

Programing the Finite Element Method with Matlab

Jack Chessa

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1 Introduction

The goal of this document is to give a very brief overview and direction in the writing of finite element code using Matlab. It is assumed that the reader has a basic familiarity with the theory of the finite element method, and our attention will be mostly on the implementation. An example finite element code for analyzing static linear elastic problems written in Matlab is presented to illustrate how to program the finite element method. The example program and supporting files are available at <http://www.tam.northwestern.edu/jfc795/Matlab/>

1.1 Notation

For clarity we adopt the following notation in this paper; the bold italics font \mathbf{v} denotes a vector quantity of dimension equal to the spatial dimension of the problem i.e. the displacement or velocity at a point, the bold non-italicized font \mathbf{d} denotes a vector or matrix which is of dimension of the number of unknowns in the discrete system i.e. a system matrix like the stiffness matrix, an uppercase subscript denotes a node number whereas a lowercase subscript in general denotes a vector component along a Cartesian unit vector. So, if \mathbf{d} is the system vector of nodal unknowns, \mathbf{u}_i is a displacement vector of node i and u_{ij} is the component of the displacement at node i in the j direction, or u_{ij} etc. Often Matlab syntax will be intermixed with mathematical notation

Graduate Research Assistant, Northwestern University (j-chessa@northwestern.edu)

Programing The Finite Element Method With Matlab

Young W. Kwon, Hyochoong Bang



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The Finite Element Method Using MATLAB Young W. Kwon, Hyochoong Bang, 2018-10-03 Expanded to include a broader range of problems than the bestselling first edition Finite Element Method Using MATLAB Second Edition presents finite element approximation concepts formulation and programming in a format that effectively streamlines the learning process It is written from a general engineering and mathematical perspective rather than that of a solid structural mechanics basis What s new in the Second Edition Each chapter in the Second Edition now includes an overview that outlines the contents and purpose of each chapter The authors have also added a new chapter of special topics in applications including cracks semi infinite and infinite domains buckling and thermal stress They discuss three different linearization techniques to solve nonlinear differential equations Also included are new sections on shell formulations and MATLAB programs These enhancements increase the book s already significant value both as a self study text and a reference for practicing engineers and scientists

MATLAB and C Programming for Trefftz Finite Element Methods Qing-Hua Qin, Hui Wang, 2008-07-21 Although the Trefftz finite element method FEM has become a powerful computational tool in the analysis of plane elasticity thin and thick plate bending Poisson s equation heat conduction and piezoelectric materials there are few books that offer a comprehensive computer programming treatment of the subject Collecting results scattered in t

MATLAB-based Finite Element Programming in Electromagnetic Modeling Özlem Özgün, Mustafa Kuzuoğlu, 2018-09-03 This book is a self contained programming oriented and learner centered book on finite element method FEM with special emphasis given to developing MATLAB programs for numerical modeling of electromagnetic boundary value problems It provides a deep understanding and intuition of FEM programming by means of step by step MATLAB programs with detailed descriptions and eventually enabling the readers to modify adapt and apply the provided programs and formulations to develop FEM codes for similar problems through various exercises It starts with simple one dimensional static and time harmonic problems and extends the developed theory to more complex two or three dimensional problems It supplies sufficient theoretical background on the topic and it thoroughly covers all phases pre processing main body and post processing in FEM FEM formulations are obtained for boundary value problems governed by a partial differential equation that is expressed in terms of a generic unknown function and then these formulations are specialized to various electromagnetic applications together with a post processing phase Since the method is mostly described in a general context readers from other disciplines can also use this book and easily adapt the provided codes to their engineering problems After forming a solid background on the fundamentals of FEM by means of canonical problems readers are guided to more advanced applications of FEM in electromagnetics through a survey chapter at the end of the book Offers a self contained and easy to understand introduction to the theory and programming of finite element method Covers various applications in the field of static and time harmonic electromagnetics Includes one two and three dimensional finite element

codes in MATLAB Enables readers to develop finite element programming skills through various MATLAB codes and exercises Promotes self directed learning skills and provides an effective instruction tool

