OPTI 210: Physical Optics I (updated 12/27/18)

OPTI 210. Physical Optics I (3). Review of math concepts, waves, and EM theory, Maxwell's equations and the wave equation, plane-wave solution and properties, Lorentz oscillator model of optical properties, reflection and refraction at a dielectric interface, Fabry-Perot, multilayer films, polarization optics, Jones calculus, Fraunhofer diffraction, single and double slit diffraction, Airy disk for a circular aperture. P, PHYS 241, MATH 223, MATH 254 and OPTI 280.

1. Math Review **(Feynman Vol. II, Chap. 2, Hecht 2.5)**
   - Scalars and vectors, position vector in Cartesian and spherical coordinates, vector algebra, scalar and cross products, vector identities.
   - Scalar and vector fields.
   - Differential vector calculus, gradient, divergence, curl, second-order derivatives of fields.
   - Integral vector calculus, Gauss' and Stokes' theorems.
   - Complex variables, basic notion of complex numbers and representation in the Argand plane, Euler formula, modulus and phase.

2. One-dimensional (1D) Waves **(Hecht 2.1-2.5)**
   - Physical examples of 1D traveling waveforms.
   - The one-dimensional wave equation.
   - Harmonic waves, wavelength, frequency, phase, and phase velocity.
   - The superposition principle and interference, examples.
   - Complex representation of harmonic waves, phasor addition of complex amplitudes.

3. Three-dimensional (3D) Waves **(Hecht 2.7-2.9,Fowles 1.3-1.4)**
   - The three-dimensional wave equation.
   - 3D harmonic waves, propagation vectors and phase fronts, dispersion relation, plane-waves, direction cosines.
   - The superposition principle and interference, examples.
   - Complex representation of 3D plane-waves.
   - Spherical waves.

4. Review of Electromagnetism **(Hecht 3.1)**
   - Experimental underpinnings of EM theory.
   - Lorentz force law.
   - Time varying magnetic fields and Faraday's law.
   - Gauss' law for electric and magnetic fields.
   - Dielectric constant.
   - Time-varying electric fields and Ampere's law.
   - Maxwell's equations in integral form.

5. Electromagnetic Waves **(Hecht 3.2-3.3, Fowles 1.2-1.4)**
   - Maxwell's equations in differential form.

- Wave equation in a dielectric medium.
- Speed of light in a medium and vacuum, refractive-index.
- Transverse electromagnetic wave solution.
- Complex wave representation.
- Wavefronts and rays.
- Poynting vector, energy flow, and irradiance.
- Photons, radiation pressure, and momentum.
- Optical fields and laser beams.
- Interference of harmonic waves.

6. Light-matter Interaction **(Hecht 3.5,6.1-6.4)**
    - Lorentz electron oscillator model for matter.
    - Electric polarization and displacement.
    - Refractive-index and dispersion.
    - Birefringence in crystals.
    - Harmonic EM waves & boundary conditions.

7. Reflection and refraction at a Dielectric Interface **(Fowles 2.6-2.9,Hecht 4.3-4.7)**
    - Laws of reflection and refraction.
    - The Fresnel equations for TE waves, examples.
    - Fresnel's equations for TM waves, examples.
    - Reflectance and transmittance.
    - Total internal reflection.
    - Critical angle and evanescent waves.
    - Brewster's angle and law for TM waves.
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8. Polarization **(Hecht 8,Fowles 2.3-2.5)**
    - Linear polarization, circular, and elliptical polarizations.
    - Jones vector representation.
    - Polarization elements, polarizers, Malus's law, wave plates.
    - Jones calculus, transformation of polarization, examples.
    - Spin angular momentum of light.

9. Interference **(Fowles 3.1-3.3 & 4.1-4.4, Hecht 9.1-9.7)**
    - General discussion and overview.
    - Wavefront-splitting interferometers, eg. Young.
    - Amplitude-splitting interferometers, eg. Michelson.
    - The two-mirror Fabry-Perot, multi-beam interferometer.
    - Transmission and the Airy function, coefficient of finesse.
    - Fringes of equal inclination, normal incidence, finesse.
    - Longitudinal modes, free spectral range, scanning Fabry-Perot.
    - Multilayer films, antireflection coatings & high-reflectance films.
10. Fraunhofer diffraction **(Hecht 10.1 & 10.2.1-10.2.6)**
    - Huygens-Fresnel principle of secondary wavelets.
    - Fraunhofer versus Fresnel diffraction.
    - Fraunhofer diffraction from a single slit.

- Double slit interference, division of wavefront.
- Fraunhofer diffraction for a rectangular aperture.
- Airy disk for a circular aperture.
- Numerical examples of diffraction.
- The Spot of Arago.

Grading Criteria:

- Homework 30%
- Midterm exam 1 20%
- Midterm exam 2 20%
- Final exam 30%

An A grade will be awarded for an overall score between 100-90%, a B grade for 89-75%, a C grade for 74-60%, a D grade for 59-50%, and an E grade for 49% or less.

Homework is governed by the honor system. Discussion with others is encouraged, but the work you hand in must be your own.

Exams:

Midterm exam 1 will be in-class on Monday Feb. 18, Midterm exam 2 in-class on Wednesday March. 2, and the final will be on Monday May. 6 from 10:30 am – 12:30 pm. The lecture before each midterm exam will be devoted to over viewing the material covered and answering questions. Make sure to mark these dates and be available as a **missed test may only be made up under exceptional circumstances** with accompanying written medical excuse or family emergency (made known to me before the test is given). NO OTHER EXCUSES will be accepted.

Teaching Assistant: TBD shall be the TA for the class this year. He/She shall grade the homework and also hold office hours. Any appeals with respect to assigned grades should be referred to Prof. Kolesik not the TA.

Textbooks: The two text books required for the class are Hecht, *Optics* (4th Edition), and Fowles, *Introduction to Modern Optics* (2nd Edition). Both will be on reserve at the College Reading room and should be available at the UA Bookstore.

Policies: A full listing of the policies associated with this class can be found at the College webpage http://www.optics.arizona.edu/classes/Opti_310.htm.