PHYSICS 504 Spring 2023

ELECTRICITY & MAGNETISM II

Midterm Exam

Room: SEC-212
Time: March 2, (Thursday), 10:20-11:40

Ground rules

• There are four problems based on the material listed below.
• This is a closed book, closed notes exam.
• Partial credit will be given. Do as many parts of a problem as possible.

Program

• 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

**Spacetime in Special Relativity:** Causal structure in Special Relativity. Light cone. Spacetime interval. Proper time. Pseudo-Euclidean (Minkowski) space $\mathbb{M}^{1,3}$. Einstein principle of relativity.

Suggested literature: Lecture notes

$\S\S$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

$\S\S$ 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

$\S\S$ 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

$\S\S$ 23-26 in [1]  
Secs. 11.9, 11.10 in [2]


Suggested literature: Lecture notes

$\S\S$ 23-25 in [1]  
Secs. 1.3, 1.4, 5.1-5.3, 5.5, 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

$\S\S$ 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]

Literature