B.SC. (HONOURS) PHYSICS

DISCIPLINE SPECIFIC CORE COURSE – DSC 20: ELECTRODYNAMICS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Electrodynamics DSC 20	4	3	1	0	Vector calculus, Maxwell's equations, and basic Special Relativity

Course Objectives

This course provides a rigorous understanding of the behavior of charges and electromagnetic fields, motion in fields, and the fundamentals of radiation. Students will gain both theoretical insight and computational tools needed in advanced physics.

Learning Outcomes

After completing this course, students will be able to:

- Apply Maxwell's equations in relativistic contexts.
- Analyze the motion of charged particles in different electromagnetic field configurations.
- Understand and compute radiation fields from various charge-current distributions.
- Use covariant and Lagrangian formulations to express electrodynamics compactly.
- Solve applied problems related to electromagnetic radiation and antenna theory.

SYLLABUS OF DSC 20
THEORY COMPONENT
(Credits: 3; Hours: 45)

Unit I **(15 Hours)**

Review of Maxwell's equations, scalar and vector potentials, gauge transformations, Coulomb and Lorentz gauges. Lorentz transformations in 4-vectors notation. Transformation of electric and magnetic fields.
EM field tensor: Construction and interpretation of $F^{\mu\nu}$, Covariance form of Maxwell's equations. Lorentz invariants of electromagnetic fields $E^2 - B^2$ and $\vec{E}.\vec{B}$.

Unit II **(8 Hours)**

Lorentz force in relativistic form. Charged particle trajectories in static electric and magnetic fields. Crossed **E** and **B** fields, guiding center approximation: Velocity and curvature drifts.

Unit III **(14 Hours)**

Green's function for wave equation, retarded potentials using Green's function. Radiation from oscillating charges, radiation zones. Multipole expansion: dipole and quadrupole. Lienard - Wiechert potentials, Lienard's and Larmor's formulas. Angular distribution of radiation. Centre-fed linear antennas.

Unit IV **(8 Hours)**

Lagrangian for free relativistic particles. Systems with infinite degrees of freedom: Classical fields. Lagrangian for charged particles in EM fields and free EM fields. Energy-momentum tensor and conservation laws.

<u>**References**</u>

Essential Readings

1. D.J. Griffiths and D.F. Schroeter, Introduction to Electrodynamics, 4th Edition, Cambridge University Press, 2017.
2. J.D. Jackson, Classical Electrodynamics, 3rd Edition, Wiley, 1998.
3. L.D. Landau and E.M. Lifshitz, The Classical Theory of Fields, Course of Theoretical Physics Vol. 2, 4th Edition, Butterworth-Heinemann (Pergamon), 1975.
4. P. Lorrain and D.R. Corson, Electromagnetic Fields and Waves, 3rd Edition, W.H. Freeman and Company, 1988.
5. C.A. Brau, Modern Problems in Classical Electrodynamics, Oxford University Press, 2004.

Additional Readings

1. M. Schwartz, Principles of Electrodynamics, Dover Publications, 1987.
2. Julian Schwinger, L.L. DeRaad Jr., K.A. Milton, W.-Y. Tsai, Classical Electrodynamics, Westview Press, 1998.
3. L.D. Landau, E.M. Lifshitz, and L.P. Pitaevskii, Electrodynamics of Continuous Media, 2nd Edition, Course of Theoretical Physics Vol. 8, Butterworth-Heinemann, 1984.
4. J.R. Reitz, F.J. Milford, R.W. Christy, Foundations of Electromagnetic Theory, 4th Edition, Addison-Wesley, 1992.
5. A. Zangwill, Modern Electrodynamics, Cambridge University Press, 2013.
6. Jerrold Franklin, Classical Electromagnetism, Addison-Wesley, 2005.
7. J. Panofsky and M. Phillips, Classical Electricity and Magnetism, 2nd Edition, Dover Publications, 2005.
8. Mark A. Heald and Jerry B. Marion, Classical Electromagnetic Radiation, 3rd Edition, Dover Publications, 2012.