QUARTERLY

OF

APPLIED MATHEMATICS

VOLUME XLIII · OCTOBER · 1985 · NUMBER 3

QUARTERLY OF APPLIED MATHEMATICS

The QUARTERLY prints original papers in applied mathematics which have an intimate connection with applications. It is expected that each paper will be of a high scientific standard; that the presentation will be of such character that the paper can be easily read by those to whom it would be of interest; and that the mathematical argument, judged by the standard of the field of application, will be of an advanced character.

Manuscripts (two copies) submitted for publication in the QUARTERLY OF APPLIED MATHEMATICS should be sent to the Editorial Office, Box F, Brown University, Providence, RI 02912, either directly or through any one of the Editors. In accordance with their general policy, the Editors welcome particularly contributions which will be of interest both to mathematicians and to scientists or engineers. Authors will receive galley proof only. The author's institution will be requested to pay a publication charge of $30 per page which, if honored, entitles the author to 100 free reprints. Detailed instructions will be sent with galley proofs.

The current subscription price per volume (April through January) is $45. Single issues can be purchased, as far as they are available, at $12 and back volumes at $45 per volume. Subscriptions and orders for back volumes must be addressed to the American Mathematical Society, P.O. Box 1571, Providence, RI 02901. All orders must be accompanied by payment. Other subscription correspondence should be addressed to the American Mathematical Society, P.O. Box 6248, Providence, RI 02940. *Quarterly of Applied Mathematics* (ISSN 0033-569X) is published four times a year (April, July, October and January) by Brown University, Department of Applied Mathematics, 182 George Street, Providence, RI 02912. Second-class postage paid at Providence, RI. POSTMASTER: Send address changes to *Quarterly of Applied Mathematics*, Membership and Sales Department, American Mathematical Society, Post Office Box 6248, Providence, RI 02940.

Second-class postage paid at Providence, Rhode Island.
Publication number 808680. (ISSN 0033-569X).

SUGGESTIONS CONCERNING THE PREPARATION OF MANUSCRIPTS FOR THE QUARTERLY OF APPLIED MATHEMATICS

The editors will appreciate the authors' cooperation in taking note of the following directions for the preparation of manuscripts. These directions have been drawn up with a view toward eliminating unnecessary correspondence, avoiding the return of papers for changes, and reducing the charges made for "author's corrections."

Manuscripts: Manuscripts should be typewritten double-spaced on one side only. Marginal instructions to the typesetter should be written in pencil to distinguish them clearly from the body of the text. The author should keep a complete copy.

The papers should be submitted in final form. Only typographical errors should be corrected in proof; composition charges for any major deviations from the manuscript will be passed on to the author.

Titles: The title should be brief but express adequately the subject of the paper. The name and initials of the author should be written as he/she prefers; all titles and degrees or honors will be omitted. The name of the organization with which the author is associated should be given in a separate line following his/her name.

Mathematical Work: As far as possible, formulas should be typewritten; Greek letters and other symbols not available on the average typewriter should be inserted using either instant lettering or by careful insertion in ink. Manuscripts containing pencilled material other than marginal instructions to the typesetter will not be accepted.

The difference between capital and lower-case letters should be clearly shown; care should be taken to avoid confusion between zero (0) and the letter O, between the numeral one (1), the letter l and the prime ($'$), between alpha and a, kappa and k, mu and u, nu and v, eta and n.

The level of subscripts, exponents, subscripts to subscripts, and exponents to exponents should be clearly indicated.

Single embellishments over individual letters are allowed, the only embellishment allowed above groups of letters is the overbar.

Double embellishments are not allowed. These may be replaced by superscripts following the symbols.

Complicated exponents and subscripts should be avoided. Any complicated expression that recurs frequently should be represented by a special symbol.

For exponentials with lengthy or complicated exponents the symbol exp should be used, particularly if such exponentials appear in the body of the text. Thus,

$$\exp\left[(a^2 + b^2)^{1/2}\right] \text{ is preferable to } e^{[a^2+b^2]^{1/2}}$$

Fractions in the body of the text and fractions occurring in the numerators or denominators of fractions should be written with the solidus. Thus,

$$\frac{\cos(x/2b)}{\cos(a/2b)} \text{ is preferable to } \frac{\cos \dfrac{x}{2b}}{\cos \dfrac{a}{2b}}$$

In many instances the use of negative exponents permits saving of space. Thus,

$$\int u^{-1} \sin u \, du \text{ is preferable to } \int \frac{\sin u}{u} du.$$

Whereas the intended grouping of symbols in handwritten formulas can be made clear by slight variations in spacing, this procedure is not acceptable in typeset formulas. To avoid misunderstanding, the order of symbols should therefore be carefully considered. Thus,

$$(a + bx)\cos t \text{ is preferable to } \cos t(a + bx).$$

Figures: Figures should be drawn in black ink with clean, unbroken lines; do not use ball point pen. The paper should be of a nonabsorbant quality so that the ink does not spread and produce fuzzy lines. If the figures are intended for reduction, they should be drawn with heavy enough lines so that they do not become flimsy at the desired reduction. The notation should be of professional quality and in proportion for the expected reduction size. Figures which are unsuitable for reproduction will be returned to the author for redrawing. Legends accompanying figures should be written on a separate sheet.

Bibliography: References should be grouped together in a Bibliography at the end of the manuscript. References in text to the Bibliography should be made by numerals between square brackets.

The following examples show the desired arrangements: (*for books*—S. Timoshenko, *Strength of materials*, vol. 2, Macmillan and Co., London, 1931, p. 237; *for periodicals*—Lord Rayleigh, *On the flow of viscous liquids, especially in three dimensions*, Phil. Mag. (5) 36, 354–372 (1893)). Note that the number of the series is not separated by commas from the name of the periodical or the number of the volume.

