

Macroscopic Electrodynamics I
Physics 5330 Syllabus

I. Survey and Introduction

- I.1 Charge conservation and quantization
- I.2 Quantum considerations
- I.3 Boundary conditions on fields
- I.4 Constitutive relations
- I.5 2-D constitutive relations

Problems

1. Introduction to Electrostatics

- 1.1 Electric field definition
- 1.2 Dirac delta function properties
- 1.3 Gauss' law and solid angles
- 1.4 Deviations from inverse square law
- 1.5 Surface charge and dipole layers
- 1.6 Boundary conditions and uniqueness of solutions
- 1.7 Dirichlet and Neumann Green functions
- 1.8 Electrostatic energy
- 1.9 Capacitance

Problems

2. Boundary Value Problems in Electrostatics

- 2.1 Method of images: flat conducting surface
- 2.2 Reduced Green function technique applied to flat conductor
- 2.3 Method of images: conducting sphere
- 2.4 Normal force on a charged surface
- 2.5 Charged conducting sphere force example
- 2.6 Expansion in orthogonal series: conducting box
- 2.7 Fourier series problems: conducting box
- 2.8 Separation of variables in cylindrical coordinates
- 2.9 Corner problem in cylindrical coordinates
- 2.10 Cylindrical halves at different potentials
- 2.11 Conformal mapping techniques

Problems

3. Electrostatics: Cylindrical and Spherical Coordinates

- 3.1 Reduced Green function technique in cylindrical coordinates and Bessel functions
- 3.2 Orthogonality of Bessel functions
- 3.3 Zeros and completeness properties of Bessel functions
- 3.4 Reduced Green function for the conducting cylinder
- 3.5 The cylinder as a boundary value problem
- 3.6 Bessel functions of imaginary argument
- 3.7 Free charge solution using Bessel functions
- 3.8 Reduced Green function/image method: conducting wedge

- 3.9 Construction of spherical harmonics: Schwinger technique
- 3.10 Orthogonality properties of spherical harmonics
- 3.11 The Coulomb expansion, completeness of spherical harmonics and the "Addition Theorem"
- 3.12 Green function for concentric spheres
- 3.13 Conducting sphere in a uniform field
- 3.14 Method of last resort: eigenfunction expansions
- Problems**

4. Multipoles, Electrostatics of Macroscopic Media, Dielectrics

- 4.1 Cartesian and spherical multipole expansions
- 4.2 Multipole energy expansions
- 4.3 External fields and forces on multipole distributions
- 4.4 Introduction of the "electric polarization" and "displacement field"
- 4.5 Green functions in the presence of linear dielectrics
- 4.6 Green function for the dielectric slab
- 4.7 Green function for the dielectric sphere
- 4.8 Field energy and dielectrics
- 4.9 Bulk forces on dielectrics: theory
- 4.10 Nonlinear dielectric example: a phenomenological quark confinement model
- 4.11 Bulk forces on dielectrics: examples
- Problems**

5. Magnetostatics

- 5.1 Analogy to electrostatics
- 5.2 Equations of magnetostatics
- 5.3 Considerations leading to Ampere's law
- 5.4 Surface current considerations
- 5.5 Solid angle result for **B**
- 5.6 Circular current loop: solution using solid angle result for **B**
- 5.7 Circular current loop: direct solution
- 5.8 Current distributions and magnetic moments
- 5.9 External fields and forces on magnetic multipole distributions
- 5.10 Introduction of "magnetization" and the **H** field
- 5.11 Analogy with dielectrics
- 5.12 Image method for magnetostatics
- 5.13 Intrinsic and induced magnetization: theory and example
- Problems**

6. Time Varying Fields I

- 6.1 Schwinger's plausibility argument leading to Maxwell's equations
- 6.2 Faraday's law
- 6.3 Models introducing macroscopic Maxwell equations

- 6.4 Second-order formulation of Maxwell's equations
- 6.5 Energy and forces in magnetostatics
- 6.6 More on magnetostatic energies
- 6.7 Bulk forces on magnetic materials: theory and examples
- 6.8 Magnetic charge and the macroscopic Maxwell equations
- Problems**