

# 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

**Peter Gritzmann, Rainer Hettich, Reiner  
Horst, Ekkehard Sachs**

## Numerische Methoden 1:

*Bifurcation Problems and their Numerical Solution* H. D. Mittelman, H. Weber, 1980      **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

*Konstruktive Methoden der finiten nichtlinearen Optimierung* Günther Meinardus, Wolfgang Wetterling, 1980      **Integer Programming and Related Areas A Classified Bibliography 1976-1978** D. Hausmann, 2012-12-06      *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      *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

*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 ldt 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 Gewölbe 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 untersttzte 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 Krmn 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 Gegen ber der 1 englischen Ausgabe wurde der Seitenumfang um 50 % auf nunmehr etwas ber 1200 Druckseiten gesteigert Das vorliegende Buch ist die erste zusammenfassende historische Gesamtdarstellung der Baustatik vom 16 Jahrhundert bis heute ber die Reihe edition Bautechnikgeschichte Mit erstaunlicher Dynamik hat sich die Bautechnikgeschichte in den vergangenen Jahrzehnten zu einer h chst lebendigen international vernetzten und viel beachteten eigenst ndigen Disziplin entwickelt Auch wenn die nationalen Forschungszug nge unterschiedliche Akzente setzen eint sie doch das Bewusstsein dass gerade die inhaltliche und methodische Vielfalt und das damit verbundene synthetische Potenzial die St rke des neuen Forschungsfeldes ausmachen Bautechnikgeschichte erschlie t neue Formen des Verstehens von Bauen zwischen Ingenieurwesen und Architektur zwischen Bau und Kunst Technik und Wissenschaftsgeschichte Mit der edition Bautechnikgeschichte erh lt die neue Disziplin erstmals einen Ort f r die Publikation wichtiger Arbeiten auf angemessenem Niveau in hochwertiger Gestaltung Die B cher erscheinen in deutscher oder englischer Sprache Beide Hauptrichtungen der Bautechnikgeschichte der eher konstruktionsgeschichtlich und der eher theoriegeschichtlich geleitete Zugang finden Ber cksichtigung das Spektrum der B nde reicht von berblickswerken ber Monographien zu Einzelaspekten oder bauten bis hin zu Biographien bedeutender Ingenieurpers nlichkeiten Ein international besetzter Wissenschaftlicher Beirat unterst tzt die Herausgeber in der Umsetzung des Konzepts

*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

*Production at the leading edge of technology* Jens Peter Wulfsberg,Wolfgang Hintze,Bernd-Arno Behrens,2019-11-23 The focus of the Congress will be leading edge manufacturing processes Topics include manufacturing at extreme speed size accuracy methodology use of resources interdisciplinarity and more Contributions from production and industrial engineering are welcome Challenges from the areas of manufacturing machines and production systems will be addressed Production research constantly pushes the boundaries of what is feasible The Congress Production at the leading edge of technology will highlight production processes that are advancing into areas that until recently were considered unfeasible also in terms of methodology use of resources and interdisciplinarity But where does the search for new limits lead Which limitations do we still have to overcome which ones do we not want to overcome The aim of the German speaking colloquium is to establish connections between the research locations and to intensify the overall transfer of results and experience with industrial users

**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 *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 **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 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 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 specialists in this field. I initiated this compilation of literature in 1970 at the Institut für Konometrie und Operations Research, University of Bonn. Since then, many collaborators have contributed to and worked on it. Among them, Dipl. Math. Claus Kastning has done the bulk of the work. With great perseverance and diligence, he has gathered all the material and checked it with the original sources. The main aim was to incorporate rare and not easily accessible sources like Russian journals, preprints, or unpublished papers. Without the invaluable and dedicated engagement of Claus Kastning, the bibliography would never have reached this final version. For this reason, he must be considered its responsible editor. As with any other collection, this literature list has a subjective viewpoint and may be in some sense incomplete. We have, however, tried to be as complete as possible. The bibliography contains 4704 different publications by 6767 authors, which were classified by 11839 descriptor entries. **Structural**

**Mechanics in Lightweight Engineering** Christian Mittelstedt, 2021-07-01. This book provides a comprehensive yet concise presentation of the analysis methods of lightweight engineering in the context of the statics of beam structures and is divided into four sections. Starting from very general remarks on the fundamentals of elasticity theory, the first section also addresses plane problems as well as strength criteria of isotropic materials. The second section is devoted to the analytical treatment of the statics of beam structures, addressing beams under bending, shear, and torsion. The third section deals with the work and energy methods in lightweight construction, spanning classical methods and modern computational methods such as the finite element method. Finally, the fourth section addresses more advanced beam models, discussing hybrid structures as well as laminated and sandwich beams, in addition to shear field beams and shear deformable beams. This book is intended for students at technical colleges and universities as well as for engineers in practice and researchers in engineering. **Rock**  
Characterization John A. Hudson, 1992

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