

# Preface

The concept of fractional dimensional space is being effectively used in many areas of physics to describe the effective parameters of physical systems. Although the space, embedding things, in real world is three dimensional Euclidean space, the material objects are not always moving in three dimensional space. The dimensionality depends upon the restraint conditions. The phenomenon of electromagnetic wave propagation, radiation and scattering in fractal structures can be described by replacing these confining fractal structures with a  $D$ -dimensional fractional space. Thus, given this simple value of  $D$ , the real system can be modeled in a simple analytical way.

With this view, a theoretical investigation of electromagnetic fields and waves in fractional dimensional space is provided in this book which is useful to study the behavior of electromagnetic fields and waves in fractal media. A novel fractional space generalization of the differential electromagnetic equations is provided. A new form of vector differential operators is formulated in fractional space. Using these modified vector differential operators, the classical Maxwell's electromagnetic equations have been worked out. The Laplace's, Poisson's and Helmholtz's equations in fractional space are derived by using modified vector differential operators. A fractional space generalization of potentials for static and time-varying fields is presented by solving Laplace's equation and inhomogeneous vector wave equation, respectively, in fractional space. The phenomenon of electromagnetic wave propagation in fractional space is studied in detail by providing full analytical plane-, cylindrical- and spherical-wave solutions of the vector wave equation in  $D$ -dimensional fractional space. An analytical solution procedure for radiation problems in fractional space has also been proposed. As an application, the fields radiated by a Hertzian dipole in fractional space have been worked out. For all the investigated cases when integer dimensional space is considered, the classical results are recovered. The differential electromagnetic equations in fractional space, established in this book, provide a basis for application of the concept of fractional space in solving electromagnetic wave propagation, radiation and scattering problems in fractal media.

This book has been divided into six chapters. In [Chap. 2](#), a novel generalization of differential electromagnetic equations in fractional space is provided on the basis of modified vector differential operators for fractional space. A new form of vector differential operator  $\text{Del}$ , written as  $\nabla_D$ , and its related differential operators is formulated in fractional space. Using these modified vector differential operators, the classical Maxwell's electromagnetic equations have been worked out. The Laplace's, Poisson's and Helmholtz's equations in fractional space are also derived by using modified vector differential operators. Also a new fractional space generalization of potentials for static and time-varying fields is presented. Most of the work in later chapters is related to the solution of the established differential electromagnetic equations in fractional space.

In [Chap. 3](#), a fractional space generalization of potentials for static and time-varying fields is presented by solving Laplace's equation and inhomogeneous vector wave equation, respectively, in fractional space.

In [Chap. 4](#), the phenomenon of wave propagation in fractional space is investigated by solving Helmholtz's equation in different coordinate systems. General plane wave solutions, in source-free and lossless as well as lossy media, in fractional space are presented by solving vector wave equation in  $D$ -dimensional fractional space. An exact solution of cylindrical as well as spherical wave equation, for electromagnetic field in  $D$ -dimensional fractional space, is also presented. All these investigated solutions of vector wave equation provide a basis for the application of the concept of fractional space to the wave propagation phenomenon in fractal media. For all investigated cases when integer dimension is considered, the classical results were recovered to validate obtained results.

[Chapter 5](#) deals with the solution procedure for radiation problems in fractional space. The proposed solution procedure can be used to study the radiation phenomenon in any non-integer dimensional fractal media. As an application, the fields radiated by a Hertzian dipole in fractional space have been worked out. Finally, conclusions are drawn in [Chap. 6](#).

In summary, the subject covered in this book is relatively new and emerging area of research in the field of electromagnetics. The concept of fractional dimensional space has potential to make a significant impact on future directions in fractional electromagnetics research. We highly recommend this book to graduate students, researchers, and professionals working in the areas of electromagnetic-wave propagation, radiation, scattering, diffraction, and other related fields of applied mathematics. The topics in this book can also be covered in any graduate course on "Advanced Engineering Electromagnetics".

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