

BE/EC 555: Introduction to Biomedical Optics

Syllabus: Fall 2022

Professor Irving J Bigio (BME and ECE)

Course Description:

This course surveys the applications of optical science, engineering and technology to a variety of biomedical problems, teaching the interactions of light with biological systems, from the nanoscale to tissue levels. Emphasis is on optical science and photonics technologies that enable real, minimally-invasive clinical and laboratory biomedical applications. The course teaches only those aspects of the physiology and biology that are necessary to understand the purpose and methods of the applications. The first weeks introduce the optical properties of tissue, and following classes cover a range of topics in three general areas: 1) Optical spectroscopy applied to diagnosis of cancer and other tissue diseases; 2) Photon migration and diffuse optical imaging of subsurface structures in tissue; and 3) new microscopy methods, laser-tissue interactions and other applications of light for biomedical purposes.

The format of this course is "semi-flipped." There are assigned readings from the required text, prior to each class. Half of class time will invoke informal lecture and discussion, to amplify and clarify the readings; and half of the class time will be in the style of a "flipped" class, devoted to working on problems and discussing and understanding the connection to the readings. The textbook must be acquired before the start of classes.

Required textbook: "Quantitative Biomedical Optics," Irving J. Bigio and Sergio Fantini, Cambridge University Press (2016); ISBN 978-0-521-87656-8. This text is available in print (purchase or rental) and as an e-book. Students have found the print version preferable.

Expectations regarding safety:

All students are expected to follow all University guidelines with respect to COVID vaccination status, daily symptom checks, regular testing, and mask wearing.

Topics by Number of Weeks:

Topic:	Number of weeks
Introduction: What is biomedical optics? What is biophotonics? Structure of the course, grading elements Motivation of the topic Nomenclature of optical parameters Overview of tissue optical properties	1
Diagnostic Optical Spectroscopy Instrumentation for biomedical spectroscopy (light waves and spectrometers) Tissue autofluorescence and reporter fluorescence Vibrational spectroscopy: Raman and IR spectroscopies Elastic-scattering theory and methods of spectroscopy Scattering and absorption properties of tissue in the sub-diffuse regime	5
Photon Migration and Optical imaging The diffusion approximation to the Boltzmann transport equation Time-domain methods for diffuse imaging Frequency-domain methods for diffuse imaging Introduction to image reconstruction approaches Optical mammography and brain imaging	5
Laser tools and recent optical methods Modern biomedical microscopy (confocal, phase-contrast, nonlinear and super-resolution) Optical coherence tomography Optical tweezers Laser-microsurgery techniques	2