PHY-204 Electrodynamics I

Credit Hours: 3-0

Pre-requisite: Electricity and Magnetism

Course Objectives: It is an advanced undergraduate course, which aims to make students understand the basics of electricity and magnetism introduce students to the concept of electric field, electric potential and magnetic field and various laws associated with them, give insight into electric and magnetic fields in matter and Maxwell's equations with sources in free space and matter.

Core Contents: Vector analysis, Electrostatics, Electric field, Electric potential, Laplace's equation, method of images and separation of variables for calculating potentials, multipole expansion, electrostatic fields in matter, magnetostatics, magnetic field in matter, Maxwell's equations in free space and in matter.

Detailed Course Contents: Vector Algebra, differential calculus, integral calculus, curvilinear coordinates, Dirac delta Function, Helmholtz theorem, potentials, electric field, divergence of electric field, Gauss's law and its applications, curl of electric field, Electric potential, Poisson's equations and Laplace's equation, boundary conditions, work and energy in electrostatics, conductors, Special techniques: Laplace's equation as special technique, the method of images, separation of variables, multipole expansion, Polarization, dielectrics and the field inside, induced dipoles, alignment of polar molecules, bound charges, Gauss's law in the presence of dielectrics, a deceptive parallel, boundary conditions, linear dielectrics and their susceptibility, permittivity and dielectric constant, boundary value problem with linear dielectrics, energy and forces on dielectrics, Lorentz force law: magnetic fields, magnetic forces, currents, the Bio-Savart law, steady currents, the magnetic field of a steady current, Straight line currents, the divergence and curl of B, applications of Ampere's law, comparison of magneto statics and electrostatics, magnetic vector potential, magneto statics boundary conditions, multipole expansion of vector potential, magnetization, diamagnets, paramagnets, Ferro magnets, torques and forces on magnetic dipoles, effect of magnetic field on atomic orbits, bound currents, magnetic field inside matter, Ampere's law in magnetized materials, a deceptive

parallel, boundary conditions, magnetic susceptibility and permeability, ferromagnetism

Course Outcomes: At the end of the course, students will be able to:

- understand the concept of electric field and various methods of calculating it for different charge distributions
- understand how electric field changes inside matter
- understand magnetic field and vector potential and the laws associated with it
- understand magnetic fields inside matter and various types of magnetization
- understand how to apply Maxwell's equations and what to infer from them.

Textbook: David F. Griffiths, Electrodynamics, 4th ed. Prentice Hall Inc., 1989 (Referred as DG)

Reference Book: F. J. Milford, R W. Christy, Foundations of Electromagnetic theory, 4th edition, Addison-Wesley, 2008.

Weekly Breakdown		
Week	Section	Topics
1	DG 1.1-1.3	Vector Algebra, Differential Calculus, Integral calculus
2	DG 1.4, 1.6	Curvilinear coordinates, Dirac Delta Function, Helmholtz Theorem, Potentials
3	DG 2.1-2.2	Electric field, divergence of electric field, Gauss's law and its applications, Curl of electric field
4	DG 2.3	Electric potential, Poisson's equations and Laplace's equations, boundary conditions
5	DG 2.4, 2.5	Work and energy in electrostatics, conductors
6	DG 3.1	Special techniques: Laplace's equation
7	DG 3.2	Special techniques: the method of images
8	DG 3.3, 3.4	Special techniques: separation of variables, multipole expansion
		Midterm Exam
9	DG 4.1, 4.2	Polarization, dielectrics and the field inside, induced dipoles, alignment of polar molecules, bound charges

10	DG 4.3-4.4	Gauss's law in the presence of dielectrics, a deceptive parallel, boundary conditions, linear dielectrics and their susceptibility, permittivity and dielectric constant, boundary value problem with linear dielectrics, energy and forces on dielectrics
11	DG 5.1, 5.2	The Lorentz force law: magnetic fields, magnetic forces, currents, the Bio-Savart law, steady currents, the magnetic field of a steady current
12	DG 5.3	Straight line currents, the divergence and curl of B, applications of Ampere's law, comparison of magneto statics and electrostatics
13	DG 5.4	Magnetic vector potential, magneto statics boundary conditions, multipole expansion of vector potential
14	DG 6.1-6.2	Magnetization, diamagntes, paramagnets, Ferro magnets, torques and forces on magnetic dipoles, effect of magnetic field on atomic orbits, bound currents, magnetic field inside matter
15	DG 6.3, 6.4	Ampere's law in magnetized materials, a deceptive parallel, boundary conditions, magnetic susceptibility and permeability, ferromagnetism