ENG EC400 A3 # Engineering Light **Spring 2024**

Description:

Technologies that use light are all around us, both in well-established and rapidly developing areas. Examples abound! Our streaming and cloud services would not function without optical fiber technology. Autofocus in smart phone cameras makes photography easy. LED light sources drastically reduce energy use for illumination. Lasers are crucial in communication, medicine, and metrology. Optical quantum communication and computation is poised to make an impact. This introductory optics course aims for students to see the potential of optics. Students will learn geometric optic and imaging, including our visual system, wave optics with diffraction and interferometry applications, and use of light sources and detectors. The class includes demonstrations, lab-visits, hands-on exercises, and student presentations. **Optical technologies** (depending on class interest) e.g., precision measurements, holography, bio photonics, lasers and applications, fiber optics and communication.

Prerequsites: Junior or senior standing (MA 221, MA222, PY211, PY212)

Credits: 4

Course objectives

To provide students with hands-on experience with optical components and experimental techniques. To raise awareness of optical solutions for technical problems. Laser safety.

Lecture:	MW4:30-6:15 (all students)		CAS 227
Labs:	R 11-1pm (B1)	R 2-4 pm (B2)	

Instructor:	Anna Swan	Office PHO228 Phone 3-1275 Email swan@bu.edu
	Preferred contact:	In person or Piazza
	Student hours	Tuesday 12-1 pm or by appointment
Lab assistants	Parker Landon	landonp@bu.edu and Piazza
	Hriteshwar Talukder	hritesh@bu.edu and Piazza

Reference textbooks	"A first Course in Laboratory Optics", Andri Gretarson Cambridge University Press "Introduction to Optics" Pedrotti, Pedrotti, Pedrotti Cambridge University press
Webpages	Blackboard for material Piazza for communication

Requirements	Labs 70%, Quiz & HW 10%, Projects 10% presentation 10%

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Lecture topics

Introduction

The nature of light (rays, waves, polarization, particle-wave duality, quantum light)
A brief history, photon -particles, Electromagnetic spectrum, Radiometry, Light sources

Geometric Optics (Ray optics)

Geometric optics, ray optics, physical optics (when $\lambda \rightarrow 0$) Law of Reflection, Law of Refraction, Snell's law, Huygens' Principle, wavefronts Fermat's principle, Total internal reflection. (and applications)
Geometrical optics and image formation Optical pathlength, Lenses and lens shapes, Thin lenses, cylindrical lenses Gaussian optics (first order expansion sin(x)~x, cos(x)~1)
Optical Instrumentation Stops, pupils and windows**,** Aberrations**,** Prisms**,** The camera.
Eye piece Microscope and Kohler illumination Telescope

Wave Optics

Wave-optics 1D wave equation**,** Harmonic waves**,** Complex numbers**,** Harmonic waves and complex functions Plane waves, Spherical waves
Superposition of waves Superposition principle of same frequency, standing waves, random and coherent sources
Interference of light 2 beam interference, double slit, dielectric films and thickness measurements, Newton's rings.
Optical interferometry Michelson interferometer, Fabry Perot interferometer, Laser cavity, LIGO
Coherence FT of finite wave train, application to OCT
Diffraction grating Free, spectral range, Dispersion, resolution and instrumentation**,** Spectroscopy

E&M radiation, Polarized light

Matrix Representation of Polarization Jones vectors and Jones matrices
Polarized light from selective absorption, reflection, scattering.
Interaction with matter Bi-refringence, optical activity

Guest lectures/lab visits

Optical Tweezers
Interference bio-detection (Virus)
Birefringence biodetection (Brain)
Deformable mirror for phase-front engineering
Zygo Interferometer for precise height measurements
Optical circuits
Fibers

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PROJECTS

- Pinhole camera, long exposure
- Interference phenomenon
- Polarization phenomenon

LABS

Lab	Week of	Lab	
	22-Jan	Project Pinhole camera	
1	29-Jan	Geometric optics 1	alignment and imaging
2	5-Feb	Geometric optics 2	f-stop and Aperture
3	12-Feb	Wave-optics	Optical interference
4	19-Feb	Wave-optics	Diffraction and spectroscopy
5	26-Feb	Wave-optics	Interferometry 1
6	4-Mar	Polarization	Polarization components, birefringence
	11-Mar	SPRING BREAK	
7	18-Mar	Build: Optical coherence tomography	Lab choice
8	25-Mar	Thorlabs: Michelson applications	Lab choice
	1-Apr	Thorlabs: Optical Spectroscopy	catch-up
9	8-Apr	Thorlabs: Fourier optics	Lab Choice
10	15-Apr	Thorlabs: "Quantum eraser"	Lab choice
	22-Apr	Thorlabs: "Quantum cryptography	Catch up
		Holography kit	
		other ideas	