Introduction to the Finite Element Method Erik G. Thompson, 2004-02-04 This text presents an introduction to the finite element method including theory coding and applications The theory is presented without recourse to any specific discipline and the applications span a broad range of engineering problems The codes are written in MATLAB script in such a way that they are easily translated to other computer languages such as FORTRAN All codes given in the text are available for downloading from the text's Web page along with data files for running the test problems shown in the text All codes can be run on the student version of MATLAB not included

Computational Framework for the Finite Element Method in MATLAB® and Python Pavel Sumets, 2022-08-11 Computational Framework for the Finite Element Method in MATLAB and Python aims to provide a programming framework for coding linear FEM using matrix based MATLAB language and Python scripting language It describes FEM algorithm implementation in the most generic formulation so that it is possible to apply this algorithm to as many application problems as possible Readers can follow the step by step process of developing algorithms with clear explanations of its underlying mathematics and how to put it into MATLAB and Python code The content is focused on aspects of numerical methods and coding FEM rather than FEM mathematical analysis However basic mathematical formulations for numerical techniques which are needed to implement FEM are provided Particular attention is paid to an efficient programming style using sparse matrices Features Contains ready to use coding recipes allowing fast prototyping and solving of mathematical problems using FEM Suitable for upper level undergraduates and graduates in applied mathematics science or engineering Both MATLAB and Python programming codes are provided to give readers more flexibility in the practical framework implementation

Introduction to Finite Element Analysis Using MATLAB and Abaqus Amar Khennane, 2013-06-10 There are some books that target the theory of the finite element while others focus on the programming side of things Introduction to Finite Element Analysis Using MATLAB and Abaqus accomplishes both This book teaches the first principles of the finite element method It presents the theory of the finite element method while maintaining a balance

MATLAB Guide to Finite Elements Peter I. Kattan, 2013-04-17 This is a book for people who love finite elements and MATLAB I We will use the popular computer package MATLAB as a matrix calculator for doing finite element analysis Problems will be solved mainly using MATLAB to carry out the tedious and lengthy matrix calculations in addition to some manual manipulations especially when applying the boundary conditions In particular the steps of the finite element method are emphasized in this book The reader will not find ready made MATLAB programs for use as blackboxes Instead step by step solutions of finite element problems are examined in detail using MATLAB Problems from linear elastic structural mechanics are used throughout the book The emphasis is not on mass computation or programming but rather on learning the finite element method computations and understanding of the underlying concepts In addition to MATLAB the MATLAB

Symbolic Math Toolbox is used in Chapters 12, 13, and 14. Many types of finite elements are studied in this book including the spring element, the bar element, two-dimensional and three-dimensional truss elements, plane and space beam and frame elements, two-dimensional elasticity elements for plane stress and plane strain problems, and one three-dimensional solid element. Each chapter deals with only one type of element. Also, each chapter starts with a summary of the basic equations for the element, followed by a number of examples demonstrating the use of the element using the provided MATLAB functions. Special MATLAB functions for finite elements are provided as M-files on the accompanying CD-ROM to be used in the examples.

MATLAB-based Finite Element Programming in Electromagnetic Modeling Ozlem Ozgun, Mustafa Kuzuoglu, 2019

Practical Programming of Finite Element Procedures for Solids and Structures with MATLAB® Salar Farahmand-Tabar, Kian Aghani, 2023-09-22

Practical Programming of Finite Element Procedures for Solids and Structures with MATLAB From Elasticity to Plasticity provides readers with step by step programming processes and applications of the finite element method FEM in MATLAB as well as the underlying theory. The hands on approach covers a number of structural problems such as linear analysis of solids and structural elements as well as nonlinear subjects including elastoplasticity and hyperelasticity. Each chapter begins with foundational topics to provide a solid understanding of the subject, then progresses to more complicated problems with supporting examples for constructing the appropriate program. This book focuses on topics commonly encountered in civil mechanical and aerospace engineering. Special situations in structural analysis, 2D and 3D solids with various mesh elements, surface and body loading, incremental solution process, elastoplasticity and finite deformation hyperelastic analysis are covered. Code that can be implemented and further extended is also provided. Covers both theory and practice of the finite element method FEM. Hands on approach that provides a variety of both simple and complex problems for readers. Includes MATLAB codes that can be immediately implemented as well as extended by readers to improve their own FEM skills. Provides special cases of structural analysis, elastoplasticity and hyperelasticity problems.

