Lecture of Theoretical Physics II: Electrodynamics

1. Einsteinian Fundamental Postulates of Special Relativity

2. Special Theory of Relativity - Basic Kinematic Results
   Lorentz transformations - light cone - causality - length contraction and time dilation - time interval - four-vector of velocity - addition of velocities - transformation of acceleration

3. Relativistic Mechanics
   stationary principle - momentum and energy - relativistic equation of motion

4. Relativistic Lagrangian of a Charged Particle in an Electromagnetic Field
   action integral - equation of motion - gauge invariance - electromagnetic field tensor - Lorentz transformation of fields - invariants

5. Covariant Formulation of Electrodynamics
   first group of Maxwell’s equations - Lagrangian for fields - continuity equation - second group of Maxwell’s equations - energy momentum tensor - symmetric stress tensor - conservation laws - Maxwell’s equations in SI units

6. Time-Independent Electromagnetic Field
   Electrostatics: scalar potential, Poisson equation - field and potential of a point charge - Green’s function - charge distributions and electric multipole expansion; magnetic field of steady currents: vector potential, gauge transformations, Biot-Savart’s law, current distributions - magnetic dipole

7. Electromagnetic Waves and Wave Propagation
   wave equation - plane waves - harmonic time dependence - polarization - abberation of light - Doppler effect - Fourier decomposition - fundamental modes - spheric waves - geometrical optics, Eikonal equation - coherence and interference of electromagnetic waves - Kirchhoff’s theory of diffraction and Huygen’s principle - Fraunhofer and Fresnel diffraction

8. Electromagnetic Fields of Moving Charges and Time-Dependent Currents
   quasi-stationarity - retarded potentials - Liénard-Wichert potentials - radiation of a relativistic accelerated charge - electric dipole radiation

9. Maxwell’s Equations for Continuous Media
   averaging microscopic Maxwell equations - polarization and magnetization - boundary conditions at the interface between different media

10. Electrostatics of Conductors and Dielectrics
    energy of the electromagnetic fields of conductors - selected techniques for the solution of problems in electrostatics (image method, conformal transformations) - electrostatic field in insulators

11. Magnetostatics of Macroscopic Media
    magnetic materials - quasi-stationary currents (energy, self- and mutual-inductance) - magnetic shielding

12. Electromagnetic Waves in Matter
    normal and anomalous dispersion - analytic properties of the dielectric function - Kramers-Kronig relations - sum rules - propagation of electromagnetic waves in dielectric materials - reflection and diffraction - Fresnel’s formula, wave propagation in dissipative media - surface impedance - Skin effect - reflection by an imperfect conductor - cylindrical wave guides - cavity resonators