AN INTRODUCTION TO ELECTRODYNAMICS FROM THE STANDPOINT OF THE ELECTRON THEORY

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FROM THE STANDPOINT OF THE ELECTRON THEORY

BY

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PREFACE

The object of this book is to present a logical development of electromagnetic theory founded upon the principle of relativity. So far as the author is aware, the universal procedure has been to base the electrodynamic equations on the experimental conclusions of Coulomb, Ampère, and Faraday, even books on the principle of relativity going no farther than to show that these equations are covariant for the Lorentz-Einstein transformation. As the dependence of electromagnetism on the relativity principle is far more intimate than is suggested by this covariance, it has seemed more logical to derive the electrodynamic equations directly from this principle.

The analysis necessary for the development of the theory has been much simplified by the use of Gibbs' vector notation. While it is difficult for those familiar with the many conveniences of this notation to understand why it has not come into universal use among physicists, the belief that some readers might not be conversant with the symbols employed has led to the presentation in the Introduction of those elements of vector analysis which are made use of farther on in the text.

Chapter I contains a brief account of the principle of relativity. In the second chapter the retarded equations of the field of a point charge are derived from this principle, and in Chapter III the simultaneous field of a moving charge is discussed in some detail. In the next chapter the dynamical equation of the electron is obtained, and in Chapter V the general field equations are derived. Chapter VI takes up the radiation of energy from electrons, and Chapters VII and VIII contain some applications of the electromagnetic equations to material media, chosen as much for their illustration of the theory as for their fundamental importance. Throughout, great pains

have been taken to distinguish between definitions and assumptions, and to carry on the *physical* reasoning as rigorously as possible. It is hoped that the book may be found useful by those lecturers and students of electrodynamics who are looking for a logical rather than a historical account of the science. The subject matter covers topics appropriate for a one-year graduate course in electrodynamics and electromagnetic theory of light.

The author wishes to acknowledge his debt to those great thinkers, Maxwell, Poynting, Gibbs, Lorentz, Larmor, and Einstein, and to express his appreciation of the inspiration and unfailing interest of his former teacher, Professor H. A. Bumstead. His thanks are due his colleague, Professor H. S. Uhler, for many suggestions tending toward greater clearness of exposition.

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INTRODUCTION

ELEMENTS OF VECTOR ANALYSIS

Addition and multiplication. A *vector* is defined as a quantity which has both magnitude and direction. It will be designated by a letter in **blackface** type, its scalar magnitude being represented by the same letter in *italics*. Geometrically, a vector may be represented by an arrow having the direction of the vector and a length proportional to its magnitude. The beginning of this representative straight line is known as its *origin*, and the end, as its *terminus*. To add two vectors **P** and **Q** place the origin of **Q** at the terminus of **P**. Then the line drawn from the origin of **P** to the terminus of **Q** is defined as the sum of **P** and **Q**. To subtract **Q** from **P** reverse the direction of **Q** and add. The *components* of a vector are any vectors whose sum is equal to the original vector. Although, strictly speaking, the components of a vector are themselves vectors, the term component will often be used to denote the magnitude alone in cases where the direction has already been specified.

A vector is often determined by its components along three mutually perpendicular axes X, Y, Z. These axes will always be taken so as to constitute a right-handed set; that is, so that a right-handed screw parallel to the Z axis will advance along this axis when rotated from the X to the Y axis through the right angle between them. Let **i**, **j**, **k** be unit vectors parallel