

Numerische Methoden

Lösungsvorschläge zur Modulprüfung

Aufgabe 1 (10 + 10 = 20 Punkte)

Gegeben seien

$$\text{die Matrix } A = \begin{pmatrix} 4 & 0 & 14 \\ 0 & 9 & 27 \\ 14 & 27 & 251 \end{pmatrix} \text{ und der Vektor } b = \begin{pmatrix} 210 \\ 477 \\ 3981 \end{pmatrix}.$$

(a) Bestimmen Sie die Cholesky-Zerlegung der Matrix A .

(b) Lösen Sie mithilfe der in (a) bestimmten Cholesky-Zerlegung das lineare Gleichungssystem $Ax = b$.

Lösung von Aufgabe 1

(a) Wir gehen Schrittwiese vor wie in Algorithmus 1.20. Zu berechnen ist die Matrix

$$L = \begin{pmatrix} l_{11} & 0 & 0 \\ l_{21} & l_{22} & 0 \\ l_{31} & l_{32} & l_{33} \end{pmatrix}.$$

Schritt 1. $i = 1$: Hier haben wir nur

$$l_{11} = \sqrt{a_{11}} = \sqrt{4} = 2.$$

Damit haben wir die Matrix

$$L = \begin{pmatrix} 2 & 0 & 0 \\ l_{21} & l_{22} & 0 \\ l_{31} & l_{32} & l_{33} \end{pmatrix}.$$

Schritt 2. $i = 2$: Hier berechnen wir

$$l_{21} = \frac{a_{21}}{l_{11}} = \frac{0}{2} = 0, \quad l_{22} = \sqrt{a_{22} - |l_{21}|^2} = \sqrt{9 - 0^2} = \sqrt{9 - 0} = \sqrt{9} = 3,$$

$$l_{31} = \frac{a_{31}}{l_{11}} = \frac{14}{2} = 7.$$

Damit haben wir die Matrix

$$L = \begin{pmatrix} 2 & 0 & 0 \\ 0 & 3 & 0 \\ 7 & l_{32} & l_{33} \end{pmatrix}.$$

Schritt 3. $i = 3$: Hier berechnen wir

$$l_{32} = \frac{1}{l_{22}} (a_{32} - l_{31}l_{21}) = \frac{1}{3} (27 - 7 \cdot 0) = \frac{27 - 7 \cdot 0}{3} = \frac{27 - 0}{3} = \frac{27}{3} = 9,$$

$$l_{33} = \sqrt{a_{33} - |l_{31}|^2 - |l_{32}|^2} = \sqrt{251 - 7^2 - 9^2} = \sqrt{251 - 49 - 81} = \sqrt{121} = 11.$$

Damit haben wir die Matrix

$$L = \begin{pmatrix} 2 & 0 & 0 \\ 0 & 3 & 0 \\ 7 & 9 & 11 \end{pmatrix} \in \mathbb{R}^{3 \times 3}$$

mit

$$A = LL^H = LL^T.$$

Numerische Methoden 1

**Prof. Dr. Juergen Nitsch, Dr. Frank
Gronwald, Prof. Dr. Gunter Wollenberg**

Numerische Methoden 1:

Konstruktive Methoden der finiten nichtlinearen Optimierung Günther Meinardus, Wolfgang Wetterling, 1980

Methods of Numerical Integration Philip J. Davis, Philip Rabinowitz, 2014-05-10 *Methods of Numerical Integration* Second Edition describes the theoretical and practical aspects of major methods of numerical integration Numerical integration is the study of how the numerical value of an integral can be found This book contains six chapters and begins with a discussion of the basic principles and limitations of numerical integration The succeeding chapters present the approximate integration rules and formulas over finite and infinite intervals These topics are followed by a review of error analysis and estimation as well as the application of functional analysis to numerical integration A chapter describes the approximate integration in two or more dimensions The final chapter looks into the goals and processes of automatic integration with particular attention to the application of Tschebyscheff polynomials This book will be of great value to theoreticians and computer programmers

