

# 2001 SYLLABUS

## OPT462: PHYSICAL OPTICS II (ELECTROMAGNETICS)

### 1 Establishment of Maxwell's equations and elementary properties

1. 1. Reality of Electromagnetic Fields
1. 2. Pre-Maxwell electromagnetism
1. 3. Microscopic / macroscopic Maxwell equations
1. 4. Wave equation, Helmholtz equation
1. 5. Constitutive relations, temporal&spatial dispersion
1. 6. Time-harmonic fields
1. 7. Angular spectrum representation of wavefields
1. 8. Homogeneous media, boundary conditions
1. 9. Refraction at plane interfaces, total internal refraction
- 1.10. Conservation of energy: Poynting's theorem
- 1.11. Conservation of momentum: Maxwell stress tensor

### 2 Potentials, Gauge transformations, Green's functions

2. 1. Vector and scalar potentials
2. 2. Gauge transformations (Coulomb, Lorentz, Poincare gauge)
2. 3. Lagrangian and Hamiltonian of electron in electromagnetic field
2. 4. Scalar Green's functions (frequency and time domain)
2. 5. Dyadic Green's functions
2. 6. Volume integral equations

### 3 Multipole expansion, Radiating systems, Scattering

3. 1. Multipole expansion of electromagnetic fields
3. 2. Dipole radiation
3. 3. Lienard-Wiechert potentials
3. 4. Radiation from moving point charge (radiation reaction, Bremsstrahlung, etc.)
3. 5. Energy spectrum of electromagnetic fields
3. 6. Mie scattering
3. 7. Optical theorem
3. 8. Quasi-statics

## 4 Material properties

4. 1. Lorentz atom model
4. 2. Complex refractive index
4. 3. Drude Model, Debye relaxation
4. 4. Kramers-Kronig relations
4. 5. Optics of metals (plasma frequency, plasmons, wave propagation, skin depth)

## 5 Polarization, Crystal optics

5. 1. Polarization state of light
5. 2. Polarization effects (Faraday rotation, Pockels effect, etc.)
5. 3. Birefringence (phase plates, Wollaston prism, Babinet compensator)
5. 4. Anisotropic media
5. 5. Jones, Stokes, and Müller matrices

## 6 Guided waves

6. 1. Paraxial approximation, Gaussian beams
6. 2. Waveguides (guided modes in layered structures, optical fibers, ...)
6. 3. Birefringence (phase plates, Wollaston prism, Babinet compensator)
6. 4. Anisotropic media
6. 5. Jones, Stokes, and Müller matrices

## 7 Special Relativity (as time permits)

7. 1. 4D-notation of electromagnetic fields
7. 2. Galilei transformation
7. 3. Lorentz transformation
7. 4. Minkowsky space
7. 5. Electrodynamics of objects moving at constant velocity