ELECTRICITY & MAGNETISM II

Final Exam

Room: ARC-333
Time: May 6, (Monday), 10am-1pm

Ground rules

• There are four problems based on the material listed below.
• This is an open-book, open-notes exam.
• IPHones and laptops are not allowed.
• Partial credit will be given. Do as many parts of a problem as possible.

PROGRAM

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]

Tensors in the Minkowski space: 4-velocity. Covariant and contravariant vectors. Tensors of rank 2. Metric tensor. Inner product in the Minkowski space. Tensors of higher rank in \( \mathbb{M}^{1,3} \). Levi-Cevita symbol in \( \mathbb{M}^{1,3} \). Pseudotensors.

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]

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]

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

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]

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


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]


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]


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

Literature