SPH 304 COURSE OUTLINE

1. **ELECTROSTATICS**
    - Introduction
    - Coulomb's law
    - Electric Field
    - Dirac delta function

2. **GAUSS LAW**
    - Derivation
    - Differential form

3. **SCALAR POTENTIAL Φ**
    - Introduction
    - Physical Interpretation of Φ

4. **SURFACE DISTRIBUTION OF CHARGES**
    - Evaluation of Electric Field and Potential
    - Potential due to Dipole layer

5. **POISSON AND LAPLACE'S EQUATIONS**
    - Poisson's equation
    - Laplace's equation

6. **GREEN'S THEOREM**
    - Introduction
    - Green's First Identity
    - Green's Second Identity (Green's Theorem)

7. **DIRICHLET AND NEUMANN BOUNDARY CONDITIONS**
    - Introduction
    - Dirichlet BC
    - Neumann BC
    - Formal Solution of Electrostatic Boundary Value Problem (BVP)

8. **ELECTROSTATIC POTENTIAL ENERGY AND ENERGY DENSITY**
    - Introduction
    - Electrostatic Potential Energy
    - Energy density

9. **BOUNDARY VALUE PROBLEM**
    - Introduction
    - Laplace Equation in Spherical Coordinates
    - Legendre Equation and Polynomial

10. **SPHERICAL HARMONICS $Y_{lm}(\theta\Phi)$**
    - Introduction
    - Associated Legendre Polynomial
    - Rodrigues Formula
    - Method of separation of variables

- Orthogonality Condition
- Completeness Relation

11. SOLUTION OF POISSON'S EQUATION
- Introduction
- Green's Function of Sphere
- Green's Function for Potential Problem
- Solution of Potential Problem

12. SOLUTION OF LAPLACE'S EQUATION
- Cylindrical Coordinates
- Bessel Function
- Neumann Function
- Hankel Function
- BVP in Cylindrical Coordinates

13. MAGNETOSTATICS
- Introduction
- Biot Savart's Law
- Ampere's Law
- Vector Potential
- Gauge Transformation
- Coulomb Gauge

14. TIME VARYING FIELDS
- Introduction
- Faraday Law
- Energy in Magnetic Field
- Maxwell's Equations
- Vector and Scalar Potentials
- Gauge Transformation, Lorentz Gauge and Coulomb Gauge

BOOKS ON RESERVE

S.NO	TITLE	AUTHOR
1	Electromagnetism- QC 760 G76	Grant
2	Electromagnetics With Application- QC 661 K72	Kraus
3	Lectures in Electrodynamics	Oppenheiman
4	Principles of Electrodynamics- QC 631 S38	Swartz M.
5	Electromagnetic Theory- QC 670 K693	Koretz

ELECTRODYNAMICS 1

TUTORIAL QUESTIONS

NOTE: ***Worked out solutions MUST be handed in during the last WEEK of lectures. The tutorials will contribute 50% of the coursework mark. A ZERO mark will be awarded for copied work. Discuss the questions but hand in individual work!***

1. Derive and distinguish Laplace's and Poisson's equations in electromagnetic theory.
2. Derive Green's first and second identities hence compare and contrast between Dirichlet and Neumann boundary conditions.
3. Discuss the concept of magnetic field H and flux density B from Ampere's point of view and hence derive an expression for force of interaction between two current elements.
4. State the main modifications in Coulomb's, Ampere's and Faraday's laws in order to obtain Maxwell's equations. What is the significance of the additional term?
5. From the concept of scalar and vector fields, explain the concept and physical significance of:
   - Coulomb's Gauge
   - Gauge Transformation
   - Lorentz Gauge
6. Describe the boundary value problem in electromagnetic theory and hence explain the special functions arising from solutions of Poisson and Laplace equations in various coordinate systems.
7. Derive the expression for the Biot-Sarvat law and hence discuss its significance in magnetostatics.
8. Present detailed steps in converting time independent wave equations into Maxwell's equation leading to two equations of potential functions **Φ** and **A** in terms of charge **ρ** and current **j** densities.
9. Starting from the Biot-Savart law, show that **▼.B=0** hence explain the physical meaning of your result.
10. (a) A charge q is distributed uniformly inside a sphere of radius **a**. Use Gauss law or otherwise to determine the electric field **E** at a distance **R** from the center of the sphere for (i) **R** greater than **a** (ii) **R** less than or equal to **a**.

    (b) Determine the electric potential in each case above.

    (c) Show that vector $E=R/R^2$ is conserved and hence determine **Φ (R)** such that **E(R) = -▼Φ (R)** and **Φ (a)=0** where a>e.

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