BME136 ENGINEERING OPTICS FOR MEDICAL APPLICATIONS

(Elective)

Catalog Data: **BME136 Engineering Optics for Medical Applications (Credit Units: 4)** Fundamentals of optical systems design, integration, and analysis used in biomedical optics. Design components: light sources, lenses, mirrors, dispersion elements, optical fibers, detectors. Systems integration: microscopy, radiometry, interferometry. Optical system analysis: resolution, modulation transfer function, deconvolution, interference, tissue optics, noise. Prerequisite: BME130, BME135, EECS180, or consent of instructor. Formerly ECE176. (Design units: 3)

Textbook: Hecht, E. *Optics,* 3rd edition, Addison-Wesley, 1998.

References: Lectures and problem sets are available and downloadable from the course website. Handouts from the instructor.

Coordinator: Bruce Tromberg

Course Outcomes: Students will:
Demonstrate knowledge of the fundamentals of optics and how basic principles are used to design and optimize optical instruments used in medical diagnostics.
Describe geometrical optics and its role in the design of microscopy instruments.
Describe wave optics and its role in the design of instrumentation for optical coherence tomography.
Describe basics of light matter interactions and its role in spectroscopy instruments.
Explain principles of diffuse optics and its role in the development of photon migration and photothermal techniques for subsurface tissue imaging.

Prerequisites by Topic: Electromagnetic fields and solutions of problems in engineering applications. Maxwell's equations and plane wave propagation.

Lecture Topics:
Introduction and overview of biomedical optics
Principles of geometrical optics, lenses, apertures, ray diagrams
Principles of geometrical optics, fibers and waveguides
Integration of geometrical optics into Microscopy systems
Applications of microscopy systems and laser scanning microscopies
Laser scanning microscopy; Principles of waves, interference, coherence
Principles of polarization and Doppler
Integration of wave concepts into the design of optical coherence tomography (OCT) systems
Applications of OCT in biology and medicine
Basic light matter interactions: absorption, emission, scattering
Photonic devices- sources: lasers, LEDs, SLDs
Photonic devices- detectors: performance theory; photomultipliers, photodiodes, array detectors; System integration: Spectroscopy
Applications of spectroscopy in biology and medicine

Physiological Optics: eye structure, performance
Physiological Optics: vision mechanisms, image formation and perception
Image processing: modulation transfer function, transformation methods
Imaging: applications of image analysis and processing in biology and medicine

Class Schedule: Meets for 3 hours of lecture and 3 hours of lab each week for 10 weeks.

Computer Usage:

Laboratory Projects: Lab projects will complement lecture topics in microscopy, interferometry, spectroscopy, and diffuse optics.

Professional Component: Contributes toward the Biomedical Engineering Topics and Major Design experience.

Relationship to Program Outcomes: This course relates to Program Outcomes (a), (e), (h), (i), (j), and (k) as stated at: http://undergraduate.eng.uci.edu/degreeprograms/biomedical/mission

Design Content Description:

Approach: Design an optical instrument that could be used to solve a fundamental problem or provide clinical information regarding one of the following broad areas of biology and medicine: cancer, heart disease, wound healing, or neuroscience. Students will work in small groups or teams. They will analyze relevant published literature and course materials, and present an instrument design in a formal class presentation and written document. The main elements that must be covered include: biological background, competing technologies, novelty of approach, integrated technology problem solving.

Lectures: 30%

Laboratory Portion: 70%

Grading Criteria:

Homework:	25%
Midterm:	12.5%
Group project:	25%
Lab:	25%
Final:	12.5%
	100%

Estimated ABET Category Content:

Mathematics and Basic Science:	0	Credit units or	0%
Engineering Science:	1	Credit units or	25%
Engineering Design:	3	Credit units or	75%

Prepared by: Bruce Tromberg **Date:** July 2007

CEP Approved: Spring 2004