PHY-301 Electrodynamics II

Credit Hours: 3-0

Pre-requisite: Electrodynamics I

Course Objectives: It is an undergraduate core course and is an extension of core course electrodynamics I. It aims to make students understand the laws governing moving charges, electromotive force and electromagnetic fields associated with various circuits and devices. It also introduces students to electromagnetic waves, wave guides and electromagnetic radiation.

Core Contents: Electrodynamics, Electromotive force, Faraday's law, Potential formulations of electrodynamics, The wave equation, Electromagnetic waves in conductors and non-conducting media, dispersion, wave guides, electromagnetic resonators, waves in complex media and plasma, scalar and vector potential, electromagnetic radiations.

Detailed Course Contents: Revision of Maxwell's equations in free space and matter, Introduction, Ohm's law, electromotive force, motional emf, electromagnetic induction, Faraday's law, the induced electric field, inductance, energy in magnetic fields, Maxwell's equations: Electrodynamics before Maxwell, fixing Ampere's law, magnetic charge, Maxwell's equations in matter, boundary conditions, charge and energy, the continuity equation, Poynting's theorem, Newton's third law in electrodynamics, Maxwell's stress tensor, conservation of momentum, conservation of angular momentum, electromagnetic waves: the wave equation, sinusoidal waves, reflection and transmission, polarization, EM waves in vacuum: the wave equation for E and B, monochromatic plane waves, energy and momentum in electromagnetic waves, EM waves in matter, propagation in linear media, reflection and transmission at normal and oblique incidence, EM waves in conductors, reflection at conducting surface, the frequency dependence of permittivity, wave guides, transverse electric waves in rectangular wave guide, the coaxial transmission line, potentials and fields: scalar and vector potentials, gauge transformations, Coulomb gauge and Lorentz gauge, continuous distributions: retarded potentials, Jefimenko's equations, point charges, Lienard-Wiechert potentials, the field of a moving point charge, radiation, electric dipole radiation, magnetic dipole radiations, radiation from an arbitrary source, power radiation by a point charge, radiation reaction, the physical basis of the radiation reaction.

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

- understand electromagnetic waves and their transmission in various media
- understand electromagnetic fields associated with various circuits and devices
- understand electromagnetic waves in vacuum and matter and phenomena in wave guides
- understand the concept of vector potential and gauge transformations
- understand radiations by point charges, electric dipoles, magnetic dipoles and arbitrary source.

Textbook: David F. Griffiths, Electrodynamics, 4th Edition, 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 7.1	Revision of Maxwell's equations in free space and matter, Introduction, Ohm's law, electromotive force, motional emf
2	DG 7.2	Electromagnetic induction, Faraday's law, the induced electric field, inductance, energy in magnetic fields
3	DG 7.3-7.4	Maxwell's equations: Electrodynamics before Maxwell, fixing Ampere's law, magnetic charge, Maxwell's equations in matter, boundary conditions
4	DG 8.1	Charge and energy, the continuity equation, Poynting's theorem
5	DG 8.2	Newton's third law in electrodynamics, Maxwell's stress tensor, conservation of momentum
6	DG 8.2, 9.1	Conservation of angular momentum, Electromagnetic Waves: The wave equation
7	DG 9.1	Sinusoidal waves, reflection and transmission, Polarization
8	DG 9.2, 9.3	EM waves in vacuum: the wave equation for E and B, monochromatic plane waves, energy and momentum in electromagnetic waves, EM waves in matter, propagation in linear media, reflection and transmission at normal and oblique incidence
9	DG 9.4, 9.5	EM waves in conductors, reflection at conducting surface, the

		frequency dependence of permittivity, wave guides, transverse electric waves in rectangular wave guide, the coaxial transmission line
10	DG 10.1	Potentials and fields: Scalar and vector potentials, gauge transformations, Coulomb gauge and Lorentz gauge
11	DG 10.2	Continuous distributions: retarded potentials, Jefimenko's equations
12	DG 10.3	Point charges, Lienard-Wiechert potentials, the field of a moving point charge
13	DG 11.1	Radiation, electric dipole radiation, magnetic dipole radiations, radiation from an arbitrary source
14	DG 11.2	Power radiation by a point charge, radiation reaction, the physical basis of the radiation reaction
15	DG 11.2	Continue