Authors' initials should precede their names rather than follow them.

In quoted titles of books or papers, capital letters should be used only where the language requires this. Thus, *On the flow of viscous fluids* is preferable to *On the Flow of Viscous Fluids*, but the corresponding German title would have to be rendered as *Über die Stromung zaher Flüssigkeiten*.

Titles of books or papers should be quoted in the original language (with an English translation added in parentheses, if this seems desirable), but only English abbreviations should be used for bibliographical details such as ed., vol., no., chap., p.

Footnotes: As far as possible, footnotes should be avoided. Footnotes containing mathematical formulas are not acceptable.

Abbreviations: Much space can be saved by the use of standard abbreviations such as Eq., Eqs., Fig., Sec., Art., etc. These should be used, however, only if they are followed by a reference number. Thus, "Eq. (25)" is acceptable but not "the preceding Eq." Moreover, if any one of these terms occurs as the first word of a sentence, it should be spelled out.

Special abbreviations should be avoided. Thus "boundary conditions" should always be spelled out and not be abbreviated as "b.c." even if this special abbreviation is defined somewhere in the text.

CONTENTS

NEW BOOKS

Bypasses: A Simple Approach to Complexity. By Z. A. Melzak. John Wiley & Sonc, Inc., New York, 1983. 237 pp. $34.95.

Bypassing, according to the author, is a process in which a complex problem is broken down into less complex component parts. Conversely, in the theory of transformations, complex processes can be built up out of simple parts. By generalizing the bypass principle, the author claims an individual can tackle the most recondite mathematical operations, master a problem in mechanical engineering, or even resolve an acting difficulty in a dramatic scene. In other words, bypassing is said to be a universal process applicable to an infinite number of problems and questions, from the most esoteric to the most mundane.

Finite Elements and Approximations. By O. C. Zienkiewicz and K. Morgan. John Wiley and Sons, New York, 1983. 322 pp. $34.95

This book provides a basic introduction to the subject for those with only an elementary knowledge of calculus. It assumes no previous experience in the numerical solution of differential equations and avoids mathematical complexities. With numerous, simple worked examples, the book shows how to use the finite element weighted residual method in the solution of differential equations. The practical implementation of the method is also described. It defines a "generalized finite element method" which embraces all the alternative variants of approximation and allows the user to choose the optimal. It begins with a chapter in finite difference methods, treats continuous trial function procedures and shows how these and the finite difference methods form part of a generalized finite element methodology. Also covered are such topics as steady and transient problems, variational methods, and standard and hierarchical high order finite elements.

Mathematics and Statistics for the Bio-sciences. By G. Eason, C. W. Coles, and G. Gettinby. John Wiley & Sons, Inc., New York. 1980. 570 pp.

This is a volume in the Ellis Horwood Series, *Mathematics and Its Application*. It presents mathematics and statistics in combination with their applications in fields such as agriculture, marine biology, medicine, veterinary science, horticulture, physiology, and zoology.

Nonlinear Programming: Theory, Algorithms, and Applications. By Garth P. McCormick. John Wiley & Sons, Inc., New York, 1983. 433 pp. $44.95.

The primary purpose of this book is the exposition of algorithms for solving nonlinear programming (optimization) problems. This book also contains the theory of nonlinear optimization, mostly concerned with the characteristics of optimal points. An important subsidiary aim is the presentation of some optimization models of real world problems that can be solved by nonlinear programming methodology. Chapter One presents a structured method for analyzing application papers and for assessing their relevance in solving the underlying problems. Later in the text, traditional and newer algorithms for solving unconstrained, linearly constrained and nonlinearly constrained optimization problems are treated, using new syntheses based on physical models. The book also provides a rigorous development of the classical first order optimality conditions based on Lagrange multipliers (the Karush-Kuhn-Tucker conditions) and second order optimality conditions. These are followed by a chapter on their application to algorithm development and sensitivity analysis. It also presents an introduction to factorable functions which provides an interface between computer coded algorithms and the algebraic representation of nonlinear programming problems and shows how to obtain global, as opposed to strictly local, solutions to nonconvex programs.

Continued on page 316

Continued from page 262

Crystal Symmetry: Theory of Colour Crystallography. By M. A. Jaswon and M. A. Rose. John Wiley & Sons, Inc., New York, 1983. 187 pp. $44.95.

This is a volume in the Ellis Horwood Series in *Mathematics and its Applications*. It divides naturally into three main parts. Part I provides an account of the classical point groups and of the colour point groups. The authors start with intuitive geometric considerations which are then supplemented by formal group theory. Part II covers space lattices and their symmetry properties, including the extension to colour space lattices. Also, some simple crystal models are discussed in order to fix ideas and pave the way for the general theory. Part III formulates space-group theory with particular empahsis on the motif pattern, i.e. the smallest microscopic arrangement of atoms which generates the whole crystal structure by translational repetition.

Partial Differential Equations of Applied Mathematics. By Eric Zauderer. John Wiley & Sons, Inc., 1983. p. 769 pp. $49.95.

This is a volume in the series *Pure and Applied Mathematics*, founded by Richard Courant. It introduces techniques for solving both linear and nonlinear partial differential equations. It analyzes the construction of models of physical processes which give rise to P.D.E.'s, shows how P.D.E.'s are classified into equations and problems of different types, and examines the exact and approximate solution of these problems. These are over five hundred exercises and over one hundred worked-out examples. The book treats perturbation and asymptotic methods for the solution of P.D.E.'s, and discusses generalized solutions and functins without introducing functional analysis. Chapter headings: 1. Random Walks and Partial Differential Equations; 2. First Order Partial Differential Equations; 3. Classification of Equations and Characteristics; 4. Initial and Boundary Value Problems in Bounded Regions; 5. Integral Transforms; 6. Integral Relations; 7. Green's Functions; 8. Variational and Other Methods; 9. Perturbation and Asymptotic Methods.

