BMED 8813/4813 Syllabus

Optical Microscopy, Section, and 3 credit hrs

[Class Day(s), Time, Location (include lab/recitation locations)**]**

Instructor Information

Instructor	Email	Office Hours & Location
Dr. Francisco Robles	robles@gatech.edu	Whitaker 3110, Hours, Days
Teaching Assistant(s)	**Email**	**Office Hours & Location**
[TBD]	[]	[]

General Information

Description

This course is design to provide advanced undergraduate and/or graduate students with an overview of optics and its application to microscopy. The course will cover the fundamental principles of optical imaging, and detail the inner workings of key technologies.

Pre- &/or Co-Requisites

The students should have a good understanding of E&M, calculous, and linear systems prior to taking the course. Pre-requisites: PHYS 2212, MATH 2551, ECE 2026.

Course Goals and Learning Outcomes

Students who complete this course will be able to:

- Understand optical imaging principles
- Use fundamentals of mathematics and physics to analyze image data
- Identify the most suitable optical imaging technique for a given application
- Use conventional and cutting-edge optical systems

Course Requirements & Grading

Lectures: Attendance will not be taken, but homework sets and exams will be based on class material.

Assignments: Problems sets will be posted periodically, and are due at the beginning of class a week after assignment is given. Late submissions will be penalized 25% per day.

Training sessions: The course will include two training sessions in the microscopy core. Attendance is required.

Exam: There will be one mid-term exam and a final exam.

Project: (Part 1) Demonstrate proficiency in 3 imaging systems in the microscopy core facility and characterize/quantify imaging performance. (Part 2) Literature review- choose one of the three systems and summarize novel technological developments and/or

identify novel applications of the technology. Work will be summarized in a written report and presented to the class. Depending on the size of the class, parts 1 and 2 will be done in groups of two or more. (Part 3—graduate students only) Model a particular aspect of one of the systems. Modeling will be done individually, and summarized in a separate report.

Graded Items	Weight (Percentage)
Assignments	25%
Mid-term	20%
Final Exam	20%
Training sessions	11%
Project	24% (Undergrad-12% per part; Grad-8% per part)

Grading Scale

Your final grade will be assigned as a letter grade according to the following scale:

A	90-100%
B	80-89%
C	70-79%
D	60-69%
F	0-59%

Course Materials

Materials/Resources

There are no required texts.

Reference material:

Hecht, E., "Optics," 3rd Edition, Addison Wesley 1998

Saleh, B.E.A., and M.C. Teich, "Fundamentals of Photonics," New York, Wiley, 1991

Mertz, J., "Introduction to Optical Microscopy," W.H. Freeman, 2009

https://www.microscopyu.com/

Reference to various research papers will be given during the course of the semester.

Course Expectations & Guidelines

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit

http://www.catalog.gatech.edu/policies/honor-code/ or http://www.catalog.gatech.edu/rules/18/.

Any student suspected of cheating or plagiarizing on an exam, assignment, or project will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or http://disabilityservices.gatech.edu/, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

Attendance and/or Participation

Attendance to class is expected, but will not be documented and will not be an explicit part of the final grade. However, attendance is required for the microscopy core training sessions and for the project presentations.

I also encourage students to ask many questions and participate in discussions.

Collaboration & Group Work

Collaboration is permitted and encouraged. However, the work you turn in must be the results of your own effort and reflect your understanding of the material. Exams will be an individual effort.

Extensions, Late Assignments, & Re-Scheduled/Missed Exams

Assignments must be submitted at the beginning of class on the day they are due. There are no undocumented exceptions. Late submissions will be penalized by 25% per day. If you have an emergency situation or a school sanctioned event, please contact me before the due date and provide some form of documentation.

Exams can only be rescheduled to earlier dates and the need must be communicated more than two weeks in advance.

Student-Faculty Expectations Agreement

At Georgia Tech we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. See http://www.catalog.gatech.edu/rules/22/ for an articulation of some basic expectation that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

Student Use of Mobile Devices in the Classroom

Please help me in minimizing screen use in the classroom. There is research evidence showing strong retention linked with handwritten notes. In addition, studies also show

detrimental effects of classroom laptops on the students as well as their neighbors. I will not ban screens from the classroom but I ask that you only access devices when necessary.

Accommodations for Individuals with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or http://disabilityservices.gatech.edu/, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs. Note that this also applies to any legitimate difficulty you may have with the course project.

Course Schedule (Tentative)

Class #	Topic	Recommended reading
1	Introduction I: Maxwell's equations, complex fields, pointing vector, intensity and radiance	Hecht Ch. 2-3
2	Basics of optical imaging I: Lenses, ray tracing, image formation	Hecht Ch. 5
3	Basics of optical imaging II: Lens makers' equations, matrix notation	Saleh & Teich Ch. 1
4	Microscope overview I: General principles, optical elements (e.g., types of objectives, stops, pupils)	Microscopy U
5	Microscope overview II: Illumination types, Bright field, oblique illumination, dark field	Microscopy U
6	Overview of lens design, aberrations and distortions	Hecht Ch. 6
7	Light sources, detectors, and noise	Mertz Ch. 8 Saleh & Teich Ch. 18
8	Gaussian beams	Saleh & Teich Ch. 3
9	Intro to Fourier Optics I: transfer functions of free-space, lenses	Hecht Ch. 11 Saleh & Teich Ch. 4
10	Intro to Fourier Optics II: diffraction, resolution limit	Saleh & Teich Ch. 4
11	Confocal microscopy	Mertz Ch. 14
12	Fluorescence microcopy, deconvolution microscopy, light sheet fluorescence microscopy	Mertz Ch. 13
13	Mid-Term	

Class #	Topic	Recommended reading
14	Microscopy Core Training I	
15	Absorption and scattering; polarization and birefringence	Mertz Ch. 9
16	Interference microscopy: Phase contrast, Nomarski/DIC	Mertz Ch. 10
17	Digital holography, optical coherence tomography	Mertz Ch. 11-12
18	Dispersion, phase scattering theorem	Saleh & Teich Ch 5.5
19	Advanced Fluorescence based techniques: FRET(Fluorescence Resonance Energy Transfer) microscopy, FCS (Fluorescence correlation spectroscopy), TIR (total internal reflection); Near Field scanning microscopy	Mertz Ch. 13
20	Nonlinear microscopy I: Introduction, Two-photon fluorescence	Mertz Ch. 15
21	Microscopy Core Training II	
22	Nonlinear microscopy II: Second harmonic and third harmonic generation	Mertz Ch. 16
23	Nonlinear microscopy III: Coherent Raman, pump-probe	Mertz Ch. 16
24	Super resolution I: Structured illumination and 4Pi microscopy	Mertz Ch. 18
25	Super resolution II: STED, PALM, STORM	Mertz Ch. 18
26	Introduction to tissue optical properties, diffuse reflectance spectroscopy	
27	Project presentations	
28	Final Exam	