Iterative Solution Of Nonlinear Equations In Several Variables Computer Science Applied Mathematics Monograph

This book serves as a set of lecture notes for a senior undergraduate level course on the introduction to numerical computation, which was developed through 4 semesters of teaching the course over 10 years. The book requires minimum background knowledge from the students, including only a three-semester of calculus, and a bit on matrices.The book covers many of the introductory topics for a first course in numerical computation, which fits in the short time frame of a semester course. Topics range from polynomial approximations and interpolation, to numerical methods for ODEs and PDEs. Emphasis was made more on algorithm development, basic mathematical ideas behind the algorithms, and the implementation in Matlab.The book is supplemented by two sets of videos, available through the author's YouTube channel. Homework problem sets are provided for each chapter, and complete answer sets are available for instructors upon request.The second edition contains a set of selected advanced topics, written in a self-contained manner, suitable for self-learning or as additional material for an honored version of the course. Videos are also available for these added topics.
A Contemporary Study of Iterative Methods: Convergence, Dynamics and Applications evaluates and compares advances in iterative techniques, also discussing their numerous applications in applied mathematics, engineering, mathematical economics, mathematical biology and other applied sciences. It uses the popular iteration technique in generating the approximate solutions of complex nonlinear equations that is suitable for aiding in the solution of advanced problems in engineering, mathematical economics, mathematical biology and other applied sciences. Iteration methods are also applied for solving optimization problems. In such cases, the iteration sequences converge to an optimal solution of the problem at hand. Contains recent results on the convergence analysis of numerical algorithms in both finite-dimensional and infinite-dimensional spaces Encompasses the novel tool of dynamic analysis for iterative methods, including new developments in Smale stability theory and polynomiography Explores the uses of computation of iterative methods across non-linear analysis Uniquely places discussion of derivative-free methods in context of other discoveries, aiding comparison and contrast between options
Linear and nonlinear systems of equations are the basis for many, if not most, of the models of phenomena in science and engineering, and their efficient numerical solution is critical to progress in these areas. This is the first book to be published on nonlinear equations since the mid-1980s. Although it stresses recent developments in this area, such as Newton-Krylov methods, considerable material on linear equations has been incorporated. This book focuses on a small number of methods and treats them in depth. The author provides a complete analysis of the conjugate gradient and generalized minimum residual iterations as well as recent advances including Newton-Krylov methods, incorporation of inexactness and noise into the analysis, new proofs and implementations of Broyden's method, and globalization of inexact Newton methods. Examples, methods, and algorithmic choices are based on applications to infinite dimensional problems such as partial differential equations and integral

equations. The analysis and proof techniques are constructed with the infinite dimensional setting in mind and the computational examples and exercises are based on the MATLAB environment.

From the Preface (1964): ``This book presents a general theory of iteration algorithms for the numerical solution of equations and systems of equations. The relationship between the quantity and the quality of information used by an algorithm and the efficiency of the algorithm is investigated. Iteration functions are divided into four classes depending on whether they use new information at one or at several points and whether or not they reuse old information. Known iteration functions are systematized and new classes of computationally effective iteration functions are introduced. Our interest in the efficient use of information is influenced by the widespread use of computing machines ... The mathematical foundations of our subject are treated with rigor, but rigor in itself is not the main object. Some of the material is of wider application ... Most of the material is new and unpublished. Every attempt has been made to keep the subject in proper historical perspective ... ''

Mathematics of Computing -- General.

Numerical Solution of Systems of Nonlinear Algebraic Equations contains invited lectures of the NSF-CBMS Regional Conference on the Numerical Solution of Nonlinear Algebraic Systems with Applications to Problems in Physics, Engineering and Economics, held on July 10-14, 1972. This book is composed of 10 chapters and begins with the concepts of nonlinear algebraic equations in continuum mechanics. The succeeding chapters deal with the numerical solution of quasilinear elliptic equations, the nonlinear systems in semi-infinite programming, and the solution of large systems of linear algebraic equations. These topics are followed by a survey of some computational techniques for the nonlinear least squares problem. The remaining chapters explore the problem of nonlinear functional minimization, the modification methods, and the computer-oriented algorithms for solving system. These chapters also examine the principles of contractor theory of solving equations. This book will prove useful to undergraduate and graduate students.