Computational Methods in Elementary Numerical Analysis. By John Ll. Morris. John Wiley & Sons, Ltd., Chichester, England, 1983. 404 pp. $41.95 hard cover. $19.95 paperback.

This text provides a thorough grounding for students on a first course in elementary numerical analysis. The emphasis is on the practical application of numerical methods in science and engineering by means of computer implementation. The text contains many examples and exercises. Chapter headings: 1. An Introduction; 2. Errors in Numerical Computation; 3. Systems of Linear Equations; 4. Interpolation; 5. Least Squares Approximation; 6. Minimax Approximation; 7. Numerical Integration; 8. Numerical Differentiation; 9. The Solution of Nonlinear Algebraic Equations; 10. The Algebraic Eigenvalue Problem; 11. The Numerical Solution of Differential Equations.

Introduction to Topology. By Theodore W. Gamelin and Robert Everist Greene. CBS College Publishing, New York, 1983. 194 pp.

This is a volume in *The Saunders Series*. The authors of this text attempt early in the book to lead the reader through a number of nontrivial applications of metric space topology to analysis, so that the relevance of topology to analysis is apparent both with more immediacy and also on a deeper level than is commonly the case. Also, in the teatment of topics from elementary algebraic topology later in the book, the authors concentrate upon results with concrete geometric meaning and present comparatively little algebraic formalism; at the same time, however, they provide proofs of some highly nontrivial results. These goals are accomplished by treating homotopy theory without considering homology theory. Thus the reader can immediately see important applications without undertaking the development of a large formal program. The metric space and point-set topology occupies the first two chapters, the algebraic topological material the remaining two chapters.

Continued on page 324

Continued from page 316

Third Workshop on Grand Unification. Edited by Paul H. Frampton, Sheldon L. Glashow, and Hendrik van Dam. Birkhäuser, Boston, 1982. 374 pp.

This is a volume of the series *Progress in Physics*. The workshop was held at the University of North Carolina, Chapel Hill, April 15–17, 1982. The experimental presentations were mainly concerned with proton decay and massive neutrinos. The theoretical papers dealt with monopole flux, the gauge hierarchy problem, the invisible axion, the top quark mass, leptons and hadrons. The most popular theoretical topic this year was super-symmetry, with six papers devoted to various aspects of it.

Finite Elements in Fluids—Volume 4. Edited by R. H. Gallagher, D. H. Norrie, J. T. Oden, and O. C. Zienkiewicz. John Wiley & Sons, New York, 1982. 644 pp. $69.95.

This is a volume in the *Wiley Series in Numerical Methods in Engineering*. It contains the Keynote lectures and expanded versions of selected contributed papers from the Third International Conference on Finite Elements in Flow Problems, held at Banff, Alberta, Canada, on 10–13 June 1980. There are 28 contributions. The first four chapters concern viscous incompressible flow, Chapters 5–8 the modelling of large bodies of water, Chapters 9–11 porous media, Chapters 12–14 natural convection, 15 and 16 the penalty function methods, 17 analysis of the atmosphere, and 18 a variety of topics such as the conjugate gradient method and least-squares technique. A review of a new technique involving boundary integrals is given in Chapter 19 and a boundary element technique in 20. Aerodynamic flow calculations are exemplified in Chapters 21–23, and the remaining five chapters are devoted to different special types of flow situations, including cascade flows, plasmas, Maxwell fluids, flows between coaxial disks, and acoustic transmission.

Cryptography: A Primer. By Alan G. Konheim. John Wiley & Sons, Inc. New York, 1981. 426 pp. $38.95.

The eleven chapters of this book are divided into two parts: Part I develops the principles underlying encipherment through an examination of a number of classical systems. Included is an analysis of the Enigma machine—the basic cryptographic system of the German military in World War II and the data encryption standard DES. Part II shows how encipherment cana be applied to individual data processing requirements. It discusses communications and file security, public key systems and electronic signatures. The book gives practice in deciphering text with problems interspersed throughout and solutions at the end.

A First Course in Bulk Queues. By M. L. Chaudhry and J. G. C. Templeton. John Wiley & Sons, Inc., New York, 1983. 361 pp. $46.50.

This book provides an introduction to queueing systems in which arrivals, services or both occur in groups. It collects, unifies and extends existing literature on bulk-arrival and bulk-service models. Knowledge only of calculus and probability is presupposed. The opening chapters focus on the necessary background material—results in analysis and probability and non-bulk queuing theory. Emphasis here is on techniques for investigating $M/G/1$ and $GI/M/1$ queues. Coverage then progresses to an in-depth examination of bulk queues—batch-arrival queues in Chapter 3, batch-services queues in Chapter 4, and multichannel bulk queues in Chapter 5. The final chapter scrutinizes relationships among different queueing systems, and expected values for busy and idle periods. The authors give particular attention to the models useful in practical industrial applications of queueing theory. There are also extensive sophisticated problems to help readers test their understanding of the subject matter.

Introduction to Statistical Thinking. By E. A. Maxwell, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1983. 567 pp. $25.95.

This book provides an introduction to statistical methods in an intuitive way, with topoics developed through examples and assuming a knowledge of elementary algebra only.

Continued on page 368

Continued from page 324

Differential Geometry and Relativity Theory: An Introduction. By Richard L. Faber. Marcel Dekker, Inc., New York, 1983. 249 pp. $29.75.

