1. Fundamental concepts

1.1. Wave optics and wave mechanics: Schrödinger and Helmholtz equations
1.2. Review of EM theory and Fourier Optics
1.3. Angular spectrum representation of optical fields
1.4. Resolution limits in classical optics
1.5. Nano-optical fields
1.6. Optics below the diffraction limit?

2. Light scattering theory and Nanoplasmonics

2.1. Fields and waves in different coordinate systems, solutions of wave equations
2.2. Analytical scattering theories: Mie theory of canonical shapes.
2.3. Generalized Mie theory, T-matrix and multi-particle scattering theories (hints)
2.4. Numerical techniques in nano-optics (hints)
2.5. Review of metal optics, surface plasmon polaritons
2.6. Localization of plasmon-polaritons
2.7. Resonant enhancement of optical fields

3. Confined Light and Quantum Electrodynamics

3.1. Canonical quantization of EM fields
3.2. Optical Microcavities: weak and strong coupling regimes
3.3. Wigner-Weisskopf theory of spontaneous emission
3.4. Optical forces, Casimir effect
3.5. Local Density of States, Spontaneous emission enhancement
3.6. Hints on Cavity Quantum Electrodynamics (Cavity-QED)

4. Light in complex media

4.1. Light in inhomogeneous media: Hamiltonian formulation
4.2. Stochastic geometric optics approach and vector approach
4.3. Eigenvalue electrodynamics of 1D, 2D, 3D periodic systems
4.4. Photonic band gaps, band-edges and defect states in photonic crystals
4.5. Random media and Aperiodic Nano-Structures
4.6. Anderson light localization

5. Transformation optics (optional chapter, time permitting only)

5.1. Coordinate transformations
5.2. Basic concepts of differential geometry (metric tensor, vectors and tensors, the covariant derivative, general differential operators, curvature and geodesics)
5.3. Maxwell’s equations in curved spaces and GRIN optics
5.4. Unruh effect, “optical black-holes”, design of perfect absorbers
5.5. Geometry of light and Invisibility: active scattering cancellation and cloaking
Topics for students’ projects and presentations

1. Near-field microscopy techniques
2. Super-resolution imaging and super-lenses
3. Optical metamaterials
4. Optical nano-antennas
5. Plasmonics technology
6. Photonic bandgap structures: waveguides, membranes and resonators
7. Photonic crystals LEDs, band-edge lasers
8. Light localization and random lasers
9. Enhanced solar cells
10. Plasmonics light guiding elements, sensors and resonators
11. Transformation optics

Books: notes will be distributed per each topic.

Suggested readings:

Principles of Nano-Optics (II Edition) by L. Novotny and B. Hecht (Cambridge)
Theory and computation of electromagnetic fields by Jian-Ming Jin (Wiley)
Scattering of electromagnetic waves (vol. 1-3) by L. Tsang, J. A. Kong, K. Ding (Wiley)
Optical properties of photonic crystals by K. Sakoda (Springer)
Introduction to wave scattering and mesoscopic phenomena by P. Sheng (Springer)
Geometry and Light by U. Leonhardt and T. Philbin (Dover)
Cavity Quantum Electrodynamics by Sergio M. Dutra (Wiley)