OPTI 510R: Photonics

Graduate Course Syllabus

Semester and Year this Document Covers:

Spring 2021 to present (this syllabus remains in effect until replaced)

Course Number and Title:

OPTI 510R: Photonics

Instructor Information:

Instructor: Professor Khanh Kieu
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Teaching Assistant (TA): TA information is announced at the beginning of each semester

Lecture Schedule and Office Hours:

Lecture: Monday and Wednesday 11:00am to 12:15pm, Rm 307
Office Hours: To be announced at the beginning of each semester and by appointment

Course Objectives:

This course has been designed to give an introduction to photonics at the graduate level. From the Photonics Dictionary at photonics.com, Photonics is defined as

> *The technology of generating and harnessing light and other forms of radiant energy whose quantum unit is the photon. The science includes light emission, transmission, deflection, amplification and detection by optical components and instruments, lasers and other light sources, fiber optics, electro-optical instrumentation, related hardware and electronics, and sophisticated systems. The range of applications of photonics extends from energy generation to detection to communications and information processing.*

This course is designed to be device oriented, with many practical examples of photonics components especially those used in the current fiber optics communication networks. The students will learn how the devices are made, designed and operated. The course can be broadly divided into two parts. The first part covers fundamentals such as theories of dispersion, absorption and birefringence. Thorough understanding of these concepts is required for the rest of the course. This review will be followed immediately by studies of passive components such as diffraction gratings, Fabry Perot filters, Bragg mirrors and polarization optics. We then move to light propagation in planar waveguide geometries, specifically integrated optics devices, with discussion of several advanced topics such as arrayed waveguide gratings and silicon photonics. There will be a midterm exam, which will provide students with enough feedback on their performance in order to make adjustment for the second half of the semester. The second part of the class covers wave propagation in optical fibers with applications to optical networks, telecommunications, and optical interconnects. Different types of fiber based devices are examined such as fused fiber couplers, wavelength division multiplexers (WDM) and fiber isolators. We will study various types of optical fiber amplifiers, specialty fibers and nonlinear effects in fibers that impact optical network performance. Many practical aspects of fiber-based devices will be covered including their design, fabrication and packaging; relevant reliability standards will also be introduced. Finally, we will examine different kinds of active lightwave devices including LEDs, lasers and photodetectors.

Lecture topics:

1. Properties of Light
2. Wave Optics
3. Interference and Devices
4. Diffraction and Devices
5. Polarization Optics
6. Planar Waveguides
7. Optical Fibers
8. Fiber Dispersion and Compensation Techniques
9. Fiber Fabrication
10. Nonlinear Optical Effects in Fibers
11. Optical Amplifiers
12. Passive Fiber Components
13. Lasers
14. Detectors
15. Introduction to Optical Network

Learning Outcomes upon completion of this course:

It is expected that students will be able to:

- Understand the fundamental concepts in Photonics such as interference, diffraction, propagation of wave packets in waveguides and light-matter interaction;
- Know the working principles and performance of photonics devices in current lightwave communication systems including planar waveguides, optical fibers, fiber-based components, lasers, detectors;
- Identify the remaining challenges in the field of Photonics and discuss possible solutions;
- Be prepared to handle and effectively use various photonics components and devices in real laboratory environment.

Grading Policy:

Two Exams		60%
Homework Assignments		40%
	TOTAL	**100%**

Exams:

We have two exams during the semester. The exams will be based on the lectures, homework assignments, and materials in the textbook. Each exam includes materials in the different parts of the class. The first exam will cover the first half of the course, while the second exam covers the second half of the course.

Homework Assignments:

There will be a homework problem set assigned approximately every two weeks. The problem set is due in class. The due date will be listed in the problem set handouts. *Late homework will be accepted up to a week after it was due, and will be graded at 50% off. All materials that are over a week late will receive zero credit.* For distance learning students, you can email scanned/electronics copies of your homework to the TA before the deadline. Recording of class lectures will be available online to distance learning students only. Please contact Cindy Robertson (cindyr@optics.arizona.edu).

