PHY-814 Advanced Electrodynamics

Credit Hours: 3-0

Pre-requisite: None

Course Description: Review of Electrostatics and Magnetostatics, Maxwell’s equation, Expressing Electric field in terms of scalar and vector potential, Introduction to gauge transformation, 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, Polarization by reflection and total internal reflection, Frequency dispersion characteristics of dielectrics, Plane waves in a non-conducting media, Linear and Circular polarization, Reflection and refraction of electromagnetic waves at a plane interface between dielectrics, Fields and radiation of a localized Oscillating source, Electric dipoles fields and radiation, Magnetic Dipole and electric quadrupole fields, Multipole expansion for localized source, Postulates of Special relativity, Lorentz transformation, Four vector notation, Invariant interval, The principle of least action, Energy and momentum using four vector notation, Invariance of Electric Charge, Covariance of Electrodynamics, Transformation of Electromagnetic fields, Lagrangian and Hamiltonian formalism of Relativistic charged particles.

Course Outcomes: Students will be able to:

- Understand the symmetry-based simplification of electrostatic problems using Gauss’s law.
- Derive and solve magnetostatic differential equations.
- Introduce and compute the **vector potential**, understanding its gauge freedom.
- Understand the concept and use of **gauge transformations**
- Solve wave equations using **Green’s functions**.
- Differentiate between **retarded** and **advanced** Green’s functions.
- Solve for **plane wave solutions** in non-conducting media.

- Applying Relativistic framework to various Electrodynamics problem.

Text Books:

Textbook 1: *Classical Electrodynamics*

Author: John David Jackson

Publisher: John Wiley

Referred to as: JDJ

Reference Books:

Reference Book: *Introduction to Electrodynamics*

Author: David .J. Griffith

Publisher: Prentice Hall

Referred to as: DJG

Reference Book: Modern Electrodynamics

Publisher: Cambridge University Press

Author: Andrew Zangwill

Referred as : AZ

Week	Ch. Sect.	Topics
1.	JDJ 1.1-1.4	Review of Electrostatics, Revisit Columb's law and Gauss's law, Expressing Electric field in terms of electrostatic potential.
2.	JDJ 5.1-5.4	Revisit Magnetostatics, Revisit Biot Savart law and Ampere's law, Differential equation of Magnetostatics and Ampere's law, Vector Potential.
3.	JDJ 6.1-6.3	Maxwell's equation, Expressing Electric field in terms of scalar and vector potential, Introduction to gauge transformation.
4.	, JDJ 6.4-6.5	Solving Green's function for a wave equation, Advanced and Retarded Green's function, Retarded solutions for the fields,
5.	JDJ 6.6-	Poynting's Theorem and conservation of energy and momentum,

	6.8	Poynting's Theorem in a media.
6.	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
7.	JDJ 7.4-7.5	Polarization by reflection and total internal reflection, Frequency dispersion characteristics of dielectrics.
8.	JDJ 9.1-9.2	Fields and radiation of a localized Oscillating source, Electric dipoles fields and radiation
9.	JDJ 9.3,9.5	Magnetic Dipole and electric quadrupole fields, Multipole expansion for localized source.
10.	JDJ 9.6, 10.1A	Spherical Wave solutions of the scalar wave equation, Scattering by Dipoles Induced in Small Scatterers
11.	JDJ 10.1B-10.1C	Scattering by a Small Dielectric Sphere and Scattering by a Small Perfectly Conducting Sphere
12.	JDJ 11.1-11.3	Postulates of Special relativity, Lorentz transformation, Four vector notation, Invariant interval, The principle of least action, Energy and momentum using four vector notation.
13.	JDJ 11.9-11.10	Invariance of Electric Charge, Covariance of Electrodynamics, Transformation of Electromagnetic fields
14.	JDJ 12.1	Lagrangian and Hamiltonian for a Relativistic charged particles,
15.	JDJ 12.7, 12.8	Lagrangian and Hamiltonian for Electromagnetic Field, Proca Lagrangian,
16.		Revision