This book focuses on the approximation of nonlinear equations using iterative methods. Nine contributions are presented on the construction and analysis of these methods, the coverage encompassing convergence, efficiency, robustness, dynamics, and applications. Many problems are stated in the form of nonlinear equations, using mathematical modeling. In particular, a wide range of problems in Applied Mathematics and in Engineering can be solved by finding the solutions to these equations. The book reveals the importance of studying convergence aspects in iterative methods and shows that selection of the most efficient and robust iterative method for a given problem is crucial to guaranteeing a good approximation. A number of sample criteria for selecting the optimal method are presented, including those regarding the order of convergence, the computational cost, and the stability, including the dynamics. This book will appeal to researchers whose field of interest is related to nonlinear problems and equations, and their approximation.

This book presents computer programming as a key method for solving mathematical problems. There are two versions of the book, one for MATLAB and one for Python. The book was inspired by the Springer book TCSE 6: A Primer on Scientific Programming with Python (by Langtangen), but the style is more accessible and concise, in keeping with the needs of

engineering students. The book outlines the shortest possible path from no previous experience with programming to a set of skills that allows the students to write simple programs for solving common mathematical problems with numerical methods in engineering and science courses. The emphasis is on generic algorithms, clean design of programs, use of functions, and automatic tests for verification.

This book deals with the efficient numerical solution of challenging nonlinear problems in science and engineering, both in finite dimension (algebraic systems) and in infinite dimension (ordinary and partial differential equations). Its focus is on local and global Newton methods for direct problems or Gauss-Newton methods for inverse problems. The term 'affine invariance' means that the presented algorithms and their convergence analysis are invariant under one out of four subclasses of affine transformations of the problem to be solved. Compared to traditional textbooks, the distinguishing affine invariance approach leads to shorter theorems and proofs and permits the construction of fully adaptive algorithms. Lots of numerical illustrations, comparison tables, and exercises make the text useful in computational mathematics classes. At the same time, the book opens many directions for possible future research.

This textbook provides a detailed description of operation problems in power systems, including power system modeling, power system steady-state operations, power system state estimation, and electricity markets. The book provides an appropriate blend of theoretical background and practical applications, which are developed as working algorithms, coded in Octave (or Matlab) and GAMS environments. This feature strengthens the usefulness of the book for both students and practitioners. Students will gain an insightful understanding of current power system operation problems in engineering, including: (i) the formulation of decision-making models, (ii) the familiarization with efficient solution algorithms for such models, and (iii) insights into these problems through the detailed analysis of numerous illustrative examples. The authors use a modern, "building-block" approach to solving complex problems, making the topic accessible to students with limited background in power systems. Solved examples are used to introduce new concepts and each chapter ends with a set of exercises.

Mathematics of Computing -- Numerical Analysis.

Contains trouble-shooting guides to the major algorithms for Newton's method, their common failure modes, and the likely causes of failure.

Examines numerical and semi-analytical methods for differential equations that can be used for solving practical ODEs and PDEs This student-friendly book deals with various approaches for solving differential equations numerically or semi-analytically depending on the type of equations and offers simple example problems to help readers along. Featuring both traditional and recent methods, Advanced Numerical and Semi Analytical Methods for Differential Equations begins with a review of basic numerical methods. It then looks at Laplace, Fourier, and weighted residual methods for solving differential equations. A new challenging method of Boundary Characteristics Orthogonal Polynomials (BCOPs) is introduced next. The book then discusses Finite Difference Method (FDM), Finite Element Method (FEM), Finite Volume Method (FVM), and Boundary Element Method (BEM). Following that, analytical/semi analytic methods like Akbari Ganji's Method (AGM) and Exp-function are used to solve nonlinear differential equations. Nonlinear differential equations using semi-analytical methods are also addressed, namely Adomian Decomposition Method (ADM), Homotopy Perturbation Method (HPM), Variational Iteration Method (VIM), and Homotopy Analysis Method (HAM). Other topics covered include: emerging areas of research related to the solution of differential equations based on differential quadrature and wavelet approach; combined and hybrid methods for solving differential equations; as well as an overview of fractal differential equations. Further, uncertainty in term of intervals and fuzzy numbers have also been

included, along with the interval finite element method. This book: Discusses various methods for solving linear and nonlinear ODEs and PDEs Covers basic numerical techniques for solving differential equations along with various discretization methods Investigates nonlinear differential equations using semi-analytical methods Examines differential equations in an uncertain environment Includes a new scenario in which uncertainty (in term of intervals and fuzzy numbers) has been included in differential equations Contains solved example problems, as well as some unsolved problems for self-validation of the topics covered Advanced Numerical and Semi Analytical Methods for Differential Equations is an excellent text for graduate as well as post graduate students and researchers studying various methods for solving differential equations, numerically and semi-analytically.

""Providing the theoretical framework to model phenomena with discontinuous changes, this unique reference presents a generalized monotone iterative method in terms of upper and lower solutions appropriate for the study of discontinuous nonlinear differential equations and applies this method to derive suitable fixed point theorems in ordered abstract spaces.

