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Electromagnetic Field Theory: A Problem Solving Approach

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PREFACE

Electromagnetic field theory is often the least popular course in the electrical engineering curriculum. Heavy reliance on vector and integral calculus can obscure physical phenomena so that the student becomes bogged down in the mathematics and loses sight of the applications. This book instills problem solving confidence by teaching through the use of a large number of worked examples. To keep the subject exciting, many of these problems are based on physical processes, devices, and models.

This text is an introductory treatment on the junior level for a two-semester electrical engineering course starting from the Coulomb–Lorentz force law on a point charge. The theory is extended by the continuous superposition of solutions from previously developed simpler problems leading to the general integral and differential field laws. Often the same problem is solved by different methods so that the advantages and limitations of each approach becomes clear. Sample problems and their solutions are presented for each new concept with great emphasis placed on classical models of such physical phenomena as polarization, conduction, and magnetization. A large variety of related problems that reinforce the text material are included at the end of each chapter for exercise and homework.

It is expected that students have had elementary courses in calculus that allow them to easily differentiate and integrate simple functions. The text tries to keep the mathematical development rigorous but simple by typically describing systems with linear, constant coefficient differential and difference equations.

The text is essentially subdivided into three main subject areas: (1) charges as the source of the electric field coupled to polarizable and conducting media with negligible magnetic field; (2) currents as the source of the magnetic field coupled to magnetizable media with electromagnetic induction generating an electric field; and (3) electrodynamics where the electric and magnetic fields are of equal importance resulting in radiating waves. Wherever possible, electrodynamic solutions are examined in various limits to illustrate the appropriateness of the previously developed quasi-static circuit theory approximations.

Many of my students and graduate teaching assistants have helped in checking the text and exercise solutions and have assisted in preparing some of the field plots.