BMED 6785/4785 Syllabus

Optical Microscopy

Instructor Information

Instructor	Email	Office Hours & Location
Dr. Francisco Robles	robles@gatech.edu	After class and by appointment

General Information

Description

This course is designed to provide graduate or advanced undergraduate 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 some understanding of E&M, calculous, and linear systems.
Suggested pre-requisites: PHYS 2211, MATH 1552 or equivalent

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.

Microscopy training sessions: Provides hands on experience with several key technologies available at GT. Attendance is mandatory.

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

Exam: There will be two mid-term exams and a final exam. Open book, open notes.

Project: (Part 1) Choose any optical imaging system or method, and conduct a thorough literature search on the forefront of this technology. The system/method must not have been discussed explicitly in class. For graduate students (Part 1b): You will also need to perform a simulation of the system (or some part of it) or conduct a thorough quantitative analysis of some aspect of this system/method. Deliverable: written report. (Part 2) Presentation (format TBD). Project will be done in groups.

Graded Items	Weight (Percentage)
Assignments	30% (4 assignments, each 7.5%)
Test I	15%
Test II	15%
Final Exam	15% (Optional. If opting out, Test I, Test II and Project will be worth 20% each)
Microscopy training sessions	10%
Project	15% (Undergrad-7.5% per part; Grad-5% 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
- Boudoux, C., "Fundamentals of Biomedical Optics," Pollux Editions, Montreal, 2016
- Boudoux, C., "Tools of Optics," in preparation (handouts will be provided).
- 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 at least 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.

Mental Health Care & Resources

Your instructors, and the BME department as a whole, care about student mental health. While your instructors can be a resource, we also want to make sure you are aware of the formal resources for receiving mental health assistance in BME and at GT. More information about these resources can be found here: https://mentalhealth.gatech.edu/

The Center for Mental Health Care and Resources (CMHCR) is the best place to engage with mental health care at GT. They are found in the Smithgall Student Services Building and can also be reached at **404-894-2575**. Their normal hours of operation are 8am to 5pm Monday through Friday. CMHCR can connect you with services including individual or group counseling, academic or personal support services, assessment and testing for learning disabilities, and other mental health providers. They can help you find the right resources for a crisis, an acute issue, or a longer-term concern.

- **BME Satellite Counselor** – In addition to the Center for Mental Health Care's centralized services, BME hosts a counselor, Kate Silverio, in Room 1105 of the Whitaker Building (in the back of the academic office). The Satellite Counselor offers 15 min appointments (in-person or virtual) during which students can discuss a brief or specific, non-emergency concern, and/or learn about mental health resources on campus. To schedule with the Satellite Counselor, please email her (kate.silverio@studentlife.gatech.edu).

- **Crisis Services** - If you require immediate support for mental health difficulties you have several options: During business hours (8 a.m.-5 p.m.). Call **404-894-2575** or go to Suite 238 in the Smithgall Student Services Building. Outside of business hours, call **404-894-2575** and select the option for the after-hours counselor. In an emergency, call Georgia Tech Campus Police at **404-894-2500** on campus or **911**.

Course Schedule (Tentative)

Class #	Topic	Recommended reading
1-2	Introduction: Maxwell's equations, complex fields, Poynting vector, intensity, refraction, Snell's law	Hecht Ch. 2-3 Boudoux (ToO) Ch. 5
3	Basics of optical imaging I: Geometrical optics, lens equation, ray tracing, image formation	Hecht Ch. 5
4-5	Basics of optical imaging II: Thick lenses, matrix notation (HW1 released)	Boudoux (ToO) Ch. 2 Hecht Ch. 5
6-7	Microscope overview: General principles, optical elements and microscopy anatomy, Illumination types, noise	Microscopy U
8	Gaussian beams (HW2 released)	Saleh & Teich Ch. 3
9	Intro to/review of linear systems	Prince Ch. 2
10-11	Confocal fluorescence microcopy Sources of noise	Boudoux (BioMedOpt) Ch. 5; Mertz Ch. 13
12	Review for test	
13	Test I	
14	No Class—Fall Break	
15	Microscopy Core Training I (Widefield and Confocal)	
16-17	Project Overview, Review Exam solutions Advanced fluorescence methods (light sheet, spinning disk) Nonlinear microscopy: Introduction, Two-photon fluorescence, Second harmonic and third harmonic generation.	Boudoux (BioMedOpt) Ch. 15 Mertz Ch. 13, 15-16
18	Overview of lens design, aberrations, and distortions (HW3 released)	Hecht Ch. 6
19	Crash course on Fourier analysis and sampling	Prince Ch. 2
20-21	Intro to Fourier Optics I: transfer functions of free-space and lenses, diffraction, resolution limit (HW4 released)	Saleh & Teich Ch. 4 Boudoux (BioMedOpt) Ch. 7-8
22	Super resolution	Mertz Ch. 18
23	Intro to interferometry	Saleh & Teich Ch. 4 Hecht Ch. 11
24-25	Microscopy Core Training II (Light sheet, structured illumination, multiphoton and D-STORM)	
26	Interference microscopy: Phase contrast, Nomarski/DIC, Digital holography	Mertz Ch. 9-10
27	Advanced Microcopy Methods	
28	Test II	
29	No Class—Thanksgiving Break	
30	Project presentations	
31	Final Exam	