One-Dimensional Finite Elements Markus Merkel, Andreas Öchsner, 2023-12-28 The basic idea of this introduction to the finite element method is based on the concept of explaining the complex method using only one dimensional elements Thus the mathematical description remains largely simple and straightforward The emphasis in each chapter is on explaining the method and understanding it itself The reader learns to understand the assumptions and derivations in various physical problems in structural mechanics and to critically assess the possibilities and limitations of the finite element method The restriction to one dimensional elements thus enables the methodical understanding of important topics e g plasticity or composite materials which a prospective computational engineer encounters in professional practice but which are rarely treated in this form at universities Thus an easy entry also into more advanced application areas is ensured by the concept of a introduction to the basics b exact derivation with restriction to one dimensional elements and in many cases also to one dimensional problems c extensive examples and advanced tasks with short solution in the appendix For illustration purposes each chapter is deepened with extensively calculated and commented examples as well as with further tasks including short solutions

Integer Programming and Related Areas A Classified Bibliography 1976-1978 D. Hausmann, 2012-12-06

Bifurcation Problems and their Numerical Solution H. D. Mittelman, H. Weber, 1980 *Zeitschrift für Angewandte Mathematik und Mechanik. Volume 69, Number 9* H. Heinrich, G. Schmid, 2022-03-21 No detailed description available for Z ANGEW MATH MECH BD 69 9 ZAMM E BOOK

Non-Linear Parametric Optimization BANK, GUDDAT, KLATTE, KUMMER, TAMMER, 2013-12-21 1985 H. Heinrich, G. Schmid, 2022-02-07 No detailed description available for 1985

Integer Programming and Related Areas R.v. Randow, 2012-12-06 **Introduction to SIMULA 67** Lamprecht Günther, 2013-04-17

Iterative Solution of Large Sparse Systems of Equations Wolfgang Hackbusch, 2016-06-21 In the second edition of this classic monograph complete with four new chapters and updated references readers will now have access to content describing and analysing classical and modern methods with emphasis on

the algebraic structure of linear iteration which is usually ignored in other literature The necessary amount of work increases dramatically with the size of systems so one has to search for algorithms that most efficiently and accurately solve systems of e g several 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 discretization of partial differential equations In this case the matrices are sparse i e they contain mostly zeroes and well suited to iterative algorithms The first edition of this book grew out of a series of lectures given by the author at the Christian Albrecht University of Kiel to students of mathematics The second edition includes quite novel approaches

One-Dimensional Finite Elements Andreas Öchsner, Markus Merkel, 2018-04-25 This textbook presents finite element methods using exclusively one dimensional elements It presents the complex methodology in an easily understandable but mathematically correct fashion The approach of one dimensional elements enables the reader to focus on the understanding of the principles of basic and advanced mechanical problems The reader will easily understand the assumptions and limitations of mechanical modeling as well as the underlying physics without struggling with complex mathematics Although the description is easy it remains scientifically correct The approach using only one dimensional elements covers not only standard problems but allows also for advanced topics such as plasticity or the mechanics of composite materials Many examples illustrate the concepts and problems at the end of every chapter help to familiarize with the topics Each chapter also includes a few exercise problems with short answers provided at the end of the book The second edition appears with a complete revision of all figures It also presents a complete new chapter special elements and added the thermal conduction into the analysis of rod elements The principle of virtual work has also been introduced for the derivation of the finite element principal equation

Linear Algebra and Analysis Helmut Wielandt, 1996 Keine ausführliche Beschreibung für Linear Algebra und Analysis verfügbar