This second edition provides much-needed updates to the original volume. Like the first edition, it emphasizes the ideas behind the algorithms as well as their theoretical foundations and properties, rather than focusing strictly on computational details; at the same time, this new version is now largely self-contained and includes essential proofs. Additions have been made to almost every chapter, including an introduction to the theory of inexact Newton methods, a basic theory of continuation methods in the setting of differentiable manifolds, and an expanded discussion of minimization methods. New information on parametrized equations and continuation incorporates research since the first edition.

Iterative Solution of Nonlinear Equations in Several VariablesElsevier

This book presents a carefully selected group of methods for unconstrained and bound constrained optimization problems and analyzes them in depth both theoretically and algorithmically. It focuses on clarity in algorithmic description and analysis rather than generality, and while it provides pointers to the literature for the most general theoretical results and robust software, the author thinks it is more important that readers have a complete understanding of special cases that convey essential ideas. A companion to Kelley's book, Iterative Methods for Linear and Nonlinear Equations (SIAM, 1995), this book contains many exercises and examples and can be used as a text, a tutorial for self-study, or a reference. Iterative Methods for Optimization does more than cover traditional gradient-based optimization: it is the first book to treat sampling methods, including the Hooke-Jeeves, implicit filtering, MDS, and Nelder-Mead schemes in a unified way, and also the first book to make connections between sampling methods and the traditional gradient-methods. Each of the main algorithms in the text is described in pseudocode, and a collection of MATLAB codes is available. Thus, readers can experiment with the algorithms in an easy way as well as implement them in other languages.

This book, written by two experts in the field, deals with classes of iterative methods for the approximate solution of fixed points equations for operators satisfying a special contractivity condition, the Fejer property. The book is elementary, self-contained and uses methods from functional analysis, with a special focus on the construction of iterative schemes. Applications to parallelization, randomization and linear programming are also considered."

There are many books on the use of numerical methods for solving engineering problems and for modeling of engineering artifacts. In addition there are many styles of such presentations ranging from books with a major emphasis on theory to books with an emphasis on applications. The purpose of this book is hopefully to present a somewhat different approach to the use of numerical methods for - gineering applications. Engineering models are in general nonlinear models where the response of some appropriate engineering variable depends in a nonlinear manner on the - plication of some independent parameter. It is certainly true that for

many types of engineering models it is sufficient to approximate the real physical world by some linear model. However, when engineering environments are pushed to - treme conditions, nonlinear effects are always encountered. It is also such - treme conditions that are of major importance in determining the reliability or failure limits of engineering systems. Hence it is essential than engineers have a toolbox of modeling techniques that can be used to model nonlinear engineering systems. Such a set of basic numerical methods is the topic of this book. For each subject area treated, nonlinear models are incorporated into the discussion from the very beginning and linear models are simply treated as special cases of more general nonlinear models. This is a basic and fundamental difference in this book from most books on numerical methods.

The book presents in comprehensive detail numerical solutions to boundary value problems of a number of non-linear differential equations. Replacing derivatives by finite difference approximations in these differential equations leads to a system of non-linear algebraic equations which we have solved using Newton's iterative method. In each case, we have also obtained Euler solutions and ascertained that the iterations converge to Euler solutions. We find that, except for the boundary values, initial values of the 1st iteration need not be anything close to the final convergent values of the numerical solution. Programs in Mathematica 6.0 were written to obtain the numerical solutions.

A cohesive and comprehensive account of the modern theory of iterative functional equations. Many of the results included have appeared before only in research literature, making this an essential volume for all those working in functional equations and in such areas as dynamical systems and chaos, to which the theory is closely related. The authors introduce the reader to the theory and then explore the most recent developments and general results. Fundamental notions such as the existence and uniqueness of solutions to the equations are stressed throughout, as are applications of the theory to such areas as branching processes, differential equations, ergodic theory, functional analysis and geometry. Other topics covered include systems of linear and nonlinear equations of finite and infinite ORD various function classes, conjugate and commutable functions, linearization, iterative roots of functions, and special functional equations.

