel waveguides, couplers, splitters, filters, multiplexers and demultiplexers, semiconductor lasers and photodetectors, optical amplifiers etc. We will learn physics of device operation, their working characteristics, and compatibility of devices in optical systems. We will discuss ultimate performance limitations set by the nature of physical interactions as well as by current technological constrains.
Course Learning Objectives:

After completing this course, students should be able to do the following:

1. Quantitatively evaluate expected performance of various optical devise based on their internal structure and properties of internal components

2. Analyze performance characteristics of optical devices and related them to ultimate physical and technological limitations

3. Design simple fiber-based and integrated-optical devices

Lecture Notes:

Lecture notes developed by instructor provide essential material for the course. Lecture notes available online at [http://ece.eng.wayne.edu/~avrutsky](http://ece.eng.wayne.edu/~avrutsky) (select Teaching, then ECE7850 current lecture notes)

Text book:

Subjects of lectures correlate with selected chapters of the textbook

Other recommended books:

Optical Fiber Telecommunications, ed. by I. P. Kaminov, T. Li, A. E. Willner (recent technical reviews on telecommunication components and systems) Academic Press, 2008

Photonics: Optical Electronics in Modern Communications, by A. Yariv and P. Yeh (comprehensive reference book for engineers and scientists in photonics) Oxford University Press, 2006

Prerequisites by Topic:

ECE 5870, Optical Communication Networks
Preferably, this course should be taken before enrolling into ECE 7850

Corequisites by Topics: none
Course Summary:

1. Optical Fibers and Waveguides
2. Optical Sources and Transmitters
3. Optical Detectors and Receivers
4. Optical Amplifiers
5. Nonlinear interactions in Optical Fibers

The course content is covered by chapters 2, 3, 4, 7, 8, 9, 10 and 11 of the textbook

Course Structure:

18 lectures covering the course topics given by the instructor
5 lectures covering sample quizzes and exams problems and home-work assignments
4 sessions reserved for Quizzes (2), Midterm Exam, and Final Exam
2 session reserved for students’ presentations based on resent review papers

Detailed schedule of lectures, quizzes and exams is attached.

Homework Report Format:

The Homework assignments are small design and/or analysis projects. Computer simulation will be required. No restriction on the programming language. Final result must be presented by printed computer-generated graphs. No hand-written reports will be accepted.

Computer Resources:

To work on home projects, students may use any tool that allow for numerical simulations based on simple algebraic or differential equations (Matlab, Mathcad, C, C++, e.t.c.). Computers are available in Engineering PC Lab as well as in libraries on campus.

Laboratory Resources: none

Class policy: General WSU policies applied.
Grading Policy

2 Home-works 10% (5% each)
2 Quizzes 20% (10% each)
Midterm Exam 25%
Final Exam 30%
In-class activities 15%

Sample assignments such as home-works, quizzes, and exams can be found online at [http://ece.eng.wayne.edu/~avrutskey](http://ece.eng.wayne.edu/~avrutskey) (select Teaching, then ECE7850 W15 lecture notes – previous year lecture notes)

Home-works will be collected in class at the due dates according to the schedule.

Quizzes and exams will be administered during normal lecture time, each occupying entire timeslot reserved for the lecture.

Credits for the in-class activities will be based primarily on students’ presentations as well as other interactions during lectures such as brief questionnaires assessing readiness for quizzes/exams, analysis of typical mistakes on quizzes/exams, etc. Regular class attendance is critical for successful completion of the course.

Time for students’ presentations is reserved in the schedule of lectures. Additional time may be allocated during lectures. The presentations should be based on recently published, within last five years, papers in peer-reviewed technical journals and related to the subject of the course.

Grading Scale:

- 95-100 A
- 90-94 A-
- 85-89 B+
- 80-84 B
- 75-79 B-
- 70-74 C+
- 65-69 C
- 60-64 C-
- Below 60 F

Testing Policy:

All quizzes and the exams will be open books and open notes. Use this freedom wisely. Prepare your own notes to use in class. All assignments should be completed by students individually. Receiving or providing unauthorized help during quizzes and exams will result in failing final grade. The final exam will cover the entire semester’s work. No make-up quizzes will be administrated. A student missing quizzes may apply for weighting quiz points with the final exam points. The petition must be in writing, including the appropriate documents explaining the reason of missing the quiz. Final exam papers will not be returned to students.
ECE Graduate Program Learning Outcomes Coverage:

This course contributes towards achieving following learning outcomes:
At the time of their graduation, students will be able to

1. *Demonstrate mastery of advanced principles pertaining to the electrical engineering research path of the Ph.D. candidate.* Studied in this course are advanced devices and systems that enable progress in development of modern photonic systems used in communication, signal processing, data storage, and sensing.

2. *Effectively communicate, both verbally and in writing, scientific and engineering concepts to audiences with a broad range of technical knowledge.* The assignments turned for grading are expected to be clearly written and to provide convincing justification of the methods and steps in solving the problems. Students’ presentations are aimed, in particular, at the development of verbal communication skills to deliver scientific and engineering concepts to audiences with a broad range of technical knowledge.

Accommodations for Students with Disabilities:

If you have a documented disability that requires accommodations, you will need to register with Student Disability Services for coordination of your academic accommodations. The Student Disability Services (SDS) office is located at 1600 David Adamany Undergraduate Library in the Student Academic Success Services department. SDS telephone number is 313-577-1851 or 313-577-3365 (TDD only). Once you have your accommodations in place, I will be glad to meet with you privately during my office hours to discuss your special needs. Student Disability Services’ mission is to assist the university in creating an accessible community where students with disabilities have an equal opportunity to fully participate in their educational experience at Wayne State University.

