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This book arose from my teaching the first quarter of the standard graduate course in electromagnetism at the University of Chicago in the winter of 2018. It had been several years since I had previously taught this course, so I approached it with fresh eyes, and it was natural for me to try to rethink how the subject of electromagnetism should be presented at the graduate level. When I did so, it became clear to me that the usual course-historical way of presenting the subject promotes some very unhealthy ways of thinking about electromagnetism. Therefore, to avoid starting off on the wrong foot, I decided to spend the first few lectures of the course describing what I now take as my chapter 1 of this book as “myths” concerning electromagnetism. I found that by starting out in this way, it became much easier to straightforwardly present the subject in a clear and concise manner, without having to make shifts in perspective as the subject developed. I taught the course again in the following 2 years and provided lecture notes to the class. These lecture notes have now evolved into this book.

The first chapter of this book is thus a quite unconventional introduction to classical magnetism. Instead of beginning with the force between charged particles, describing how this gives rise to a “field” concept, and so forth, my aim in chapter 1 is to explain to students how they should think about electromagnetism from a modern and mathematically precise perspective. The major points made in this chapter are that (i) the potentials, not the field strengths, are the fundamental dynamical variables in electrostatics (ii) the energy and momentum properties of the electromagnetic field are an essential part of the formulation of the theory and cannot properly be derived by “work done” arguments (iii) electromagnetic fields should not be thought of as being produced by charges; and (iv) at a fundamental level, the charged matter in classical electrodynamics must be viewed as continuously distributed rather than consisting of point charges. Many of these points cannot be fully explained until the later chapters in the book—particularly chapters 9 and 10—but my intent is to lay out these ideas in a sufficiently clear and explicit way in chapter 1 that I can take these perspectives unapologetically in the remainder of the book.

The topics treated in chapters 2–7 are ones that virtually would be covered in any graduate course in electromagnetism. Electrostatics is treated in chapter 2, but starting with Poisson’s equation, not Coulomb’s law. Dielectric materials and conductors are treated in chapter 3, with considerable care given to how the appropriate averaging is done and to the treatment of energy. Magnetostatics is treated in chapter 4, with a full discussion of the sign difference between magnetostatics and electrostatics in the field interaction energy of a dipole in an external field—and the difference in the change in the rest mass of a magnet when it is quasi-statically moved in an external magnetic field. Electrodynamics and radiation are discussed in depth in chapter 5. In addition to topics