Textbook:

We have one required textbook for the class:

B. E. A. Saleh and M. C. Teich, "Fundamentals of Photonics," 2nd Edition, John Wiley & Sons, Inc. 2007.

There will be handouts given during class to supplement the materials not in the textbook. Supplements and additional materials are available on the class website (https://wp.optics.arizona.edu/kkieu/opti-510r/) , which will be updated periodically during the semester.

Course Policies:

It is ***very important*** to attend all lectures. If you must be absent, it is your responsibility to obtain and review the information you missed. The students are encouraged to ask questions during the lecture. Attendance is not mandatory. If you miss an exam, it may not be made up unless you have a documented medical or family emergency.

If you need to leave the room during lecture, please do so discretely, so that you won't disturb the professor and the students.

You are encouraged to work with each other as a team. You should not, however, copy each other's homework.

Additional Information:

Academic Integrity
According to the Arizona Code of Academic Integrity (http://dos.web.arizona.edu/uapolicies/cai2.html), "Integrity is expected of every student in all academic work. The guiding principle of academic integrity is that a student's submitted work must be the student's own." Unless otherwise noted by the instructor, work for all assignments in this course must be conducted independently by each student. CO-AUTHORED WORK OF ANY KIND IS UNACCEPTABLE. Misappropriation of exams before or after they are given will be considered academics misconduct.

Misconduct of any kind will be prosecuted and may result in any or all of the following:
* Reduction of grade
* Failing grade
* Referral to the Dean of Students for consideration of additional penalty, i.e. notation on a student's transcript re. academic integrity violation, etc.

Students with a Learning Disability:

If a student is registered with the Disability Resource Center, he/she must submit appropriate documentation to the instructor if he/she is requesting reasonable accommodations. (http://drc.arizona.edu/instructor/syllabus-statement.shtml).

References
[1] Class notes are taken partially from those prepared by Alan Kost and Seppo Honkanen
[2] E. Hecht, *Optics*, 4th ed., Pearson Education, (2001).
[3] G. R. Fowles, *Introduction to Modern Optics*, Dover (1989).
[4] K. D. Moller, *Optics*, Springer-Verlag (2002).
[5] M. Born and E. Wolf, *Principles of Optics*, Cambridge University Press (1999).
[6] M. V. Klein and T. E. Furtak, *Optics*, John Wiley & Sons (1986).
[7] K. Okamoto, *Fundamentals of Optical Waveguides*, Academic Press (2000).
[8] G. Joos, *Theoretical Physics*, 3rd ed., Dover (1986).
[9] B.E.A. Saleh and M.C. Teich, *Fundamentals of Photonics*, Wiley (2007).
[10] A. Yariv and P. Yeh, *Optical Waves in Crystals*, Wiley (1984).
[11] A. E. Siegman, *Lasers*, University Sciences Books (1986).
[12] J. W. Goodman, *Introduction to Fourier Optics*, 2nd ed., McGraw-Hill (1996).
[13] G. P. Agrawal and N. K. Dutta, *Long-wavelength Semiconductor Lasers*, Van Nostrand Reinhold (1986).
[14] C. Pollock and M. Lipson, *Integrated Photonics*, Kluwer Academic Publishers (2003).
[15] G. Lifante, *Integrated Photonics Fundamentals*, John Wiley and Sons (2002).
[16] H. Zimmermann, *Integrated Silicon Opto-electronics*, Springer (2000).
[17] H. H. Barrett and K. J. Myers, *Foundations of Image Science,* John Wiley and Sons (2004).

[18] D. R. Goff, *Fiber Optic Reference Guide,* 3rd ed., Focal Press (2002).
[19] J. Crisp and B. Elliott, *Introduction to Fiber Optics,* 3rd ed., Newnes (2005).
[20] J. Hecht, *Understanding Fiber Optics*, 5th ed., Pearson (2006).
[21] R. G. Hunsperger, *Integrated Optics: Theory and Technology*, 3rd ed. Springer-Verlag (1991).
[22] T. Tamir, *Guided-Wave Optoelectronics*, 2nd ed. Springer-Verlag (1990).
[23] J. M. Liu, *Photonic Devices*, Cambridge University Press (2005).
[24] C. C. Chen, *Guided-Wave Optics*, Wiley Interscience (2007).