

As seen on page The General Vector Radiative Transfer Equation of the previous chapter, radiative transfer theory rests on the theory of electromagnetism as expressed by Maxwell's equations. In spite of their fundamental importance to everything in optical oceanography and ocean remote sensing, most oceanography texts mention Maxwell's equations only in passing: a dozen or so pages in Apel (1987), two pages in Shifrin (1988), one paragraph in Walker (1994), and no mention at all in Neumann and Pierson (1966), Jerlov (1976) or Mobley (1994). Specialized, advanced texts like Bohren and Huffman (1983) and Mishchenko et al. (2002) make extensive use of Maxwell's equations, but with the assumption that the reader is already familiar with them. It thus seems fitting to present an overview of these equations at a level that minimizes the mathematics and physics but still gives a non-physicist reader some appreciation of these equations and their implications.

All of the discussion related to Maxwell's Equations is at Level 2. The first of this chapter's Level 2 pages introduces the basics of electric and magnetic fields and the mathematical notation needed for Maxwell's equations. The equations are then presented for electromagnetic fields in a vacuum. The next page then reformulates them for use in material media. The equations are then used to study the propagation of electromagnetic waves, i.e. light, in dielectrics like water. This development shows how the absorption coefficient arises from the decay with distance of the electric and magnetic fields of a plane wave propagating through matter. Two pages on dispersion follow—the first on the basic concepts of dispersion and the differences in phase and group speeds, and the second on anomalous dispersion. The discussion of anomalous dispersion ends with a brief statement of the Kramers-Kronig relations that show the intimate connection between the absorption coefficient and the real index of refraction. The solution of Maxwell's equations for a plane electromagnetic wave incident onto a homogeneous dielectric sphere, the so-called Mie theory, is then developed in three subsequent pages.