The CERN Accelerator School

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Theory of EM fields II

Monday, 19 June 2023 12:00 (1 hour)

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In the presentation, theoretical foundations of electromagnetic fields are reviewed. First, general terms and concepts of field theory are discussed (scalar fields, vector fields, normal and tangential fields, dot product, cross product etc.) and then Maxwell's equations in the integral form and material equations are recapitulated. It is shown how Maxwell's equations in the integral form are transferred to the differential form by considering infinitely small Gaussian volumes and area elements. In this context, various vector operators are repeated and their properties are discussed. Based on the properties of these vector operators, conservation principles such as conservation of charges and conservation of energy are derived and interpreted. In the second part of the talk, field problems described by Maxwell's equations are classified into electro-static, magneto-static and full-wave solutions. Poisson equation for electric potentials, Poisson equation for magnetic vector potentials, curl-curl equation and wave equation as well as Helmholtz equation in 2D and 3D are derived from Maxwell's equation. Selected application examples and solutions of these equations and their properties are discussed.

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