The Finite Element Method Using MATLAB, Second Edition Young W. Kwon, Hyochoong Bang, 2000-07-28

Expanded to include a broader range of problems than the bestselling first edition. Finite Element Method Using MATLAB Second Edition presents finite element approximation, concepts, formulation, and programming in a format that effectively streamlines the learning process. It is written from a general engineering and mathematical perspective rather than that of a solid structural mechanics basis. What's new in the Second Edition: Each chapter in the Second Edition now includes an overview that outlines the contents and purpose of each chapter. The authors have also added a new chapter of special topics in applications including cracks, semi-infinite and infinite domains, buckling, and thermal stress. They discuss three different linearization techniques to solve nonlinear differential equations. Also included are new sections on shell formulations and MATLAB programs. These enhancements increase the book's already significant value both as a self-study text and a reference for practicing engineers and scientists.

Finite Element Method Using Young W. Kwon, Hyochoong

Bang,1996-08 The finite element method FEM has become one of the most important and useful tools for scientists and engineers This new book features the use of MATLAB to present introductory and advanced finite element theories and formulations MATLAB is especially convenient to write and understand finite element analysis programs because a MATLAB program manipulates matrices and vectors with ease The book is suitable for introductory and advanced courses in the Finite Element Method as well as a reference for practicing engineers *The Finite Element Method Using MATLAB* Young W. Kwon,Hyochoong Bang,1997 The finite element method FEM has become one of the most important and useful tools for scientists and engineers This new book features the use of MATLAB to present introductory and advanced finite element theories and formulations MATLAB is especially convenient to write and understand finite element analysis programs because a MATLAB program manipulates matrices and vectors with ease The book is suitable for introductory and advanced courses in the Finite Element Method as well as a reference for practicing engineers *The Finite Element Method in Engineering* Singiresu S. Rao,2017-10-31 The Finite Element Method in Engineering Sixth Edition provides a thorough grounding in the mathematical principles behind the Finite Element Analysis technique an analytical engineering tool originated in the 1960 s by the aerospace and nuclear power industries to find usable approximate solutions to problems with many complex variables Rao shows how to set up finite element solutions in civil mechanical and aerospace engineering applications The new edition features updated real world examples from MATLAB Ansys and Abaqus and a new chapter on additional FEM topics including extended FEM X FEM Professional engineers will benefit from the introduction to the many useful applications of finite element analysis Includes revised and updated chapters on MATLAB Ansys and Abaqus Offers a new chapter Additional Topics in Finite Element Method Includes discussion of practical considerations errors and pitfalls in FEM singularity elements Features a brief presentation of recent developments in FEM including extended FEM X FEM augmented FEM A FEM and partition of unity FEM POUFEM Features improved pedagogy including the addition of more design oriented and practical examples and problems Covers real life applications sample review questions at the end of most chapters and updated references **An Introduction to the Finite Element Method** Erik G. Thompson,2005

Introduction to the Finite Element Method and Implementation with MATLAB® Gang Li,2020-07-30 Connecting theory with numerical techniques using MATLAB this practical textbook equips students with the tools required to solve finite element problems This hands on guide covers a wide range of engineering problems through nine well structured chapters including solid mechanics heat transfer and fluid dynamics equilibrium steady state and transient and 1 D 2 D and 3 D problems Engineering problems are discussed using case study examples which are solved using a systematic approach both by examining the steps manually and by implementing a complete MATLAB code This topical coverage is supplemented by discourse on meshing with a detailed explanation and implementation of 2 D meshing algorithms Introducing theory and numerical techniques alongside comprehensive examples this text increases engagement and provides students with the

