PHY-805 Electromagnetism

Credit Hours: 3-0
Prerequisite: None

Objectives and Goals: It is an advanced level course to learn concepts of charges at rest, current, alternating currents, magnetism and time varying electric and magnetic fields.

Core Contents: We are going to begin our journey in this course by quick review of Laplace equation in all co-ordinates system, We then proceed towards Maxwell's equation, Gauge transformations, Green's function as a superposition of eigen functions, Review of complex variables, Green's function for the wave equation, Retarded solutions for the fields, Poynting's Theorem and conservation laws, Electromagnetic waves in the presence of dielectrics, Waveguides, Multipoles and the multipole expansion of the electromagnetic field, Scattering at long wavelengths, Perturbation theory of Scattering.

Detailed Course Contents: Review of separation of variables; solution of Laplace equation in rectangular co-ordinates, Example of Laplace equation in rectangular co-ordinates, Laplace equation in plane polar co-ordinates, Example of Laplace equation in plane polar
co-ordinates, Solution of Laplace equation in spherical co-ordinates, Legendre Equation and Legendre polynomials, Boundary value problems with azimuthal symmetry, Laplace equation in cylindrical co-ordinates, Boundary value problems in cylindrical co-ordinates, Review of Maxwell's Equations, Gauge transformations, Green's function for Ordinary differential Equation, Green's function as a superposition of eigen functions, Review of complex integration, Cauchy's theorem, Cauchy's Integral formula, Residue theorem and its application, Solving Green's function for a wave equation, Advanced and Retarded Green's function, Retarded solutions for the fields, Poynting's Theorem and conservation of energy and momentum, Poynting's Theorem in a media, Plane waves in a non-conducting media, Linear and Circular polarization, Reflection and refraction of electromagnetic waves at a plane interface between dielectrics, Fields at the surface of and Within a conductor, Cylindrical cavities and Waveguides, Fields and radiation of a localized Oscillating source, Electric dipoles fields and radiation, Magnetic Dipole and electric quadrupole fields, Multipole expansion for localized source, Spherical Wave solutions of the scalar wave equation , Scattering by Dipoles Induced in Small Scatterers, Scattering by a Small Dielectric Sphere and Scattering by a Small Perfectly Conducting Sphere, Perturbation Theory of Scattering, Born Approximation.

Course Outcomes: Students will be able to:

- learn electric charge, forces, and fields
- apply the above-mentioned concepts to complex charge configurations
- learn electric current, magnetic force and apply to various current carrying sources and configurations

- learn how time varying electric force produces magnetic field and the same magnetic force produces induced electric force
- learn the concept of alternating current

Textbook: John David Jackson (JDJ), Classical Electrodynamics, 3rd ed. John Wiley and Sons 2001.

Reference books: David J. Griffith, Introduction to Electrodynamics, 4th ed. Prentice Hall 2013.

Weekly Breakdown		
Week	***Section***	***Topics***
1	* JDJ 2.9-2.11	Review of separation of variables; solution of Laplace equation in Rectangular co-ordinates, Example of Laplace equation in rectangular co-ordinates, Laplace equation in plane polar co-ordinates, Example of Laplace equation in plane polar co-ordinates.
2	* JDJ 3.1-3.3	Solution of Laplace equation in spherical co-ordinates, Legendre Equation and Legendre polynomials, Boundary value problems with azimuthal symmetry
3	*JDJ 3.7-3.8JDJ 6.1-6.2	Laplace equation in cylindrical co-ordinates, Boundary value problems in cylindrical co-ordinates, Review of Maxwell's Equations.
4	* RHB 15.2.5,17.5	Gauge transformations, Green's function for Ordinary differential Equation, Green's function as a superposition of eigen functions
5	* RHB 24.8-24.10	Review of complex integration, Cauchy's theorem, Cauchy's Integral formula
6	*RHB , 24.12, JDJ 6.4	Residue theorem and its application, Solving Green's function for a wave equation, Advanced and Retarded Green's function.
7	JDJ 6.5-6.8	Retarded solutions for the fields, Poynting's Theorem and conservation of energy and momentum, Poynting's Theorem in a media.
8	JDJ 7.1-7.3	Plane waves in a non-conducting media, Linear and Circular polarization, Reflection and refraction of electromagnetic waves at a plane interface between dielectrics
9	JDJ 7.4-7.5	Polarization by reflection and total internal reflection, Frequency dispersion characteristics of dielectrics.
10	JDJ 8.1-8.3	Fields at the surface of and within a conductor, cylindrical cavities and Waveguides.
11	JDJ 8.4-8.5	Modes in a Rectangular Waveguide, Energy Flow and Attenuation in Waveguides.
12	JDJ 9.1-9.2	Fields and radiation of a localized Oscillating source, Electric dipoles fields and radiation
13	JDJ 9.3,9.5	Magnetic Dipole and electric quadrupole fields, Multipole expansion for localized source.
14	JDJ 9.6, 10.1A	Spherical Wave solutions of the scalar wave equation, Scattering by Dipoles Induced in Small Scatterers
15	JDJ 10.1B-10.1C ,10.2A-10.2B	Scattering by a Small Dielectric Sphere and Scattering by a Small Perfectly Conducting Sphere, Perturbation Theory of Scattering, Born Approximation.

* The topics represents the mathematical background which is very necessary to understand the core of Electrodynamics.