This is a tentative schedule of what we will cover in the course. It is subject to change, often without notice. These will occur in response to the speed with which we cover material, individual class interests, and possible changes in the topics covered. Use this plan to read ahead from the lecture notes and following textbooks, so you are better equipped to ask questions in class.

2. J.D. Jackson “Classical Electrodynamics” 3rd edition

Special Relativity with basics of relativistic Field Theory

- PRELIMINARIES


  Suggested literature: Lecture notes
  Secs.1.2.1-1.2.4,1.7 in [3]
  Secs. 4.1-4.6 in [4]


  Suggested literature: Lecture notes
  Secs. 1.2.5,1.8 in [3]
  Secs. 4.7,4.8 in [4]


  Suggested literature: Lecture notes
  Sec.22.2 in [3]
• KINEMATICS OF SPECIAL RELATIVITY


Suggested literature: Lecture notes

§§1-3 in [1]
Sec. 11.1 in [2]
Sec.22.3 in [3]
Sec.7.1 in [4]

Lorentz group: Definition. Parity and time reversal transformations. Proper, improper, orthochronous, non-orthochronous Lorentz transformations. General structure of the Lorentz group. Lorentz boosts. Group of proper, orthochronous Lorentz transformations $SO^+(1,3)$.

Suggested literature: Lecture notes

§§4,5 in [1]
Sec.11.2 in [2]
Sec.22.4 in [3]


Suggested literature: Lecture notes

§§6,7 in [1]
Secs.11.3,11.4,11.6 in [2]
Secs.22.5.1,22.5.2 in [3]

Matrix representations of the Lorentz group: Rank 2 antisymmetric tensor. Quadratic invariants. Finite dimensional irreducible representations of $SO^+(1,3)$, $O^+(1,3)$ and $O(1,3)$.

Suggested literature: Lecture notes

• COVARIANT FORM OF MAXWELL’S EQUATIONS

First pair of Maxwell’s eqs.: Fields. Field-strength tensor. Covariant form(s) of the first pair of Maxwell’s eqs.

Suggested literature: Lecture notes

§§23-26 in [1]
Secs.11.9,11.10 in [2]


Suggested literature: Lecture notes

§§23-25 in [1]
Secs.1,3,1,4,5,1-5,3,5,15,6,1,6,11,6,12 in [2]
Secs.1,4,2,1,2,2 in [3]

Second pair of Maxwell’s eqs.: Covariant form. 4-current. The continuity equation.

Suggested literature: Lecture notes

§§28-30 in [1]
Sec.1.5 in [3]


Suggested literature: Lecture notes

Sec.1.9 in [3]
**4-potential:** Definition. Bianchi identity. Maxwell’s equation in terms of the 4-potential. Gauge invariance. Gauge fixing condition. Lorenz gauge.

Suggested literature: Lecture notes
§18 in [1]
Secs.6.2,6.3 in [2]
Secs.15.3 in [3]

• **VARIATIONAL PRINCIPLE**

**Poisson’s equation in curvilinear coordinates:** Variational principle for Poisson’s equation. Laplacian in curvilinear coordinates. Orthogonal coordinates.

Suggested literature: Lecture notes
Secs.1.7-1.12 in [2]

**Variational principle for Maxwell’s equations:** The principle of least action in relativistic Field Theory. Lagrangian density. Euler-Lagrange equations. The action functional of the electromagnetic field.

Suggested literature: Lecture notes
§§27,30,32 in [1]
Sec.12.7 in [2]
Secs.13.1,13.2 in [4]

**Maxwell’s equations in curvilinear coordinates:** Tensor fields in curvilinear coordinates. Differentiation. Exterior derivative. Divergency of a vector field. First pair of Maxwell’s equations in curvilinear coordinates. The action functional of the electromagnetic field in curvilinear coordinates. Lorenz gauge fixing condition in curvilinear coordinates.

Suggested literature: Lecture notes
§§81-83,90 in [1]


Suggested literature: Lecture notes
§§8,9,15−17 in [1]
Secs.6.7,12.1 in [2]
Secs.7.9,7.10 in [4]

• **CONSERVATION LAWS**

**Symmetries:** Continuous and discrete symmetries of Classical Electrodynamics. Noether’s theorem.

Suggested literature: Lecture notes
Sec.6.10 in [2]
Secs.15.1,15.2,24.4.2 in [3]
Sec.13.7 in [4]


Suggested literature: Lecture notes
§§32,33,94 in [1]
Secs.6.7,12.10 in [2]
Secs.13.3,13.5,13.6 in [4]
Rotational invariance and angular momentum: 4-tensor of angular momentum. The center-of-energy theorem. Pauli-Lubanski 4-vector.

Suggested literature: Lecture notes
§§14, 32 in [1]
Secs.15.6,15.7 in [3]

Applications of Classical Electrodynamics

• MAGNETOSTATICS


Suggested literature: Lecture notes
§§43,44 in [1]
Sec.5.3-5.6 in [2]
Secs.11.1,11.2 in [3]

Macroscopic equations: Magnetization. The magnetic field (intensity). Boundary conditions. Relation between magnetic (field) induction and magnetic field (intensity). Methods of solving boundary value problems in magnetostatic.

Suggested literature: Lecture notes
Sec.5.8-5.13 in [2]


Suggested literature: Lecture notes
§§45 in [1]
Sec.5.7 in [2]

• QUASI-STATIC FIELDS


Suggested literature: Lecture notes
Sec.5.16,5.17 in [2]


Suggested literature: Lecture notes
Sec.6.3,5.18 in [2]
Secs.14.5-14.7, 14.10 in [3]

• ELECTROMAGNETIC WAVES


Suggested literature: Lecture notes
§§46-48 in [1]
Sec.7.1,7.2 in [2]
Secs.16.1-16.4.4, 16.6 in [3]
**Waves in simple matter:** Waves in nondispersive media. Wave impedance. Index of refraction. Reflection and refraction: Snell’s law, Fresnel equations, reflection and transmission coefficients, polarization by reflection, Brewster’s angle, total internal reflection.

Suggested literature: Lecture notes
- Sec.7.1,7.3,7.4 in [2]
- Secs.17.1-17.3 in [3]

**Waves in dispersive matter I:** Constitutive relations in a dispersive medium. Kramers-Kronig relations. Lorentz model for dispersion.

Suggested literature: Lecture notes
- Secs.6.10,7.5, 7.10 in [2]
- Secs.18.1, 18.2, 18.51,18.54, 18.7 in [3]

**Waves in dispersive matter II:** Plane waves in dispersive media. Phase velocity and group velocity. Conservation of energy in dispersive media: Poynting vector, effective energy density.

Suggested literature: Lecture notes
- Secs.6.7,6.8, 7.8 in [2]
- Secs.18.3,18.4, 18.6 in [3]

• **RETARDATION AND RADIATION**

  **Fields from moving charges:** Green’s functions for the wave equation. Lienard-Wiechert potentials and fields for a point charge. Point charge in uniform motion. Spectral decomposition of the retarded potentials.

  Suggested literature: Lecture notes
  - §§62-64, in [1]
  - Secs.6.4, 6.5, 12.11, 14.1 in [2]
  - Secs.20.1-20.3, 23.1, 23.2 in [3]

  **Multipole fields and radiation:** Fields of a system of charges at large distances. Dipole radiation. Quadrupole and magnetic dipole radiation.

  Suggested literature: Lecture notes
  - §§ 66,67,71 in [1]
  - Secs.9.1-9.3 in [2]
  - Secs.20.5, 20.7 in [3]