This is Volume 76 of the series *Pure and Applied Mathematics*. It is an introduction to differential and Riemannian geometry and to the rudiments of special and general relativity, making the general theory available to mathematics majors whose background includes only multivariable calculus and linear algebra. Chapter I is a mini-course in differential geometry. Topics include curves in the plane and 3-space, the first and second fundamental forms of surfaces in 3-space, curvature and geodesics, the Theorema Egregium of Gauss, and abstrct surfces and manifolds. Chapter II presents the physical foundations of special relativity and its geometric interpretation as the geometry of flat spacetime. Here the emphasis is on coordinates, the Lorentz metric, and spacetime diagrams. Chapter III begins with an intuitive and non-technical account of the key ideas of Einstein's general theory of relativity. Following this is a more mathematical treatment using the tools developed in Chapter I. the requirement that general relativity should give close agreement with classical Newtonian physics is used to explain how Einstein arrived at his field equations. The Schwarzschild solution is derived, and the orbital equations are deduced, both for classical physics and general relativity. Additional consequences of general relativity, such as the "bending" of light, the gravitational redhsift and perihelial precession, are also discussed.

Polynomials and Linear Control Systems. By Stephen Barnett, Marcel Dekker, Inc., New York, 1983, $35.00. 447 pp.

This is Volume 77 of the series *Pure and Applied Mathematics*. In such topics in applied mathematics as linear control systems, electrical networks, signal processing, and coding theory, polynomial manipulations are an essential element of problem solving. This monograph provides a contemporary study of polynomials and polynomial matrices, allowing simplified treatment of problems involving time-invariant linear control systems. Chapter headings: 1. Polynomials: Approaches to Greatest Common Divisor; 2. Basic Properties of Control Systems; 3. Root Location and Stability; 4. Feedback, Realization, and Polynomial Matrices; 5. Generalized Polynomial Matrices.

Commutative Group Algebras. By Gregory Karpilovsky. Marcel Dekker, Inc., 1983. 218 pp. $ 39.75.

This volume 78 of the series *Pure and Applied Mathematics*. The study of commutative group algebras has developed in recent decades from a collection of isolated results into a cohesive, well-structured body of basic mathematical knowledge. Beginning with necessary background information, this volume systematically examines the varied areas of continuing interest, providing a comprehensive overview of the subject. Chapter headings: 1. Preequisites; 2. Preliminary Results; 3. Ring-Theoretic Properties; 4. Integral Domains; 5. Study of Units; 6. Isomorphism Questions.

Measurement and Tuning of Computer Systems. By Domenico Ferrari, Giuseppe Serazzi, and Alessandro Zeigner. Prentice Hall, Inc., New Jersey, 1983. 512 pp. $35.00.

The authors intend this book to be a simple, easily readable, practically oriented introduction to the field, rather than a research monograph or student text. It presents a pragmatic treatment of the subject, based on practical experience as well as on solid conceptual foundations. Measurement techniques and tuning projects are emphasized. One of the main goals of evaluation activities is considered to be improvement of the cost-performance ratio of the installation. Chapter headings: 1. Problem Definition; 2. The Workload; 3. Measurement Principles; 4. The Representation of Measurement Data; 5. Instrumentation; 6. A Tuning Methodology; 7. System Tuning; 8. Program Tuning; 9. Analytic Models and Their Applications; 10. Economic Considerations.

Continued on page 384

Continued from page 368

Fundamental Concepts in the Numerical Solution of Differential Equations. By J. F. Botha and G. F. Pinder. John Wiley & Sons, 1983. 194 pp. $24.95.

This book is designed to provide a reference on the methodology available for the solution of ordinary and partial differential equations in science and engineering. The various numerical methods are developed from one fundamental base—the theory of interpolation polynomials. In general, the illustrative problems and student exercises are designed to be worked on a hand calculator. Only in a fe cases need one resort to a more powerful computer. The book considers both linear and nonlinear partial differential equations. Finite difference, finite element, collocation, and boundary elements are discussed. There is also an extensive treatment of an alternating direction methodology for finite element simulation using collocation. Chapter headings: 1. Introduction; 2. Basic Concepts; 3. The Finite Element Concept in Two Dimensions; 4. Elliptic Partial Differential Equations; 5. Parabolic Partial Differential Equations; 6. Hyperbolic Partial Differential Equations; 7. Nonlinear and Singular Equations.

Fundamentals of the Theory of Operator Algebras, Volume 1, *Elementary Theory*. By Richard V. Kadison and John R. Ringrose. Academic Press, Inc., 1983. 383 pp. $29.50.

This is a volume in the series "Pure and Applied Mathematics." It is the first of two volumes, of which the second will treat the advanced theory of operator algebras. The starting point in chapter 1 is finite-dimensional linear algebra, but readers are assumed to be familiar with that subject; infinite-dimensional algebraic results, needed later, are proved. The volumes deal almost exclusively with infinite-dimensional phenomena; their subject matter is, also, non-commutative real analysis, although there are many references to the abelian or commutative case. Chapter headings: 1. Linear Spaces; 2. Basics of Hilbert Space and Linear Operators; 3. Banach Algebras; 4. Elementary C^*-Algebra Theory; 5. Elementary von Neumann Algebra Theory.

An Introduction to Statistical Modelling. By A. J. Dobson. Chapman & Hall, 1983. 118 pp. $33.00 hardcover, $14.95 paperback.

This book introduces a reader familiar with the most commonly used statistical concepts and methods to the subjects of regression, analysis of variances and covariances, logistic repression, log-linear models for contingency tables and several more specialised techniques by providing a unified theoretical and computational framework for them.

Holomorphic Functions of One Variable. By Serge Colombo. Gordon and Breach, New York, 1983. 271 pp.

This book is an introduction to the study of special functions and differential equations in the complex domain. It should be of interest to theoretical physicists, astrophysicists, and geophysicists; it presupposes a sound knowledge of elementary analysis. The work originated from a course delivered over 13 years at the University of Louvain. It uses ;the terminology and notation adopted by Einar Hille in his now classic treatise on analytic function theory.

