Weak formulation of Maxwell's Equations

$$\int_{\Omega_{int}} \left\{ \left(\nabla \times \overline{\mathbf{\Phi}}\right) \cdot \left(\mu^{-1}\nabla \times \mathbf{E}\right) - \omega^2 \varepsilon \, \overline{\mathbf{\Phi}} \cdot \mathbf{E} \right\} d^3 r = \int_{\Gamma=\partial\Omega_{int}} \overline{\mathbf{\Phi}} \cdot \mathbf{F} d^2 r \, , \, \forall \mathbf{\Phi} \in V$$

define following bilinear and linear form:

$$a(\mathbf{w},\mathbf{v}) = \int_{\Omega_{int}} \left\{ \left(\nabla \times \overline{\mathbf{w}}\right) \cdot \left(\mu^{-1}\nabla \times \mathbf{v}\right) - \omega^2 \varepsilon \, \overline{\mathbf{w}} \cdot \mathbf{v} \right\} d^3 r$$

$$f(\mathbf{w}) = \int_{\Gamma} \overline{\mathbf{w}} \cdot \mathbf{F} d^2 r$$

weak formulation of Maxwell's equations:

Find $\mathbf{v} \in V = H\left(\text{curl},\Omega_{int}\right)$ such that

$$a(\mathbf{w},\mathbf{v}) = f(\mathbf{w}) \, , \, \forall \mathbf{w} \in V$$

discretization $\longrightarrow$

finite element space V_h

$$\dim V_h = N_h < \infty$$

Find $\mathbf{v} \in V_h \subset V$ such that

$$a(\mathbf{w},\mathbf{v}) = f(\mathbf{w}) \, , \, \forall \mathbf{w} \in V_h$$

Finite Element Methods For Maxwells Equations

P. Monk

Finite Element Methods For Maxwells Equations:

   Finite Element Methods for Maxwell's Equations Peter Monk,2003-04-17 Finite Element Methods For Maxwell s Equations is the first book to present the use of finite elements to analyse Maxwell s equations This book is part of the Numerical Analysis and Scientific Computation Series   *Finite Element Methods for Maxwells Equations* Peter Monk,2003   **Finite Element Methods for Maxwells Equations** Peter Monk,2003   **Time-Domain Finite Element Methods for Maxwell's Equations in Metamaterials** Jichun Li,Yunqing Huang,2012-12-15 The purpose of this book is to provide an up to date introduction to the time domain finite element methods for Maxwell s equations involving metamaterials Since the first successful construction of a metamaterial with both negative permittivity and permeability in 2000 the study of metamaterials has attracted significant attention from researchers across many disciplines Thanks to enormous efforts on the part of engineers and physicists metamaterials present great potential applications in antenna and radar design sub wavelength imaging and invisibility cloak design Hence the efficient simulation of electromagnetic phenomena in metamaterials has become a very important issue and is the subject of this book in which various metamaterial modeling equations are introduced and justified mathematically The development and practical implementation of edge finite element methods for metamaterial Maxwell s equations are the main focus of the book The book finishes with some interesting simulations such as backward wave propagation and time domain cloaking with metamaterials   Finite Element Methods for Maxwells Equations Peter Monk,2003   *The Finite Element Method for Electromagnetic Modeling* Gérard Meunier,2010-01-05 Written by specialists of modeling in electromagnetism this book provides a comprehensive review of the finite element method for low frequency applications Fundamentals of the method as well as new advances in the field are described in detail Chapters 1 to 4 present general 2D and 3D static and dynamic formulations by the use of scalar and vector unknowns and adapted interpolations for the fields nodal edge face or volume Chapter 5 is dedicated to the presentation of different macroscopic behavior laws of materials and their implementation in a finite element context anisotropy and hysteretic properties for magnetic sheets iron losses non linear permanent magnets and superconductors More specific formulations are then proposed the modeling of thin regions when finite elements become misfit Chapter 6 infinite domains by using geometrical transformations Chapter 7 the coupling of 2D and 3D formulations with circuit equations Chapter 8 taking into account the movement particularly in the presence of Eddy currents Chapter 9 and an original approach for the treatment of geometrical symmetries when the sources are not symmetric Chapter 10 Chapters 11 to 13 are devoted to coupled problems magneto thermal coupling for induction heating magneto mechanical coupling by introducing the notion of strong and weak coupling and magneto hydrodynamical coupling focusing on electromagnetic instabilities in fluid conductors Chapter 14 presents different meshing methods in the context of electromagnetism presence of air and introduces self adaptive mesh refinement procedures Optimization techniques are then covered in Chapter 15 with

the adaptation of deterministic and probabilistic methods to the numerical finite element environment Chapter 16 presents a variational approach of electromagnetism showing how Maxwell equations are derived from thermodynamic principles

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Ferrari,1996-09-05 Like the earlier editions this text begins by deriving finite elements for the simplest familiar potential fields then advances to formulate finite elements for a wide range of applied electromagnetics problems A wide selection of demonstration programs allows the reader to follow the practical use of the methods **Finite Element Methods for Maxwell's Equations** Kit Hung Chan,1999 Maxwell's Equations in Periodic Structures Gang Bao,Peijun Li,2021-11-22 This book addresses recent developments in mathematical analysis and computational methods for solving direct and inverse problems for Maxwell s equations in periodic structures The fundamental importance of the fields is clear since they are related to technology with significant applications in optics and electromagnetics The book provides both introductory materials and in depth discussion to the areas in diffractive optics that offer rich and challenging mathematical problems It is also intended to convey up to date results to students and researchers in applied and computational mathematics and engineering disciplines as well **Finite Element Methods For Maxwell'S Equations** P. Monk,2003 **Partial Differential Equations and the Finite Element Method** Pavel Ŝolín,2005-12-16 A systematic introduction to partial differential equations and modern finite element methods for their efficient numerical solution Partial Differential Equations and the Finite Element Method provides a much needed clear and systematic introduction to modern theory of partial differential equations PDEs and finite element methods FEM Both nodal and hierachic concepts of the FEM are examined Reflecting the growing complexity and multiscale nature of current engineering and scientific problems the author emphasizes higher order finite element methods such as the spectral or hp FEM A solid introduction to the theory of PDEs and FEM contained in Chapters 1 4 serves as the core and foundation of the publication Chapter 5 is devoted to modern higher order methods for the numerical solution of ordinary differential equations ODEs that arise in the semidiscretization of time dependent PDEs by the Method of Lines MOL Chapter 6 discusses fourth order PDEs rooted in the bending of elastic beams and plates and approximates their solution by means of higher order Hermite and Argyris elements Finally Chapter 7 introduces the reader to various PDEs governing computational electromagnetics and describes their finite element approximation including modern higher order edge elements for Maxwell s equations The understanding of many theoretical and practical aspects of both PDEs and FEM requires a solid knowledge of linear algebra and elementary functional analysis such as functions and linear operators in the Lebesgue Hilbert and Sobolev spaces These topics are discussed with the help of many illustrative examples in Appendix A which is provided as a service for those readers who need to gain the necessary background or require a refresher tutorial Appendix B presents several finite element computations rooted in practical engineering problems and demonstrates the benefits of using higher order FEM Numerous finite element algorithms are written out in detail alongside implementation discussions Exercises including many that involve programming the FEM are designed to assist the reader in solving typical problems in engineering and science Specifically designed as a coursebook this student tested publication is geared to upper level undergraduates and graduate students in all disciplines of

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