Operations Research '91 Peter Gritzmann, Rainer Hettich, Reiner Horst, Ekkehard Sachs, 2012-12-06 The volume comprises a collection of 172 extended abstracts of talks presented at the 16th Symposium on Operations Research held at the University of Trier in September 1991 It is designated to serve as a quickly published documentation of the scientific activities of the conference Subjects and areas touched upon include theory modelling and computational methods in optimization combinatorial optimization and discrete mathematics combinatorial problems in VLSI scientific computing stochastic and dynamic optimization queueing scheduling stochastics and econometrics mathematical economics and game theory utility risk insurance financial engineering computer science in business and economics knowledge engineering and production and manufacturing

The History of the Theory of Structures Karl-Eugen Kurrer, 2018-06-19 Zehn Jahre nach der 1 Auflage in englischer Sprache legt der Autor sein Buch The History of the Theory of Structures in wesentlich erweiterter Form vor nunmehr mit dem Untertitel Searching for Equilibrium Mit dem vorliegenden Buch lädt der Verfasser seine Leser zur Suche nach dem Gleichgewicht von Tragwerken auf Zeitreisen ein Die Zeitreisen setzen mit der Entstehung der Statik und Festigkeitslehre eines Leonardo und Galilei ein

und erreichen ihren ersten Höhepunkt mit den baustatischen Theorien über den Balken Erddruck und das Gewicht von Coulomb am Ende des 18. Jahrhunderts. Im folgenden Jahrhundert formiert sich die Baustatik mit Navier, Culmann, Maxwell, Rankine, Mohr, Castigliano und Müller-Breslau zu einer technikwissenschaftlichen Grundlagendisziplin, die im 20. Jahrhundert in Gestalt der modernen Strukturmechanik bei der Herausbildung der konstruktiven Sprache des Stahl-Stahlbeton-Flugzeug-Automobil und des Schiffbaus eine tragende Rolle spielt. Dabei setzt der Autor den inhaltlichen Schwerpunkt auf die Formierung und Entwicklung moderner numerischer Ingenieurmethoden wie der Finite-Elemente-Methode und beschreibt ihre disziplinäre Integration in der Computational Mechanics. Kurze durch historische Skizzen unterstützte Einblicke in gängige Berechnungsverfahren erleichtern den Zugang zur Geschichte der Strukturmechanik und Erddrucktheorie vom heutigen Stand der Ingenieurpraxis und stellen einen auch einen wichtigen Beitrag zur Ingenieurpädagogik dar. Dem Autor gelingt es, die Unterschiedlichkeit der Akteure hinsichtlich ihres technisch-wissenschaftlichen Profils und ihrer Persönlichkeit plastisch zu schildern und das Verständnis für den gesellschaftlichen Kontext zu erzeugen. So werden in 260 Kurzbiografien die subjektive Dimension der Baustatik und der Strukturmechanik von der frühen Neuzeit bis heute entfaltet. Dabei werden die wesentlichen Beiträge der Protagonisten der Baustatik besprochen und in die nachfolgende Bibliografie integriert. Berücksichtigt wurden nicht nur Bauingenieure und Architekten, sondern auch Mathematiker, Physiker, Maschinenbauer sowie Flugzeug- und Schiffbauer. Neben den bekannten Persönlichkeiten der Baustatik wie Coulomb, Culmann, Maxwell, Mohr, Müller-Breslau, Navier, Rankine, Saint-Venant, Timoshenko und Westergaard wurden u.a. auch G. Green, A. N. Krylov, G. Li, A. J. S. Pippard, W. Prager, H. A. Schade, A. W. Skempton, C. A. Truesdell, J. A. L. Waddell und H. Wagner berücksichtigt. Den Wegbereitern der Moderne in der Baustatik J. H. Argyris, R. W. Clough, Th. v. Kármán, M. J. Turner und O. C. Zienkiewicz wurden umfangreiche Biografien gewidmet. Eine ca. 4500 Titel umfassende Bibliografie rundet das Werk ab. Neue Inhalte der 2. Auflage sind Erddrucktheorie, Traglastverfahren, historische Lehrbuchanalyse, Stahlbrückenbau, Leichtbau, Platten und Schalentheorie, Greensche Funktion, Computerstatik, FEM, Computergestützte Graphostatik und Historische Technikwissenschaft. Gegenüber der 1. englischen Ausgabe wurde der Seitenumfang um 50 % auf nunmehr etwas über 1200 Druckseiten gesteigert. Das vorliegende Buch ist die erste zusammenfassende historische Gesamtdarstellung der Baustatik vom 16. Jahrhundert bis heute über die Reihe *edition Bautechnikgeschichte*. Mit erstaunlicher Dynamik hat sich die Bautechnikgeschichte in den vergangenen Jahrzehnten zu einer höchst lebendigen, international vernetzten und viel beachteten eigenständigen Disziplin entwickelt. Auch wenn die nationalen Forschungszugänge unterschiedliche Akzente setzen, eint sie doch das Bewusstsein, dass gerade die inhaltliche und methodische Vielfalt und das damit verbundene synthetische Potenzial die Stärke des neuen Forschungsfeldes ausmachen. Bautechnikgeschichte erschließt neue Formen des Verstehens von Bauen zwischen Ingenieurwesen und Architektur, zwischen Bau und Kunst, Technik und Wissenschaftsgeschichte. Mit der *edition Bautechnikgeschichte* erhält die neue Disziplin erstmals einen Ort für die Publikation wichtiger Arbeiten auf angemessenem