Educated Guessing: How to Cope in an Uncertain World. By Samuel Kotz and Donna F. Stroup. Marcel Dekker, Inc., New York, 1983. 182 pp. $15.95.

It is the aim of this book to close the gap between vague intuition and precise mathematical logic, highlighting the pitfalls that occur with faulty reasoning and lead to incorrect conclusions. It considers applications of probability, statistics, and information theory in such aras as scientific research, recreational sports, gambling, marketing, politics, communication, and ordinary social situations. Furthermore, the book establishes a solid foundation in probability and statistics methodology to prepare the reader for advanced study in the field. There are end-of-chapter excercises and solutions. Only a high school mathematics background is required.

Continued on page 394

Continued from page 384

Multivariate Statistics: A Vector Space Approach. By Morris L. Eaton. John Wiley & Sons, 1983. 501 pp. $34.95.

This is a volume in the "Wiley Series in Probability and Mathematical Statistics." It is its purpose to present a version of multivariate statistical theory in which vector space and invariance methods replace, to a large extent, more traditional multivariate methods. In Chapter 1, the elements of vector space theory are presented. There is an emphasis on inner product spaces where the notions of length, angle, and orthogonal projection make sense. Random vectors taking values in inner product spaces is the general topic of Chapter 2. Here, induced distributions, means, covariances, and independence are introduced in the inner product space setting. These results are then used to establish many traditional properties of the multivariate normal distribution in Chapter 3. In Chapter 4, a theory of linear models is given that applies directly in multivariate problems. Chapter 5 contains some standard matrix factorizations and some invariant integrals (measures) is outlined. Statistical applications of invariance ranging from the invariance of likelihood methods to the use of invariance in deriving distributions and establishing independence, are given in Chapter 7. Invariance arguments are used throughout the remainder of the book. The last three chapters are devoted to a discussion of some problems in multivariate analysis. The connections between classical likelihood methods, linear model considerations and invariance arguments are stressed here. In Chapter 8, the Wishart distribution is defined via its representation in terms of normal random vectors. Chapter 9 begins with a thorough discussion of the multivariate analysis of variance (MANOVA) model. Variations on the MANOVA model includin multivariate linear models with structured covariances are the main topic of the rest of Chapter 9. An invariance argument that leads to the relationship between canonical correlations and angles between subspaces is the lead topic in Chapter 10. After a discussion of some distribution theory, the chapter closes with the connection between testing for independence and testing in multivariate regression models.

Theoretical Glaciology. By K. Hutter. D. Reidel Publishing Co., 1983. 510 pp. $104.00.

This book is designed as a comprehensive mathematical introduction to the science of the behavior of glaciers and ice sheets in their geophysical environment. It is the intention of the author to stand up for clear unification of the mathematical description of problems that may be collectively summarized under the term *ice mechanics*. One goal of the book is to make the reader aware of the usefulness of merging modern constitutive theories with material science. It is divided into two parts: I. Fundamental Physics and Materials Technology of Ice, and II. The Deformation of an Ice Mass Under its Own Weight. Chapter 1 presents the general background of continuum mechanics and chapter 2 a review of the mechanical properties of ice. Chapter 3 presents a continuum model for a polythermal glacier or ice sheet. Chapters 4 to 6 continue the analysis of glacier and ice-sheet models by allowing the surface and bottom geometry to vary with position and time, but assuming ice-flow and temperature distributions to be plane. Finally, in Chapter 7, three-dimensional effects are studied.

Preconditioning Methods: Analysis and Applications. David J. Evans, editor. Gordon and Breach Science Publishers, 1983. 550 pp.

This is volume 1 in the series "Topics in Computer Mathematics." It provides an up-to-date account of a new research topic concerned with the numerical solution of partial differential equations, i.e., the analysis and application of preconditioning strategies. The main purposes of the book are to present sufficient theoretical and practical details to enable the reader to implement the presented methods in order to solve practical problems and/or to pursue theoretical studies to advance the knowledge of preconditioning theories. Also included in the presentation are practical applications involving elliptic and parabolic partial differential equations, eigenvalue problems, least squares and variational methods, optimal control, engineering structures, transonic flows and parallel computation. There are 20 papers by various authors.

Non-Equilibrium Entropy and Irreversibility. By Goran Lindblad. D. Reidel Publishing Company, 1983. 155 pp. $29.50.

This is a volume in the series "Mathematical Physics Studies." The monograph starts from the idea that the derivation of irreversible thermodynamics from reversible microscopic dynamics should be based on the concepts which are common to both, namely energy and work. It is the author's aim to present an approach differing in some key aspects from the standard treatments and to develop it as far as possible using rather simple tools (mainly inequalities of various kinds). Chapter headings: 1. Introduction and Summary; 2. Dynamics and Work; 3. Information Entropy; 4. Heat Baths; 5. Reversible Processes; 6. Closed Finite Systems; 7. Open Systems; 8. External Perturbations; 9. Thermodynamic Limit; 10. Thermodynamic Entropy; 11. Measurements, Entropy and Work; 12. Other Approaches. There is an appendix on quantum Markov processes.

Linear Statistical Analysis of Discrete Data. By Mikel Aickin. John Wiley & Sons, 1983. 334 pp. $36.95.

This is a volume in the "Wiley Series in Probability and Mathematical Statistics." The author's aim is to integrate the three themes of application, computation and theory in his analysis of contingency tables. Typical models discussed specify the independence of some factors from others, the conditional independence of some factors given the values of others, lack of high-order interaction among variables, and the expression of probabilities or functions of probabilities in terms of fixed background factors (covariates). The material presented also includes log-linear models for cross-classifications, models specified in terms of linear constraints on probabilities, and logistic regression and its more complicated relatives. There are numerous examples of analyses of data that arose in actual experiments or surveys.

