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Graduate Program in Physics
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Classical Electromagnetic Theory I

Course code: FSC410129

Credit hours: 6

Duration: 18 weeks

DESCRIPTION: Electrostatics. Electrostatic field in dielectric media. Magnetostatics and magnetism. Maxwell equations. Electromagnetic waves. Special relativity and transformations of the electromagnetic field. Conservation laws in electrodynamics. Electromagnetic radiation.

COURSE CONTENT:

1. Electrostatics: Laplace and Poisson equations. Green's theorem. Uniqueness of the solution with Dirichlet or Neumann boundary conditions. Electrostatic energy. Laplace equation in two and three dimensions. Green's function expansion in spherical and cylindrical coordinates.
2. Electrostatic Field in Dielectric Media: Multipole expansion of the potential and energy of a charge distribution. Electrostatic equation in dielectric media and boundary value problems. Electrostatic energy in dielectric media. Models for electric polarizability. Molecular polarizability and susceptibility
3. Magnetostatics and Magnetism in Continuous Media: Differential equations of magnetostatics. Vector potential. Magnetic moment. Equations of magnetostatics in continuous media. Boundary conditions on B and H. Methods of solving boundary-value problems in magnetostatics. Energy of the magnetic field. Magnetic susceptibility, diamagnetism, paramagnetism and ferromagnetism

4. Maxwell Equations: Faraday law of induction. Ampère-Maxwell law. Maxwell equations, scalar and vector potentials. Poynting's theorem; energy conservation, linear and angular momentum of the electromagnetic field. Transformation properties of the electromagnetic fields under rotations, spatial reflections and time reversal.
5. Electromagnetic Waves: Waves in nonconducting medium, Linear and Circular Polarization. Stokes Parameters. Reflection and Refraction of Electromagnetic Waves at a Plane Interface Between Two Dielectrics. Frequency Dispersion Characteristics of Dielectrics, Conductors, and Plasmas. Electromagnetic waves in conducting or dissipative media. Causality and the Kramers-Kronig relations. Arrival of a Signal After Propagation Through a Dispersive Medium.
6. Special Relativity and the Covariant Formulation of Electromagnetism: Space-time geometry. Lorentz transformations. Gauge symmetry and Maxwell equations. Current-density 4-vector and 4-vector potential. Electromagnetic tensor and the covariant formulation of Maxwell equations. Invariants of the electromagnetic field. Maxwell equations and the variational principle.
7. Electromagnetic Radiation: Liénard-Wiechert potentials. Electromagnetic field of a moving charge. Multipole expansion of the electromagnetic radiation

BIBLIOGRAPHY:

1. Classical Electrodynamics, J.D. Jackson, 3rd edition (Wiley).
2. Classical Electricity and Magnetism, W.K.H. Panofsky and M. Phillips, (Dover).
3. Electrodynamics of Continuous Media, L.D. Landau, E.M.Lifshitz e L.P.Pitaevskii, 2nd edition (Elsevier).
4. Introduction to Electrodynamics, D.J. Griffiths, 3rd edition (Prentice Hall).
5. Classical Theory of Fields, L.D. Landau, E.M. Lifshitz, 4th Edition: Volume 2 (Course of Theoretical Physics Series).
6. Classical Electrodynamics, R. S. Ingarden, A. J. Jamiolkowski; Elsevier Science Ltd (June 1985).
7. Equations of Mathematical Physics, V. S. Vladimirov; Marcel Dekker, Inc, New York 1971.