

FALL 2021 – PHYSICS 460/EE 470 – PHYSICAL OPTICS

MWF 8:30–9:20 WAT 114

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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, nonlinear optics including the coupled wave theory of second harmonic generation, and the theory and operation of the Laser Interferometer Gravitational-Wave Observatory.

Textbook: B.E.A. Saleh and M.C. Teich, *Fundamentals of Photonics*, 2nd Ed., Wiley, New York, 2007

Course websites: <https://lulima.hawaii.edu> → PHYS-460-001 [MAN.87997.FA21] → Resources
<https://lulima.hawaii.edu> → EE-470-001 [MAN.87634.FA21] → Resources

Grade distribution: Problem sets (50%); Quizzes (10%); Midterm exam (15%); Final exam (25%)

Grade assignment:

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

COURSE OUTLINE

1. Preliminary: - Fourier analysis and linear systems theory *App A, B*
- Maxwell's equations and optical fields in media *Ch 5*
 2. Polarization: - physical and mathematical description; Jones matrix analysis *Ch 6*
- anisotropic media; birefringence vs. optical activity
- polarization control and devices
 3. Ray optics: - review of principles *Ch 1*
- paraxial analysis of simple elements; aberrations
- ABCD matrix analysis; applications to periodic systems
 4. Wave optics: - solutions of the wave equation; mathematical representation and physical properties *Ch 2*
- solutions of the paraxial wave equation; validity of the paraxial approximation
- spatial and temporal properties of waves; diffraction and interference
 5. Beam optics: - the fundamental and higher-order Gaussian transverse modes *Ch 3*
- propagation and transformation of Gaussian beams in ABCD systems
- transverse mode analysis; orthogonal functions and mode decomposition
- (Midterm examination Oct 22) —————
6. Spatial coherence and diffraction theory: - integral solutions of the wave equation (Huygen vs. Fresnel) *Ch 4*
- Fresnel and Fraunhofer diffraction
- Fourier optics and spatial filtering; holography
 7. Temporal coherence and interferometry: - concept of coherence; physical description of interference *Ch 11*
- interferometers and spectral analysis
 8. Laser resonator theory: - longitudinal mode structure and feedback; tunability *Ch 10*
- transverse mode structure and resonator stability analysis
 9. Nonlinear optics: - physical description; taxonomy of nonlinear optical processes *Ch 21*
- coupled-wave analysis of second harmonic generation
 10. LIGO - design; detection *notes*

————— (Final examination) —————

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Corrections to Weekly Problem Sets

Up until one week after any weekly problem set is returned to you, you may resubmit any corrected problem on that problem set, together with the original problem set, for up to an additional 3 points per problem (out of 10). 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 go over any questions you may have.