Vibrations and Waves. By W. Gough, J. P. G. Richards, R. P. Williams. John Wiley & Sons, 1983. 269 pp. $64.95.

This text is intended mainly for first and second year students of physics. Chapter headings: 1. Introduction; 2. The theory of vibrations; 3. Damped and forced vibrations; 4. Mathematical description of wave motion; 5. Waves in physical media; 6. Boundary conditions and energy transfer; 7. Fourier's theorem; 8. Further topics in Fourier theory; 9. Some wave phenomena; 10. Sound; 11. Light.

Constructive Methods in the Analysis of Nonlinear Systems. Translated by Ram S. Wakhwa. Mir Publishers, Moscow, 1983. 328 pp. $9.95.

This book develops the ideas of A. M. Lyapunov and reflects the trend in modern mathematics toward computational techniques and algorithmization. It deals with asymptotic and iterative methods for solving equations in various branches of mathematics and non-linear mechanics.

A First Course in Differential Geometry. By Izu Vaisman. Marcel Dekker, Inc., 1984. 164 pp. $32.50.

This is volume 20 of "Monographs and Textbooks in Pure and Applied Mathematics." The distinguishing feature of the text is its more ample involvement of differentiable manifolds, which led to a specific choice of the topics included. The text is divided into three chapters: Differentiable Manifolds in R'', Curves in E^2 and E^3, and Surfaces in E^3; each chapter is in turn divided into several sections. Each section is informally subdivided into parts, which, it is hoped, will facilitate an understanding of the text. Each section is followed by a number of exercises, whose aim is to permit the reader to interact actively with the text.

Robot Motion: Planning and Control. M. Brady, J. M. Hollerbach, T. L. Johnson, T. Lozano-Perez, and M. T. Mason, editors. The MIT Press, 1982. 565 pp. $37.50.

This book is an attempt to identify the evolving scientific basis for robotics and to place a coherent structure on the motion planning and control aspects of robotics. It deals only with those aspects of robotics involving the planning and control of manipulator motions. Within manipulator planning and control, five major areas have been identified, namely dynamics, feedback control, trajectory planning, compliance, and task planning. The book is structured as a collection of important papers in these five major areas. By gathering important papers into one place, the editors hope to provide a convenient reference book for state of the art research in these areas and to raise the level of understanding of problems and solutions in motion planning and control. They have also written sizable introductory chapters to each of the five major areas which serve as a historical context for work in each area, a critique of work in each area, and an identification of future trends. The first chapter introduces the five major areas by working out solutions to planning and control for a two link planar manipulator. This integrated presentation of the major areas of planning and control will not only acquaint readers who are new to the field with the appropriate concepts and definitions, but also indicate how the areas are interrelated. The reader is not assumed to have any previous experience in robotics.

Robot Manipulators: Mathematics, Programming, and Control—The Computer Control of Robot Manipulators. By Richard S. Paul. The MIT Press, 1981. 271 pp. $29.95.

This book brings together theories from computer graphics, kinematics, dynamics, control, and programming. It is written in the style of a text and has been used to teach robotics to graduate and undergraduate students in engineering and computer science. It presents one theory in each area. These theories were selected by the authors because they can be brought together to provide a working and consistent approach to the overall problem of robot manipulator control. Most of the material in the book is at the level of trigonometry but is conceptually new and different. The chapter on dynamics assumes that the student is prepared to accept the Lagrangian formulation of dynamics. The chapter on control makes use of the Laplace transformation, and the final chapter on programming assumes a knowledge of Pascal.

Encyclopedia of Statistical Sciences, Volume 3. S. Kotz, N. L. Johnson, editors. John Wiley & Sons, 1983. 722 pp. $79.50.

This volume brings the entries in the Encyclopedia from Faa di Bruno's Formula to Hypothesis Testing. The work will eventually comprise eight volumes, and with each of approximately the size of the present volume, will be able to give attention to nearly all the many fields of enquiry in which statistical methods play a role. An effort is also being made to make the articles pleasant and interesting to read to encourage browsing through the volumes. Historical background is included when it seems important to the development of statistical methods and ideas.

Encyclopedia of Statistical Sciences, Volume 4. S. Kotz and N. L. Johnson, editors. John Wiley & Sons, 1983. 657 pp. $79.50.

This volume contains entries Icing the Tails through Limit Theorem. See also preceding review.

Statistics on Spheres. By Geoffrey S. Watson. John Wiley & Sons, 1983. 231 pp.

This is volume 6 in the series "University of Arkansas Lecture Notes in the Mathematical Sciences." The work was motivated by questions from workers in the Earth Sciences and in Animal Behaviour, but is now a subject of independent theoretical interest. Chapter 1 gives practical examples that raise statistical problems and some data-analytical tricks. Chapter 2 studies the basic distribution, the uniform on the n-dimensional sphere. Chapter 3 deals with both theoretical statistical reasons and applied probability reasons for the prevalence of certain non-uniform distributions on the n-dimensional sphere. In chapters 4 and 5 a large sample theory is given for the several-sample problem for two classes of distributions.

Spinor and Non-Euclidean Tensor Calculus with Applications. By I. Beju, E. Soos, and P. Teodorescu. Heyden & Sons, Inc., 1983. 275 pp. $59.00.

