

## An introduction to multivectors, dyadics, and differential forms for electrical engineers

"The author is a true scholar with an unusual sense of time, place, and history. He is internationally well-known and respected. His knowledge of differential forms is equaled by only a tiny number of electromagnetic researchers, most of whom were associated with Professor Deschamps, either as colleagues or students. The presentation in this book is a true reflection of the author's grasp of the subject and his skills as a writer."

—Professor Donald G. Dudley, Editor, IEEE Press Series on Electromagnetic Wave Theory

"Professor Deschamps' goal of completing a monograph on differential forms and their applications to electromagnetics was never realized. I, like most of his students, fondly remember the excitement and challenges that his interest in differential forms brought to our lives. With the kind dedication of his book to Professor Deschamps and his expert presentation of this very mathematically challenging representation of electromagnetic phenomena, Professor Lindell nicely conveys those feelings to the reader."

—Professor Richard W. Ziolkowski, University of Arizona

While physicists have long applied differential forms to various areas of theoretical analysis, dyadic algebra is also the most natural language for expressing electromagnetic phenomena mathematically. George Deschamps pioneered the application of differential forms to electrical engineering but never completed his work. Now, Ismo V. Lindell, an internationally recognized authority on differential forms, provides a clear and practical introduction to replacing classical Gibbsian vector calculus with the mathematical formalism of differential forms.

In *Differential Forms in Electromagnetics*, Lindell simplifies the notation and adds memory aids in order to ease the reader's leap from Gibbsian analysis to differential forms, and provides the algebraic tools corresponding to the dyadics of Gibbsian analysis that have long been missing from the formalism. He introduces the reader to basic EM theory, and wave equations for the electromagnetic two-forms, discusses the derivation of useful identities, and explains novel ways of treating problems in general linear (bi-anisotropic) media.

Clearly written and devoid of unnecessary mathematical jargon, *Differential Forms in Electromagnetics* helps engineers master an area of intense interest for anyone involved in research on metamaterials.

ISMO V. LINDELL, PHD, is a professor of electromagnetic theory at the Helsinki University of Technology, Department of Electrical and Communication Engineering, where he was the founder of the Electromagnetics Laboratory in 1984. Dr. Lindell has received numerous awards, including recognition as an IEEE Fellow for his contributions to electromagnetic theory and for the development of education in electromagnetics in Finland. He is a member of URSI and IEEE, and is the recipient of the IEE Maxwell Premium for both 1997 and 1998, as well as the IEEE S. A. Schelkunoff Best Paper prize in 1987. In addition to two books in English, Dr. Lindell has authored or coauthored ten books in Finnish along with several hundred articles.



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Differential Forms in Electromagnetics

Lindell



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The IEEE Press Series on Electromagnetic Wave Theory  
Donald G. Dudley, Series Editor