

PHY235 - ELECTROMAGNETISM II – SPECIAL RELATIVITY

(1.) Electromagnetic Waves

Maxwell Equations in Vacuum and in Matter, Wave Equation, Waves in 1 Dimension, Transverse and Longitudinal Waves, Linear and Circular Polarisation, Boundary Conditions.

(2.) Electromagnetic Waves in Non-Conductive Media

Electromagnetic Waves in Non-Conductive Media, Energy and Momentum of the Electromagnetic Field, Poynting Vector, Intensity of Electromagnetic Waves, Reflection and Transmission of Electromagnetic Waves, Boundary Conditions, Perpendicular and Side Incidence, Fresnel Equations, Total Reflection, Brewster Angle, Reflection and Transmission Coefficients.

(3.) Electromagnetic Waves in Conductors

Continuity Equation, Wave Equations with Damping, Ideal, Good and Bad Conductors, Wave Properties, Boundary Conditions.

(4.) Dispersion

Electromagnetic Properties of Materials, Dispersion, Phase and Group Velocity, Polarisation in Non-Conducting Media, Anomalous Dispersion, Cauchy Equation, Free Electrons in Conductors, Conductivity, Variations of the Damping Coefficient and of the Index of Refraction.

(5.) Electromagnetic Radiation

Inhomogeneous Wave Equation, Lorentz Gauge, Static and Non-Static Case, Retarded and Advanced Potentials, Radiation of Electric and Magnetic Dipole, Corresponding Strength of the Electric and Magnetic Field, Mean Radiated Power and Energy.

(6.) Symmetries and Conservation Laws

Symmetries in Physical Laws, Translation and Rotation, Time Reversal, Space Inversion, Relative Motion, Motion of Reference Systems with a Constant Velocity, Galilean Transformations, Accelerated Frames of Reference, Situation before the Special Theory of Relativity.

(7.) Special Theory of Relativity

Principles of Special Theory of Relativity, Unified Description of Matter-Energy, Einstein's Box, Rest Mass, Energy and Momentum, Propagation of Light, Determination of the Speed of Light, Aberration, Ether, Fizeau and Michelson-Morley Experiments, Fresnel's Resistance Coefficient.

(8.) Lorentz Transformations

Simultaneous Events, Lorentz Transformations, Spacetime Invariant Quantities, Spacetime Distance between Events, Length Contraction, Proper Length, Time Dilation, Proper Time, Synchronizing Watches, Minkowski Diagram, Cosmic Lines, Light Cone, Transformation of Velocities, Transformation of Accelerations, Transformation of Angles.

(9.) Doppler Effect

Regular and Relativistic Doppler Effect, The Satellite Problem, Artificial Rotation of an

Object, Twin Paradox and its Interpretation.

(10.) Relativistic Dynamics

Elastic Collisions, Conservation of Energy and Momentum, Absorption and Emission of Photons, Moessbauer Effect, Pair Production, Scattering, Threshold Production of Particles, Particle Decays, Compton Scattering, Energy-Momentum Transformations, Transformation of Forces.

(11.) Covariant Formulation

Four-Vectors, Covariant and Contravariant Vectors, Dot Product and Magnitude of Vectors, Tensors, Metric Tensor, Four-Gradient, Four-Velocity and Four-Momentum.

(12.) Classical Electrodynamics

Principle of Minimum Action, Euler-Lagrange Equations, Generalized Momentum, Lorentz Force, Gauge Transformations, Electromagnetic Field Tensor, Transformation of Electromagnetic Field, Maxwell Equations, Current Four-Vector, Continuity Equation, Equation of Motion of Electromagnetic Field.

Suggested Textbooks

1. "Special Relativity", Anthony Philip French, W.W. Norton & Company (1968).
2. "Introduction to Electrodynamics", David. J. Griffiths, Prentice Hall (1989).
3. "Ηλεκτρομαγνητισμός", Ε.Παπαδημητράκη-Χλίχλια, Ι.Α. Τσουκαλά, Εκδόσεις Ζήτη (1994).
4. "Introduction to Special Relativity", Robert Resnick, John Wiley & Sons (1968).
5. "Mechanics and Electrodynamics", L. D. Landau & E. M. Lifshitz (1972).
6. "Introduction to Special Relativity", M. Schwartz, Krieger Publishing Company (1977).