Preface

This text is intended for physics majors or electrical engineering students in their Junior or Senior years or, depending upon their background, first year graduate students. It is assumed that the students will have a background in calculus and differential equations or an equivalent course in mathematical physics. An introductory course in modern physics would be useful but not necessary.

Based upon many years of teaching electricity and magnetism this text was developed to address the following issues:

(1) For many students the advanced undergraduate course in electricity and magnetism is their first experience with stringent applications of mathematics. Therefore what often is needed is more examples and background in the mathematics, particularly with the applications of "special" functions such a Bessel functions and Legendre Polynomials. In this text these topics are introduced in a natural way, not introduced ad hoc, and are revisited to emphasize these are not special functions at all but fundamental functions which describe the electromagnetic field and are a natural extension of the theory. For example, the Bessel functions are first introduced as a solution to Laplace's Equation in cylindrical coordinates, then as solutions to the spherical wave equation, next as a description of the diffraction pattern of a circular aperture and finally as a description of the electromagnetic waves in cylindrical waveguides. Appendices treat the δ-function, Bessel Functions, Legendre Polynomials and spherical harmonics, elliptic integrals and the Fourier Integral approach to the solution of the wave equation.

(2) The traditional course in optics at many institutions has been replaced by other courses deemed more necessary for the physics major. To address this trend there are many topics in physical optics included in the text. However, there is a more compelling reason to do this. Derivation of the optical phenomena of reflection, refraction, diffraction and interference provides the most descriptive examples of the power of Maxwell's theory. That such a wide variety of phenomena could be so easily explained by four simple looking equations is a powerful pedagogical tool.

(3) Many texts leave out key concepts in derivations and assume that the student has background which he or she may not have. In introducing advanced topics care has been taken, to the extent that reasonable space allows, to put in all the steps so that the student can follow a derivation without having to draw upon prior knowledge. Included in the text are both simple and complex problems.

(4) The normal topics usually included in the undergraduate course are not left out. This means that there is more material in the text than can be covered in a two-semester course, but it also means that the teacher has more choice, depending upon the local curriculum, to pick and choose what topics he or she wishes to study in

more depth. It is intended that the text should become a useful reference guide for the student going on in physics as some of the more advanced topics are covered in later courses.

(5) Topics are covered in depth which students should be acquainted with because of their importance in either modern technology or in research itself. Thus the text has more material on waveguides, fiber optics and radiation than is common at this level. There is also some discussion of the electromagnetic properties of plasmas and some topics related to solid state physics.

(6) Finally this text is intended to bridge the gap between the usual undergraduate texts in electricity and magnetism and the texts which will be used at the graduate level. There is just too wide a gap between the theoretical and mathematical levels of each group of texts. Many topics covered in this text will address that issue.

Problems are dispersed throughout the text, whenever possible, by topic, and within topic, by level of difficulty. Some of the problems would be good exercises for those students who have access to the current computer algebra software. Some of the illustrations in the text have been generated this way (Mathcad 2000®). In addition other functions, such as elliptical integrals, the sine and cosine integrals and the Cornu spiral are easily evaluated with these systems.

Finally, the usual sequence of topics has been modified somewhat. The discussion of the electric and magnetic field is usually too separated in a typical course. Thus two topics which are really connected, to the student appear not to be so. It is easy for a student to forget the characteristics of one while studying the other. In order to address this issue we have treated the electric and magnetic fields in vacuo first and then discussed the fields in materials. Between these two sections, in Chapter III, we have discussed the solutions to Laplace's and Poisson's Equations. If the teacher wishes, these topics could be delayed until after the treatment of the magnetic field with little impact on continuity.

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