OPTI 403A/503A: Mathematical Methods for Optics and Photonics
Effective Spring 2014

Description:

This course covers the basic mathematics needed for an in-depth understanding of the science and technology of fiber-optical communication systems. This is an optical sciences application course that uses mathematics, as opposed to a purely mathematics course. Every mathematical tool/technique developed in this course will first be motivated by the relevant application. All application examples will be designed to show the usefulness of the mathematical methods in specific areas of optical science and photonics engineering, e.g., diffraction theory, grating analysis, stable propagating modes in optical fibers, optical pulse shaping and distortion, etc. The students are not expected to have a broad-based prior knowledge of the topics covered in this course, but they should generally be familiar with the basics of algebra, Euclidean geometry, trigonometry, integral and differential calculus, simple differential equations, and the rudiments of complex number analysis. The course will cover Complex Analysis, Fourier transform theory, and method of stationary phase (in the context of optical diffraction), vector algebra, linear algebra, ordinary and partial differential equations (e.g., Maxwell's electrodynamics, wave equation, diffusion equation), special functions (e.g., Bessel functions needed to study the guided modes of optical fibers), and probability theory (needed for understanding various sources of noise in communication systems, photodetection theory, digital communication via noisy channels, information theory, etc.).

Pre-requisites:

Math 322- Mathematical Analysis for Engineers: students should have familiarity with basic calculus, Euclidean geometry, algebra, trigonometry and the complex number system.

Locations and Times:

TBD

Instructor Information:

Professor Masud Mansuripur
Meinel, Room 638
520-621-4879
Masud@optics.arizona.edu
Office Hours: T/Th 2 pm -3:30pm (Meinel room 638)
Course website: https://sites.google.com/site/mmansuripur/home
Instructor website: http://www.optics.arizona.edu/masud

Expected Learning Outcomes:

To learn the tools and techniques of scientific analysis in the context of their applications in optics and photonics.

Required Texts:

The following texts are recommended but not required:

1. G. B. Arfken and H. J. Weber, “Mathematical Methods for Physicists,” 6th edition, Academic Press, 2005.
2. F. B. Hildebrand, "Advanced Calculus for Applications," 2nd edition, Prentice-Hall, New Jersey, 1976.
3. R. Bracewell, “Fourier Transform and its Applications,” 3rd edition, McGraw-Hill, New York, 1999.
4. M. Mansuripur, “Introduction to Information Theory,” Prentice-Hall, New Jersey, 1987.
5. J. Mathews and R. L. Walker, "Mathematical Methods of Physics," 2nd edition, Benjamin/Cummings Publishing, California, 1970.
6. G. Stephenson and P. M. Radmore, "Advanced Mathematical Methods for Engineering and Science Students," Cambridge University Press, United Kingdom, 1990.

Topics:

- Elementary calculus, exponential and logarithmic functions, Taylor series expansion
- Approximation methods
- Complex number theory, complex integration and differentiation, simple functions in the complex domain
- Special functions: Rectangular and triangular functions, delta-function and its derivatives, sinc function, etc.
- The convolution operation
- Linear, shift-invariant systems
- Fourier transform theory, theorems, useful Fourier transform pairs
- The method of stationary phase
- Applications of Fourier theory to optical diffraction
- Linear algebra, operations with matrices, matrix inversion
- Eigen-values and eigen-vectors, matrix diagonalization
- Vector algebra, vector identities
- Divergence, curl, gradient, and Laplacian operators
- Ordinary differential equations; elementary methods of solution
- Partial differential equations, method of separation of variables
- The diffusion equation
- Maxwell’s equations; the wave equation
- Solutions of the wave equation in Cartesian, cylindrical, and spherical coordinate systems
- Special functions: Bessel functions of the 1^{st}, 2^{nd}, and 3^{rd} kind; modes of an optical fiber
- Probability theory
- Statistical properties of thermal noise, shot noise, and modal noise in fiber optics systems
- Introduction to Information Theory and Coding
- Communication via noisy channels; Shannon’s noisy channel capacity
- Compression codes, error-correction codes, modulation coding

Number of Exams and Papers:

One midterm exam and one final exam will be required. All will be administered in class allowing open note and open book. No term papers will be required

Course Policies:

<u>Grading Policy</u>

Midterm (in class, open book/open note)	30%
Final Exam (in class, open book/open note)	50%
Homework assignments	20%

<u>Attendance Policy:</u>

It is important to attend all classes, as what is discussed in class is pertinent to adequate performance on assignments and exams. If you must be absent, it is your responsibility to obtain and review the information you missed.

If you miss the midterm or final exams, they may not be made up unless you have a documented medical or family emergency.

"All holidays or special events observed by organized religions will be honored for those students who show affiliation with that particular religion. Absences pre-approved by the UA Dean of Students (or Dean's designee) will be honored."

<u>Classroom Behavior:</u>
The Arizona Board of Regents' Student Code of Conduct, ABOR Policy 5-308, prohibits threats of physical harm to any member of the University community, including to one's self. See: http://policy.web.arizona.edu/threatening-behavior-students.

<u>Student Code of Academic Integrity:</u>
According to the Arizona Code of Academic Integrity, "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. See: http://deanofstudents.arizona.edu/codeofacademicintegrity

<u>Accessibility and Accommodations:</u>

It is the University's goal that learning experiences be as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, please let me know immediately so that we can discuss options. You are also welcome to contact Disability Resources (520-621-3268) to establish reasonable accommodations.

Please be aware that the accessible table and chairs in this room should remain available for students who find that standard classroom seating is not usable.

Please note: the information contained in the course syllabus may be subject to change with reasonable advance notice, as deemed appropriate by the instructor.