Please refer to the SDS website for further information about students with disabilities and the services we provide for faculty and students: http://studentdisability.wayne.edu/

**Prepared By:** Ivan Avrutsky, Associate Professor of Electrical and Computer Engineering

**Last Revised:** January 6, 2016
<table>
<thead>
<tr>
<th>Lecture #</th>
<th>Date</th>
<th>Lecture Subject</th>
<th>Chapters</th>
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</thead>
<tbody>
<tr>
<td>#1</td>
<td>Jan. 11, M</td>
<td>General introduction to ECE 7850</td>
<td>Lecture notes.</td>
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<tr>
<td>#2</td>
<td>Jan. 13, W</td>
<td>Wavelengths scale of electromagnetic waves. Geometrical and wave optics.</td>
<td>2</td>
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<td></td>
<td>Jan. 18, M</td>
<td>No classes. Martin Luther King Jr. Day.</td>
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<tr>
<td>#3</td>
<td>Jan. 20, W</td>
<td>Numerical aperture and intermodal dispersion. Step-index and graded index fibers.</td>
<td>2</td>
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<tr>
<td>#4</td>
<td>Jan. 25, M</td>
<td>Wave equation. Plane waves in a uniform medium. Complex index of refraction.</td>
<td>2</td>
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<tr>
<td>#5</td>
<td>Jan. 27, W</td>
<td>Modes in optical waveguides. Single-mode and multi-mode fiber.</td>
<td>2</td>
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<tr>
<td>#6</td>
<td>Feb. 1, M</td>
<td>Dispersion in single-mode fibers: Group velocity, material, waveguide, polarization, and high-order dispersion. Dispersion induced limitations.</td>
<td>2</td>
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<tr>
<td>#7</td>
<td>Feb. 3, W</td>
<td>Fiber loss. Material absorption, Rayleigh scattering, waveguide imperfections.</td>
<td>2</td>
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<tr>
<td>#8</td>
<td>Feb. 8, M</td>
<td>Raman and Brillouin scattering, nonlinear refraction, four-wave mixing. Fiber manufacturing.</td>
<td>2</td>
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<tr>
<td>#9</td>
<td>Feb. 10, W</td>
<td>Examples of problems for quizzes and exams</td>
<td></td>
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<tr>
<td>#10</td>
<td>Feb. 15, M</td>
<td>Quiz #1 (Lectures #1-9).</td>
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<tr>
<td>#11</td>
<td>Feb. 17, W</td>
<td>Light emission and absorption in semiconductors.</td>
<td>3</td>
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<td>#12</td>
<td>Feb. 22, M</td>
<td>Light-emitting diodes (LED). Output power, spectrum, modulation response.</td>
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<tr>
<td>#13</td>
<td>Feb. 24, W</td>
<td>Semiconductor lasers. Single-mode and single-frequency operation.</td>
<td>3</td>
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<td>Deadline for HmWrk#1.</td>
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<tr>
<td>#14</td>
<td>Feb. 29, M</td>
<td>Analysis of HmWrk#1. Examples of problems for MidTerm Exam.</td>
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<tr>
<td>#15</td>
<td>Mar. 2, W</td>
<td>MidTerm Exam (Lectures #1-14).</td>
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<tr>
<td>#16</td>
<td>Mar. 7, M</td>
<td>Photodetectors: p-n, p-i-n, avalanche diodes, and MSM structures.</td>
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<tr>
<td>#17</td>
<td>Mar. 9, W</td>
<td>Noise in light detectors. Light quantization, shot noise, and thermal noise.</td>
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<td></td>
<td>Mar. 14, M</td>
<td>No Classes. Spring Recess</td>
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<td></td>
<td>Mar. 16, W</td>
<td>No Classes. Spring Recess</td>
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<tr>
<td>#18</td>
<td>Mar. 21, M</td>
<td>Bit error rate versus signal to noise ratio.</td>
<td>4</td>
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<tr>
<td>#19</td>
<td>Mar. 23, W</td>
<td>Gain spectrum and bandwidth of optical amplifiers. Amplifier noise.</td>
<td>7</td>
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<tr>
<td>#20</td>
<td>Mar. 28, M</td>
<td>Semiconductor laser amplifiers.</td>
<td>7</td>
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<tr>
<td>#21</td>
<td>Mar. 30, W</td>
<td>Optical fiber amplifiers.</td>
<td>7</td>
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<tr>
<td>#22</td>
<td>Apr. 4, M</td>
<td>Brief review on dispersion compensation techniques.</td>
<td>8</td>
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<tr>
<td>#23</td>
<td>Apr. 6, W</td>
<td>Examples of problems for quizzes and exams.</td>
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<tr>
<td>#24</td>
<td>Apr. 11, M</td>
<td>Quiz #2 (All topics).</td>
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<tr>
<td>#25</td>
<td>Apr. 13, W</td>
<td>Presentations prepared by students</td>
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<tr>
<td>#26</td>
<td>Apr. 18, M</td>
<td>Presentations prepared by students</td>
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<tr>
<td>#27</td>
<td>Apr. 20, W</td>
<td>Analysis if Quiz #2. Deadline for HmWrk#2.</td>
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<tr>
<td>#28</td>
<td>Apr. 25, M</td>
<td>Analysis of HmWrk#2. List of important formulas. Examples for Final Exam.</td>
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<tr>
<td>#29</td>
<td>Apr. 27, W</td>
<td>Final Exam. All topics.</td>
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