confidence needed to implement their own computer codes to solve given problems **MATLAB Codes for Finite Element Analysis** Antonio J. M. Ferreira, Nicholas Fantuzzi, 2020-06-16 This book illustrates how MATLAB compact and powerful programming framework can be very useful in the finite element analysis of solids and structures The book shortly introduces finite element concepts and an extensive list of MATLAB codes for readers to use and modify The book areas range from very simple springs and bars to more complex beams and plates in static bending free vibrations buckling and time transient problems Moreover laminated and functionally graded material structures are introduced and solved **Structural Analysis with the Finite Element Method. Linear Statics** Eugenio Oñate, 2010-02-25 STRUCTURAL ANALYSIS WITH THE FINITE ELEMENT METHOD Linear Statics Volume 1 The Basis and Solids Eugenio Oñate The two volumes of this book cover most of the theoretical and computational aspects of the linear static analysis of structures with the Finite Element Method FEM The content of the book is based on the lecture notes of a basic course on Structural Analysis with the FEM taught by the author at the Technical University of Catalonia UPC in Barcelona Spain for the last 30 years Volume 1 presents the basis of the FEM for structural analysis and a detailed description of the finite element formulation for axially loaded bars plane elasticity problems axisymmetric solids and general three dimensional solids Each chapter describes the background theory for each structural model considered details of the finite element formulation and guidelines for the application to structural engineering problems The book includes a chapter on miscellaneous topics such as treatment of inclined supports elastic foundations stress smoothing error estimation and adaptive mesh refinement techniques among others The text concludes with a chapter on the mesh generation and visualization of FEM results The book will be useful for students approaching the finite element analysis of structures for the first time as well as for practising engineers interested in the details of the formulation and performance of the different finite elements for practical structural analysis STRUCTURAL ANALYSIS WITH THE FINITE ELEMENT METHOD Linear Statics Volume 2 Beams Plates and Shells Eugenio Oñate The two volumes of this book cover most of the theoretical and computational aspects of the linear static analysis of structures with the Finite Element Method FEM The content of the book is based on the lecture notes of a basic course on Structural Analysis with the FEM taught by the author at the Technical University of Catalonia UPC in Barcelona Spain for the last 30 years Volume 2 presents a detailed description of the finite element formulation for analysis of slender and thick beams thin and thick plates folded plate structures axisymmetric shells general curved shells prismatic structures and three dimensional beams Each chapter describes the background theory for each structural model considered details of the finite element formulation and guidelines for the application to structural engineering problems Emphasis is put on the treatment of structures with layered composite materials The book will be useful for students approaching the finite element analysis of beam plate and shell structures for the first time as well as for practising engineers interested in the details of the formulation and performance of the different finite elements for practical structural analysis *The Finite Element Method:*

Its Basis and Fundamentals O. C. Zienkiewicz, R. L. Taylor, J. Z. Zhu, 2005-05-26 The Sixth Edition of this influential best selling book delivers the most up to date and comprehensive text and reference yet on the basis of the finite element method FEM for all engineers and mathematicians Since the appearance of the first edition 38 years ago The Finite Element Method provides arguably the most authoritative introductory text to the method covering the latest developments and approaches in this dynamic subject and is amply supplemented by exercises worked solutions and computer algorithms The classic FEM text written by the subject's leading authors Enhancements include more worked examples and exercises With a new chapter on automatic mesh generation and added materials on shape function development and the use of higher order elements in solving elasticity and field problems Active research has shaped The Finite Element Method into the pre eminent tool for the modelling of physical systems It maintains the comprehensive style of earlier editions while presenting the systematic development for the solution of problems modelled by linear differential equations Together with the second and third self contained volumes 0750663219 and 0750663227 The Finite Element Method Set 0750664312 provides a formidable resource covering the theory and the application of FEM including the basis of the method its application to advanced solid and structural mechanics and to computational fluid dynamics The classic introduction to the finite element method by two of the subject's leading authors Any professional or student of engineering involved in understanding the computational modelling of physical systems will inevitably use the techniques in this key text **Applied Mechanics Reviews**, 1997

Programming Phase-Field Modeling S. Bulent Biner, 2017-01-25 This textbook provides a fast track pathway to numerical implementation of phase field modeling a relatively new paradigm that has become the method of choice for modeling and simulation of microstructure evolution in materials It serves as a cookbook for the phase field method by presenting a collection of codes that act as foundations and templates for developing other models with more complexity Programming Phase Field Modeling uses the Matlab Octave programming package simpler and more compact than other high level programming languages providing ease of use to the widest audience Particular attention is devoted to the computational efficiency and clarity during development of the codes which allows the reader to easily make the connection between the mathematical formalism and the numerical implementation of phase field models The background materials provided in each case study also provide a forum for undergraduate level modeling simulations courses as part of their curriculum

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