

PHYSICS 460 – PHYSICAL OPTICS – FALL 2024

MWF 8:30–9:20 WAT 114

Instructor: Eric B. Szarmes, Associate Professor of Physics
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Course description: This course presents the fundamentals of classical physical optics in sufficient depth to provide both a solid understanding of optical phenomena, and a solid background for research in contemporary optics. Fundamental ideas are unified through a mathematical treatment emphasizing Fourier analysis and linear systems theory for the description of linear wave propagation. Core topics include the propagation and interaction of optical fields and waves in matter, the vector nature of polarization phenomena, and the wave nature of light including temporal coherence and interferometry and spatial coherence and diffraction (Fourier optics). Specialized topics of interest include Gaussian transverse mode analysis and laser resonator optics, optical pulse propagation and pulse compression, and the theory and operation of the Laser Interferometer Gravitational-Wave Observatory.

Textbook: E. Hecht, *Optics*, 5th ed., Pearson Education, New York, 2017

References: B.E.A. Saleh and M.C. Teich, *Fundamentals of Photonics*, 2nd ed., Wiley, New York, 2007
A.E. Siegman, *Lasers*, University Science Books, Mill Valley, 1986

Course websites: <https://laulima.hawaii.edu> → PHYS-460-001 [MAN.78821.FA24] → Resources

Grade distribution: Problem sets (100%)

<u>Grade assignment:</u>	A+ 90 >	B+ 75–80	C+ 60–65	C– 40–50
	A 80–90	B 65–75	C 50–60	D/F < 40

COURSE TOPICS AND OUTLINE

- Preliminary:** - the wave equation; Maxwell's equations and optical fields in media
- Fourier analysis and linear systems Ch 3
Ch 7
- Polarization:** - physical and mathematical description; Jones matrix analysis
- anisotropic media; birefringence and optical activity
- polarization control and devices Ch 8
- Ray optics:** - review of principles Ch 4-6
- paraxial analysis of simple elements; aberrations
- ABCD matrix analysis; applications to periodic systems
- Wave optics:** - solutions of the wave equation; mathematical representation and physical properties Ch 2,7
- solutions of the paraxial wave equation; validity of the paraxial approximation
- spatial and temporal properties of waves; diffraction and interference
- Beam optics:** - the fundamental and higher-order Gaussian transverse modes notes
- propagation and transformation of Gaussian beams in ABCD systems
- transverse mode analysis; orthogonal functions and mode decomposition
- Diffraction and interferometry:** - Fresnel and Fraunhofer diffraction Ch 9-11
- Fourier optics and spatial filtering
- interferometers and spectral analysis
- Laser resonator theory:** - longitudinal mode structure and resonance notes
- transverse mode structure and resonator stability
- Pulse propagation:** - group velocity; pulse compression; frequency chirping notes
- space-time analogy and pulse shaping
- LIGO** - design and operation notes

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Corrections to Weekly Problem Sets

Up until one week after any problem set is returned to you, you may submit corrections to any number of problems on that problem set, together with the original problem set, for up to an additional 3 points (out of 10) **per problem**. Corrections must be done on the original problem set (written directly on the original writeup for small corrections) or on a separate page (attached to the original problem set for longer corrections) as needed.

If you are not sure where you made your original error, or have trouble understanding anything about a problem for which you lost points, you may meet with me to discuss any questions you might have.