PHY385 H1F 2013-2014 Introductory Optics
SYLLABUS

Lecturer: Dr. Natalia Krasnopolskaia
Textbook: Optics by E. Hecht, 4th Ed.

The course includes theory of one-, two- and three-dimensional waves, theory of electromagnetic waves, foundations of interaction of electromagnetic waves and matter, laws of geometrical optics, theoretical and experimental study of optical systems, theoretical and experimental study of aberrations in optical systems, superposition of waves, theoretical and experimental study of polarization, introduction to theory of interference and diffraction, and experimental study of these phenomena. Students are expected to know calculus, differential equations, differential operators, operations with matrices, theory of functions of a complex variable, and probability theory. Course of Electromagnetism is a prerequisite.

The course consists of lectures (two hours weekly) and Practicals in the physics laboratory (two hours weekly). Materials of Practicals are strictly linked to the lectures' topics. The lectures combine the PowerPoint presentation, derivations of equations on the black board and demonstration of a variety of optical phenomena with special physical equipment.
The term work includes 5 homework assignments in pen-and-paper format, six in-class quizzes, two midterm tests and a final exam.

Schedule and contents of lectures:

Lecture 1. Section 2.1 of the textbook.
1. Introduction to the course PHY385 H1F.
2. Propagation of disturbance in one dimension
3. Differential wave equation

Lecture 2. Sections 2.2, 2.3
1. Harmonic waves: frequency, period, amplitude, wavelength, phase, wave number
2. Phase velocity

Lecture 3. Sections 2.4 – 3.1.
1. Superposition principle
2. Complex presentation of wave function
3. Phasors
4. Plane wave
5. Three-dimensional wave equation
6. Electromagnetic field
7. Basic laws of classical electromagnetic theory

Lecture 4. Sections 3.2 – 3.3.1.
1. Electromagnetic waves (EMW)
2. Properties of electromagnetic waves: speed of wave; orientation of vectors E and B
3. Transverse waves
4. Energy density in EMW
5. Poynting vector

Lecture 5. Sections 3.3.2 – 3.4.
1. Irradiance (intensity) and inverse square law
2. Photons

3. Radiation pressure and momentum.
4. Momentum and index of reflection
5. Production of EMW
    - Linearly accelerated charge
    - Synchrotron radiation
    - Electric dipole radiation
    - Emission of light by atoms
6. Optical cooling

Lecture 6. Sections 3.5 – 3.7, 4.8

1. Propagation of EMW in a material medium: absorption and scattering.
2. Dispersion in dielectrics. Dispersion equation.
3. Optical properties of metals. Dispersion equation.
4. Electromagnetic spectrum.
5. Quantum field theory.

Lecture 7. Sections 4.1 – 4.5.

1. Rayleigh scattering
2. Transmission and the index of refraction
3. Internal and external reflection. Law of reflection. Rays.
4. Law of refraction.
5. Huygens's principle.
6. Fermat's principle

Lecture 8. Sections 4.6 – 4.7, 4.11.

1. Waves at an interface.
2. Fresnel equations.
3. Intensity and polarization at the boundary of two dielectrics.
4. Reflectance and transmittance.
5. Total internal reflection.
6. Laws of reflection and refraction for photons

Midterm Test I (Materials of lectures 1 – 8)

Lecture 9. Sections 5.1 – 5.2.

1. Refraction at spherical surfaces. Lenses.
2. Thin lens equation. Lensmaker's equation.
3. Image formation by optical systems.
4. Newtonian form of the lens equation.
5. System of thin lenses. Optical power

Lecture 10. Section 5.3, 5.4.

1. Stops. Relative Aperture and f-number.
2. Plane (planar) and spherical mirror.
3. Mirror formula.

Lecture 11. Sections 5.1 – 5.4..

1. Simple problems with ray diagram
2. Image formation and sign convention
3. Analytical solution for a system of thin lenses
4. More precise description of lens optics

Lecture 12. Sections 5.5, 5.6.

1. Prism: dispersing prism and reflecting prism
2. Total internal reflection
3. Fiber optics

Lecture 13. Section 5.7.1 – 5.7.5.

1. Eye as an optical system. Structure of the eye
2. Accommodation; near point; far point
3. Eyeglasses
4. Nearsightedness (myopia) and farsightedness (hyperopia)
5. How we are using a magnifier
6. The compound microscope

Lecture 14. Sections 5.7.6, 5.7.7..

1. The camera: aperture, exposure and f-number
2. Pinhole camera, obscura
3. Digital camera
7. Telescope
    - Refractor
    - Reflector

Lecture 15. Sections 6.1, 6.3.

1. Thick lens equation
2. Spherical aberration
3. Coma
4. Astigmatism
5. Distortion
6. Chromatic aberrations
7. Section 6.4 – self-study.

Midterm Test II (Material of lectures 9 – 15)

Lecture 16. Sections 7.1, 7.2.1.

1. Superposition of waves of same frequency
2. Standing waves
3. Superposition of waves of different frequency. Beats

Lecture 17. Sections 7.2.2, 7.4.3..

1. Beats
2. Phase and group velocity
3. Wave packet
4. When velocity exceeds c.
5. Coherence time and coherence length.

Lecture 18. Sections 8.1 – 8.2.

1. Linear polarization of EMW
2. Elliptical and circular polarization. Sunlight.
3. Polarization and angular momentum
4. Polarizers. Malus's law

Lecture 19. Sections 8.3 – 8.10.

1. Dichroism
2. Birefringence
3. Wave plates
4. Polarization by scattering and reflection
5. Optical activity

Lecture 20. Sections 8.11 – 8.12, 9.1 - 9.2.

1. Interference of polarized light
2. Induced optical effects. Photoelasticity
3. Liquid crystals.
4. Interference. Revising superposition of waves of same frequency
5. Temporal and spatial coherence

Lecture 21. Sections 9.3, 9.4.1. 9.7.2, 9.8..

1. Division of wave front. Young's double-slit experiment
2. Division of amplitude. Interference in thin films.
3. Antireflection coatings
4. Interferometers.

Lecture 22. Section 10.1 – 10.2.6, 10.2.8, 13.3.

1. Fraunhofer diffraction.
    - Single slit.
    - Diffraction grating.
    - Circular aperture.
2. Resolution of optical systems.
3. Fresnel diffraction and Babinet's principle.
4. Holography.