C. F. GauS in a letter from Dec. 26, 1823 to Gerling: 3c~ empfe~le 3~nen biegen IDlobu9 aur 9tac~a~mung. ec~werlic~ werben eie ie wieber bi reet eliminiren, wenigftens nic~t, wenn eie me~r als 2 Unbefannte ~aben. :Da9 inbirecte 93erfa~ren 109st sic~ ~alb im ec~lafe ausfii~ren, ober man fann wo~renb be9gelben an anbere :Dinge benfen. [CO F. GauS: Werke vol. 9, Gottingen, p. 280, 1903] What difference exists between solving large and small systems of equations? The standard methods well-known to any student of linear algebra are appli cable to all systems, whether large or small. The necessary amount of work, however, increases dramatically with the size, so one has to search for algo rithms that most efficiently and accurately solve systems of 1000, 10,000, or even one million equations. The choice of algorithms depends on the special properties the matrices in practice have. An important class of large systems arises from the discretisation of partial differential equations. In this case, the matrices are sparse (i. e. , they contain mostly zeros) and well-suited to iterative algorithms. Because of the background in partial differential equa tions, this book is closely connected with the author's Theory and Numerical Treatment of Elliptic Differential Equations, whose English translation has also been published by Springer-Verlag. This book grew out of a series of lectures given by the author at

the Christian-Albrecht University of Kiel to students of mathematics.

This book explores mathematics in a wide variety of applications, ranging from problems in electronics, energy and the environment, to mechanics and mechatronics. The book gathers 81 contributions submitted to the 20th European Conference on Mathematics for Industry, ECMI 2018, which was held in Budapest, Hungary in June 2018. The application areas include: Applied Physics, Biology and Medicine, Cybersecurity, Data Science, Economics, Finance and Insurance, Energy, Production Systems, Social Challenges, and Vehicles and Transportation. In turn, the mathematical technologies discussed include: Combinatorial Optimization, Cooperative Games, Delay Differential Equations, Finite Elements, Hamilton-Jacobi Equations, Impulsive Control, Information Theory and Statistics, Inverse Problems, Machine Learning, Point Processes, Reaction-Diffusion Equations, Risk Processes, Scheduling Theory, Semidefinite Programming, Stochastic Approximation, Spatial Processes, System Identification, and Wavelets. The goal of the European Consortium for Mathematics in Industry (ECMI) conference series is to promote interaction between academia and industry, leading to innovations in both fields. These events have attracted leading experts from business, science and academia, and have promoted the application of novel mathematical technologies to industry. They have also encouraged industrial sectors to share challenging problems where mathematicians can provide fresh insights and perspectives. Lastly, the ECMI conferences are one of the main forums in which significant advances in industrial mathematics are presented, bringing together prominent figures from business, science and academia to promote the use of innovative mathematics in industry.

This book is published open access under a CC BY 4.0 license. This book presents computer programming as a key method for solving mathematical problems. This second edition of the well-received book has been extensively revised: All code is now written in Python version 3.6 (no longer version 2.7). In addition, the two first chapters of the previous edition have been extended and split up into five new chapters, thus expanding the introduction to programming from 50 to 150 pages. Throughout the book, the explanations provided are now more detailed, previous examples have been modified, and new sections, examples and exercises have been added. Also, a number of small errors have been corrected. The book was inspired by the Springer book TCSE 6: A Primer on Scientific Programming with Python (by Langtangen), but the style employed is more accessible and concise, in keeping with the needs of engineering students. The book outlines the shortest possible path from no previous experience with programming to a set of skills that allows students to write simple programs for solving common mathematical problems with numerical methods in the context of engineering and science courses. The emphasis is on generic algorithms, clean program design, the use of functions, and automatic tests for verification.

Solving nonlinear equations in Banach spaces (real or complex nonlinear equations, nonlinear systems, and nonlinear matrix equations, among others), is a non-trivial task that involves many areas of science and technology. Usually the solution is not directly affordable and require an approach using iterative algorithms. This Special Issue focuses mainly on the design, analysis of convergence, and stability of new schemes for solving nonlinear problems and their application to practical problems. Included papers study the following topics: Methods for finding simple or multiple roots either with or without derivatives, iterative methods for approximating different generalized inverses, real or complex dynamics associated to the rational functions resulting from the application of an iterative method on a polynomial. Additionally, the analysis of the convergence has been carried out by means of different sufficient conditions assuring the local, semilocal, or global convergence. This Special issue has allowed us to present the latest research results in the area of iterative processes for solving nonlinear equations as well as systems and matrix equations. In addition to the theoretical papers, several manuscripts on signal processing, nonlinear integral equations, or partial differential equations, reveal the connection between iterative methods and other branches of science and engineering.