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ZAMM E BOOK Radiating Nonuniform Transmission-Line Systems and the Partial Element Equivalent Circuit Method Prof. Dr. Juergen Nitsch, Dr. Frank Gronwald, Prof. Dr. Gunter Wollenberg, 2009-10-29 High frequencies of densely packed modern electronic equipment turn even the smallest piece of wire into a transmission line with signal retardation dispersion attenuation and distortion In electromagnetic environments with high power microwave or ultra wideband sources transmission lines pick up noise currents generated by external electromagnetic fields These are superimposed on essential signals the lines acting not only as receiving antennas but radiating parts of the signal energy into the environment This book is outstanding in its originality While many textbooks rephrase that which has been written before this book features an accessible introduction to the fundamentals of electromagnetics an explanation of the newest developments in transmission line theory featuring the transmission line super theory developed by the authors a unique exposition of the increasingly popular PEEC partial element equivalent circuit method including recent research results Both the Transmission Line Theory and the PEEC method are well suited to combine linear structures with circuit networks For engineers researchers and graduate students this text broadens insight into the basics of electrical engineering It provides a deeper understanding of Maxwellian circuit like representations of multi conductor transmission lines justifies future research in this field A New Fast and Accurate Grid Deformation Method for R-adaptivity in the Context of High Performance Computing Matthias Grajewski, 2008 Thema der vorliegenden Arbeit ist die Entwicklung und Realisierung einer neuen Methode zur Gitterdeformation im Hinblick auf die Anwendung in r und rh adaptiven Verfahren Das neu entwickelte Verfahren wird sowohl numerisch als auch theoretisch analysiert Die vorliegende Arbeit ist in sechs Kapitel gegliedert Das erste Kapitel stellt den gegenwertigen Stand der Mathematik auf den Gebieten Fehlerkontrolle und Gittersteuerung dar Besonderes Augenmerk liegt auf einer Übersicht gängiger Verfahren zur Gitterdeformation also Methoden zur Neuordnung der Punkte eines gegebenen Gitters unter Beibehaltung seiner Topologie Hinzu kommt die Darstellung des Aspekts der hardware orientierten Numerik Hier geht es darum durch ein geeignetes Design der numerischen Verfahren die Leistungsfähigkeit heutiger Computer voll auszuschöpfen Im zweiten Kapitel wird das Basisverfahren zur Gitterdeformation hergeleitet und grundlegende Eigenschaften der Methode bewiesen Das neue Verfahren wird mit dem Vorlaufverfahren von Liao verglichen wobei die weitaus größere Flexibilität der neuen Methode deutlich wird Im letzten Teil dieses Kapitels wird die