The necessity of modelling mathematically the objective character of certain geometrical, mechanical, physical and other quantities led to the problem of invariant behaviour of the representation of these quantities under the transformations of reference frames and of co-ordinates. Besides physical quantities of scalar, vectorial, or Euclidean tensorial character, there occur physical quantities of spinorial and non-Euclidean tensorial character. In the introductory part of the work, the corresponding concepts and fundamental results are presented, for example spinors and their relation to tensors, while tensors defined on differentiable manifolds are introduced and operations with these tensors, as well as their most important structural properties are examined. Special stress is laid on the possibility of applying the mathematical formalism, presented in a unitary frame, in various fields of geometry (connected spaces, Riemannian spaces), of mechanics (deformable continuous bodies, dislocations), and of physics (relativistic theory of gravitation), where its efficacy is fully confirmed. This work is addressed to a large audience, particularly those interested in mathematical methods, such as engineers in various industries, researchers and designers, astronomers, physicists, geophysicts, graduate and postgraduate students and teachers.

Groups of Divisibility. By Jiri Mockor. D. Reidel Publishing Compnay, 1983. 171 pp. $39.50.

This is a volume in "Mathematics and Its Applications" (East European Series).

Kinematics. By Joseph Stiles Beggs. Springer-Verlag, 1983. 220 pp.

This concise text and reference guide about kinematics is intended for students and professionals who are primarily concerned with studying or working in related engineering fields such as dynamics or machines. The algebraic basis of kinematics is tersely covered and the notation is highly mnemonic. The broad application of matrices is illustrated with their application to moving mirrors and space mechanisms. The first six chapters develop necessary mathematical tools, applying matrices, vectors, and quaternions in a form suitable for programming on a computer. The final chapter illustrates how kinematics can solve a broad range of problems, from calculating the time of sunrise to steering a tractor trailer, and from machining a gerar tooth to determining the motion of a rocket-born, shock mounted, payload when the rocket engine is fired.

Geometric Dynamics. J. Palis Jr., editor. Springer-Verlag, 1983. 825 pp. $32.50.

This is volume 1007 of "Lecture Notes in Mathematics." It is the proceedings of an international symposium held at the Institute de Matematica Pura e Aplicada, Rio de Janeiro, Brasil, July–August 1981, and is dedicated to Mauricio Peixoto on his sixtieth birthday. The texts of 43 papers comprise this volume.

Dynamics and Processes. Ph. Blanchard and L. Streit, editors. springer-Verlag, 1983. 203 pp. $

This is volume 1031 of "Lecture Notes in Mathematics" and contains the proceedings of the Third Encounter in Mathematics and Physics, held in Bielefeld, Germany, Nov. 30–Dec. 4, 1981. There are eleven papers on subjects such as symmetries, C^* algebras, quantum field theory, fluctuations, hamiltonian systems.

Linear Programming. By V. Chvatal. W. H. Freeman and Company, 1938. 496 pp. $49.50 cloth, $24.95 paper.

This exposition of linear programming is accessible to readers with only a minimal mathematical background. It covers basic theory, selected applications, network flow problems and advanced techniques. The presentation is geared toward modern efficient implementations of the simplex method and appropriate data structures for network flow problems.

Sequential Program Structures. By Jim Welsh, John Elder and David Bustard. Prentice-Hall, Inc., New Jersey, 1984. v + 385 pp. $26.95.

The topics covered in this book are the structures, both in program and in data, that arise in substantial computer programs of a sequential nature—those which imply no concurrency in their execution. In practical terms, it provides an introduction to the classification and organization of data structures, to their encapsulation as abstract data types, and to modular (sequential) programming in general. Chapters 1 to 5 introduce a methodology for the design, implementation and testing of programs with a well-defined modular structure, and a notation for expressing that structure within the program text. Chapter 6 then introduces the concept of abstract data types, using the concept of a program module to maintain a clear separation of the definition and use of an abstract type from the means chosen for its implementation. Within this general model, subsequent chapters introduce stacks, queues, lists, trees, graphs and tables as abstract data types. For each type a specification is developed, an external representation is defined, its use in practical programming context is illustrated, and major methods for its internal representation are described. The representation described are those suitable for use in a preliminary stage only, but a final chapter outlines how these representations can be saved in, and retrieved from, secondary storage when necessary.

Lecture Notes in Computer Science. By Tosiyasu L. Kunii. Springer-Verlag, New York, 1984. v + 307 pp. $14.00.

This is volume 163 of Lecture Notes in Computer Science. It focuses on VLSI-related engineering as it is used to produce application-oriented computers. In Chapter 1, the authors compare software and hardware (especially VLSI) from the viewpoint of design processes. Chapter 2 reports the development of various advanced architectures which includes 5th generation computers, object-oriented architecture and tightly coupled network architecture. Chapter 3 addresses the problem of optimal implementation of a class of computational processes. Chapter 4 is devoted to VLSI design and testing and Chapter 5 deals with VLSI implementation and database systems and document image processors.

Commutative Semigroup Rings. By Robert Gilmer. The University of Chicago Press, 1984. v + 380 pp. $11.00 paperback, $27.00 hardback.

This is a volume in the Chicago Lectures in Mathematics Series. Contents: I. Commutative Semigroups, II. Semigroup Rings and their Distinguished Elements, III. Ring-Theoretic Properties of Monoid Domains, IV. Ring-Theoretic Properties of Monoid Rings, V. Dimension Theory and the Isomorphism Problems.

Strict Convexity and Complex Strict Convexity. By V. I. Istratescu. Marcel Dekker, New York, 1984. v + 312 pp. $49.75.

This is volume 89 in the series Lecture Notes in Pure and Applied Mathematics. The book contains three chapters. The first chapter is devoted to some of the basic results of linear functional analysis. The second chapter presents several characterizations of strictly convex spaces. Uniformly convex spaces and the modules of convexity are considered next and the chapter concludes with applications to approximation, fixed point and probability theory. In the third chapter, the problem is solved of characterizing those Banach spaces for which the maximum modulus holds for analytic functions with values in the spaces.