This book is the first on the topic and explains the most cutting-edge methods needed for precise calculations and explores the development of powerful algorithms to solve research problems. Multipoint methods have an extensive range of practical applications significant in research areas such as signal processing, analysis of convergence rate, fluid mechanics, solid state physics, and many others. The book takes an introductory approach in making qualitative comparisons of different multipoint methods from various viewpoints to help the reader understand applications of more complex methods. Evaluations are made to determine and predict efficiency and accuracy of presented models useful to wide a range of research areas along with many numerical examples for a deep understanding of the usefulness of each method. This book will make it possible for the researchers to tackle difficult problems and deepen their understanding of problem solving using numerical methods. Multipoint methods are of great practical importance, as they determine sequences of successive approximations for evaluative purposes. This is especially helpful in achieving the highest computational efficiency. The rapid development of digital computers and advanced computer arithmetic have provided a need for new methods useful to solving practical problems in a multitude of disciplines such as applied mathematics, computer science, engineering, physics, financial mathematics, and biology. Provides a succinct way of implementing a wide range of useful and important numerical algorithms for solving research problems Illustrates how numerical methods can be used to study problems which have applications in engineering and sciences, including signal processing, and control theory, and financial computation Facilitates a deeper insight into the development of

methods, numerical analysis of convergence rate, and very detailed analysis of computational efficiency Provides a powerful means of learning by systematic experimentation with some of the many fascinating problems in science Includes highly efficient algorithms convenient for the implementation into the most common computer algebra systems such as Mathematica, MatLab, and Maple This book is open access under a CC BY 4.0 license. This easy-to-read book introduces the basics of solving partial differential equations by means of finite difference methods. Unlike many of the traditional academic works on the topic, this book was written for practitioners. Accordingly, it especially addresses: the construction of finite difference schemes, formulation and implementation of algorithms, verification of implementations, analyses of physical behavior as implied by the numerical solutions, and how to apply the methods and software to solve problems in the fields of physics and biology.

Provides a compendium of applied aspects of ordering and selection procedures. Computer Science and Applied Mathematics: Iterative Solution of Nonlinear Equations in Several Variables presents a survey of the basic theoretical results about nonlinear equations in n dimensions and analysis of the major iterative methods for their numerical solution. This book discusses the gradient mappings and minimization, contractions and the continuation property, and degree of a mapping. The general iterative and minimization methods, rates of convergence, and one-step stationary and multistep methods are also elaborated. This text likewise covers the contractions and nonlinear majorants, convergence under partial ordering, and convergence of minimization methods. This publication is a good reference for specialists and readers with an extensive functional analysis background.

This book differs from traditional numerical analysis texts in that it focuses on the motivation and ideas behind the algorithms presented rather than on detailed analyses of them. It presents a broad overview of methods and software for solving mathematical problems arising in computational modeling and data analysis, including proper problem formulation, selection of effective solution algorithms, and interpretation of results.? In the 20 years since its original publication, the modern, fundamental perspective of this book has aged well, and it continues to be used in the classroom. This Classics edition has been updated to include pointers to Python software and the Chebfun package, expansions on barycentric formulation for Lagrange polynomial interpretation and stochastic methods, and the availability of about 100 interactive educational modules that dynamically illustrate the concepts and algorithms in the book. Scientific Computing: An Introductory Survey, Second Edition is intended as both a textbook and a reference for computationally oriented disciplines that need to solve mathematical problems.

An introduction into numerical analysis for students in mathematics, physics, and engineering. Instead of attempting to exhaustively cover everything, the goal is to guide readers towards the basic ideas and general principles by way of the main and important numerical methods. The book includes the necessary basic functional analytic tools for the solid mathematical foundation of numerical analysis -- indispensable for any deeper study and understanding of numerical methods, in particular, for differential equations and integral equations. The text is presented in a

concise and easily understandable fashion so as to be successfully mastered in a one-year course.

This easy-to-understand textbook presents a modern approach to learning numerical methods (or scientific computing), with a unique focus on the modeling and applications of the mathematical content. Emphasis is placed on the need for, and methods of, scientific computing for a range of different types of problems, supplying the evidence and justification to motivate the reader. Practical guidance on coding the methods is also provided, through simple-to-follow examples using Python. Topics and features: provides an accessible and applications-oriented approach, supported by working Python code for many of the methods; encourages both problem- and project-based learning through extensive examples, exercises, and projects drawn from practical applications; introduces the main concepts in modeling, python programming, number representation, and errors; explains the essential details of numerical calculus, linear, and nonlinear equations, including the multivariable Newton method; discusses interpolation and the numerical solution of differential equations, covering polynomial interpolation, splines, and the Euler, Runge–Kutta, and shooting methods; presents largely self-contained chapters, arranged in a logical order suitable for an introductory course on scientific computing. Undergraduate students embarking on a first course on numerical methods or scientific computing will find this textbook to be an invaluable guide to the field, and to the application of these methods across such varied disciplines as computer science, engineering, mathematics, economics, the physical sciences, and social science.