numerische Realisierung der Deformationsmethode mithilfe von FE Ansätzen thematisiert Das dritte Kapitel beinhaltet den Kern der Dissertation Die theoretische und numerische Analyse des im zweiten Kapitel vorgestellten Basisverfahrens Nach der Formulierung eines geeigneten Konvergenzbegriffes wird die Konvergenz der numerischen Realisierung des Deformationsverfahrens bewiesen Sowohl der Konvergenzbegriff als auch die Konvergenzaussage sind neu und wurden bisher in der Literatur auch nicht in ähnlicher Weise formuliert Ausführliche numerische Tests bestätigen die theoretischen Ergebnisse Das in Kapitel 2 eingeführte Basisverfahren wird hinsichtlich Genauigkeit und Robustheit weiterentwickelt Durch geeignete Ausnutzung der Gitterhierarchie gelingt es mit der sog Multilevel Deformation ein Verfahren bereitzustellen welches von optimaler Komplexität ist Im letzten Teil des Kapitels wird diese Multilevel Deformation auf das L Gebiet angewandt Den Schwerpunkt im vierten Kapitel bildet die Anwendung der Gitterdeformation auf die Poisson Gleichung auf dem L Gebiet Der Gradientenfehler wird auf a priori deformierten Gittern betrachtet Die mit der Gitterdeformation erzeugten Gitter ermöglichen eine für Q_1 Elemente optimale Konvergenzordnung Nach einer numerischen Untersuchung des ZZ Schatzers auf solchen Gittern wird ein voll r adaptiver Algorithmus formuliert und getestet Die Gitterdeformation wird nun vollautomatisch durch der geschätzten Fehlerverteilung gesteuert Die so gewonnenen Ergebnisse sind in ihrer Genauigkeit mit den a priori gewonnen Resultaten vergleichbar Das fünfte Kapitel beinhaltet eine Erweiterung des zuvor eingeführten r adaptiven Verfahrens um reguläre Gitterverfeinerung und ihre Anwendung auf die Laplace Gleichung auf dem L Gebiet Es werden zwei rh adaptive Algorithmen betrachtet Der zweite Algorithmus verzichtet auf hangende Knoten und erweist sich dem ersten als überlegen die Resultate entsprechen in ihrer Genauigkeit etwa den mit reiner r Adaptivität gewonnen Werten erfordern aber eine erheblich geringere Rechenzeit Im letzten Abschnitt wird die zuvor entwickelte rh adaptive Methode auf Diffusionsprobleme mit anisotropem Diffusionstensor angewendet die sich aus Problemen des Grundwasserflusses motivieren Mithilfe des rh adaptiven Verfahrens können nicht nur der Gradientenfehler sondern auch abgeleitete Größen wie der Punktfehler signifikant verringert werden Hierbei wird die Verteilung des Punktfehlers mithilfe der DWR Methode ermittelt Das sechste und letzte Kapitel beinhaltet eine Zusammenfassung der Arbeit und zeigt Ansatzpunkte für eine Fortentwicklung auf

18th European Symposium on Computer Aided Process

Engineering Bertrand Braunschweig, Xavier Joulia, 2008-06-18 Plenary Lectures Topic 1 Off Line Systems Topic 2 On Line Systems Topic 3 Computational Numerical Solutions Strategies Topic 4 Integrated And Multiscale Modelling And Simulation Topic 5 Cape For The Users Topic 6 Cape And Society Topic 7 Cape In Education

Integer Programming and Related Areas C. Kastning, 2013-11-11 Integer Programming is one of the most fascinating and difficult areas in the field of

Mathematical Optimization Due to this fact notable research contributions to Integer Programming have been made in very different branches of mathematics and its applications Since these publications are scattered over many journals proceedings volumes monographs and working papers a comprehensive bibliography of all these sources is a helpful tool even for

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