PHY7131 : Electrodynamics-II

Programme: M.Sc. (Physics)	Year: Second	Semester : 3rd
Course : Core Course	Credits : 4	Hours (LTP): 40+12+0

Course context and overview:

Electromagnetic force is one of the four fundamental forces in nature and along with gravity it is the interaction which governs most of the phenomena on everyday scale. The theory, as enunciated by Maxwell in his equations, unified the apparently different fields of electricity, magnetism and light. This theory not only serves as a guide to build more advanced and sophisticated models of particle interactions but it also is at the foundation of a lot of technological advancements (electricity, communications etc.). Not only this, electrodynamics provided the theoretical motivation for the special theory of relativity. A sound understanding of electrodynamics is therefore necessary of physics majors and in this course we will try to cover the various aspects of this beautiful theory.

Prerequisite Courses:

Mathematical Physics I and II, Electrodynamics-I

On completion of this course
CO1: Students will learn to use Maxwell's equations in specific technological applications of electromagnetic fields in case of waveguides and cavity resonator.
CO2: Students will acquire an understanding of the concept of electromagnetic radiation and its basic theoretical destription.
CO3: Students will acquire basic understanding of the scattering of electromagnetic radiations and related physical phenomena.
CO4: Students will learn the relativistic formulation of electrodynamics and would be able to use similar techniques in more advanced areas of physics like quantum field theory and particle physics.

Course Topics:

Topics	Lectures+Tutorials
Wave guides and transmission line: Rectangular waveguide, cut-off frequency, modes of the rectangular waveguide, energy flow and attenuation in waveguides, coaxial transmission line**.**	3+1
Resonant cavities: Cavity Modes, power losses in a cavity, Q of a cavity, Earth and ionosphere as a resonant cavity.	2+1
Solutions of Maxwell's equations in the presence of sources: Retarded potentials, Jefimenko's equations for the fields.	3+1
Radiation: Electric and magnetic dipole radiation, example of center fed linear antenna, multipole expansion of retarded potentials.	5+2
Radiation by moving charges: Lienard-Wiechert potentials and	5+1

fields for a point charge, Potential for a charge moving with constant velocity – the Lorentz formula, Power radiated by an arbitrarily moving charge – the Larmor formula.	
Electrodynamics and relativity: Non-invariance of Maxwell equations under Galilean transformation, Lorentz formula as a motivation for Lorentz transformation, Michelson-Morley experiment and special relativity, recapitulation of important results of special relativity, magnetism as a relativistic phenomena (change of frame), electrodynamics in relativistic notation – four vectors and four potential, Lorentz transormation of the fields, the electromagnetic field tensor, electrodynamics in tensor notation, Lagrangian for the electromagnetic field.	10+3
Dynamics of relativistic particles: Motion in uniform, static magnetic field, motion in combined, uniform, static electric and magnetic fields, motio in nonuniform, static magnetic fields.	2+1
Scattering: Scattering at long wavelengths by (induced) dipoles, scattering by a collection of scatterers, Rayleigh scattering and the Blue sky, polarization of radiation by scattering, scattering in the short wavelength limit, scattering by free charges (Thomson scattering).	5+2
Bremsstrahlung and synchrotron radiation: Radiation emitted during collisions, Bremsstrahlung in Coulomb collisions, Radiation emitted by a relativistic charged particle in circular motion (qualitative treatment of synchrotron radiation).	5+2

Text Books:

1. D.J. Griffiths, Introduction to Electrodynamics (Pearson Edu.; 4th edition, 2015).
2. J.D. Jackson, Classical electrodynamics (John Wiley; 3rd edition, 2007).

Additional References:

1. L.D. Landau and E.M. Lifshitz, Classical Theory of Fields, (BH; 4th edition, 1987).
2. W. K. H. Panofsky and M. Phillips, Classical Electricity and Magnetism (Addison-Wesley, 1962).
3. R.P. Feynman, R. Leighton and M. Sands, Feynman Lectures on Physics (Vol. 1 & 2): The New Millennium Edition (Pearson Education India, 1st edition, 2012).

Additional Resources (NPTEL, MIT Video Lectures, Web resources etc.):

1. Lecture notes are available from MIT open courseware. The link is https://ocw.mit.edu/courses/physics/

Evaluation Scheme

Sl. No.	Components	Weightage
1.	3 Quizzes	15%
2.	3 Assignments	15%
3.	Term Paper and presentation	20%
4.	Mid Term	20% (1.5 hours)
5.	End Term	30% (2.5 hours)