Optimization Theory and Algorithms. Edited by Jean-Baptiste Hiriart-Urruty, Werner Oettli and Josef Stoer. Marcel Dekker, New York, 1983. iii + 253. $45.00.

This is volume 86 in the series Lecture Notes in Pure and Applied Mathematics. It contains a collection of 15 papers presented at a conference held in March 1981 at Confolant (Puy-de-Dome, France). It is divided into three parts: theory (seven papers), algorithms (three papers) and applications (five papers).

An Introduction to Stability Theory. By Anand Pillay. Clarendon Press, Oxford, 1983. 140 pp. $29.95.

This is a volume in the series "Oxford Logic Guides." The aim of the book is to present in a readable and coherent manner some of the basic concepts and machinery of stability theory, so as to enable the reader to understand something of current research in the area. Thus the book is directed towards graduate students in logic as well as towards the logical and mathematical community at large. The reader is assumed to have some knowledge of model theory, as well as some knowledge of elementary set theory (cardinals and ordinals). Chapter headings: 0. Notation and preliminaries; 1. Definable types; 2. Stability and order; 3. Forking; 4. Forking and definability; 5. Superstability and w-stability; 6. Dividing and ranks; 7. Indiscernibles; 8. Further properties of stable theories; 9. Aleph$_1$-categorical theories and regular types.

Random Perturbations of Dynamical Systems. By M. I. Freidlin and A. D. Wentzell. Springer-Verlag, 1984. 313 pp. $56.00.

This is volume 260 of "Grundlehren der mathematischen Wissenschaften." It is a translation of a Russian edition first published in 1979. The aim of this monograph is to investigate limit theorems for random processes of studying dynamic systems subject to small random perturbations. The results relate to one-dimensional, and to some extent two-dimensional, dynamical systems and perturbations leading to diffusion processes. Various asymptotic problems are considered which arise when the parameter characterizing the size of the random perturbations tends to zero. Perturbations over large time-intervals are emphasized. In this context, theorems on the asymptotic behavior of probabilities of large deviations (rare events) for random processes are studied, and applications such as the limit behavior of an invariant measure, exit of a random number domain, and stability under random perturbations. The problems being studied are considered as problems of the asymptotic study of integrals in a function space, and the fundamental tools employed can be looked upon as an infinite-dimensional generalization of the method of Laplace. In the cases where diffusion processes result from the analysis, the problems are closely related to elliptic and parabolic differential equations with a small parameter. Chapter headings: 1. Random Perturbations; 2. Small Random Perturbations on a Finite Time Interval; 3. Action Functional; 4. Gaussian Perturbations of Dynamical Systems; 5. Perturbations Leading to Markov Processes; 6. Markov Perturbations on Large Time Intervals; 7. The Averaging Principle. Fluctuations in Dynamical Systems with Averaging; 8. Stability Under Random Perturbations.

Introduction to Robust and Quasi-Robust Statistical Methods. By William J. J. Rey. Springer-Verlag, 1983. 206 pp. $

The first part of this book (chapters 2–5) surveys available robust statistical methods. The theory is presented in an expository style and in a unifying manner. The second part (chapters 6–11) treats the methods as they are encountered in real life situations. Chapter headings: 1. Introduction and summary; 2. Sample spaces, distributions, estimators; 3. Robustness, breakdown point and influence function; 4. The jackknife method; 5. Bootstrap methods, sampling distributions; 6. Type M estimators; 7. Type L estimators; 8. Type R estimator; 9. Type MM estimators; 10. Quantile estimators and confidence intervals; 11. Miscellaneous.

Planning & Analysis of Observational Studies. By William G. Cochran. John Wiley & Sons, New York, 1983. v + 145 pp. $21.95.

This is a volume in the Wiley Series in Probability and Mathematical Statistics. During the last years of his life, William Cochran began working on a short reference work on the use of statistical methods in observational studied (as contrasted with controlled experimental investigations). He completed six-and-a-half of seven proposed chapters before his death. In the book, the author tackles the problem of bias in the design and analysis of observational studies and focuses on the behavior of a statistical procedure when one or more of the assumptions underlying its mathematical justification is false in some degree. Contents: 1. Variation, Control, and Bias. 2. Statistical Introduction. 3. Preliminary Aspects of Planning. 4. Further Aspects of Planning. 5. Matching. 6. Adjustments in Analysis. 7. Simple Study Structures.

The Visual Display of Quantitative Information. By Edward R. Tufte. Graphics Press, Box 430 Cheshire, Conn. 06410, 1983. 1 + 190 pp.

This is a truly unique work. It does not—as the title might suggest—present the latest hardware and software tools of computer graphics for the display of quantitative data, but it is a learned historical and methodological account how quantitative information has been displayed visually from 1700 to 1982, with numerous and beautifully reproduced examples of the finest graphical work of the period, as well as a theoretical development of the principles underlying graphic design. The first part of the book reviews the graphical practice of the two centuries since William Playfair who developed and improved upon nearly all the fundamental graphical designs, seeking to replace conventional tables of numbers with systematic visual representation. The second part provides a language for discussing graphics and a practical theory of data graphics. Applying to most visual displays of quantitative information, the theory leads to changes and improvements in design, suggests why some graphics might be better than others, and generates new types of graphics. The emphasis is on maximizing principles, empirical measures of graphical performance, and the sequential improvement of graphics through revision and editing. The book is essentially about design of statistical graphics, but also about how to communicate information through the simultaneous presentation of words, numbers and pictures.

Statistics and Probability. Ed. By J. Mogyorodi, I. Vincze, and W. Wertz. Akademiai Kiado, Budapest, 1984. 1 + 409. $45.75

This volume contains the text of thirty-six papers presented at the conferences.

Dynamics. By S. Neil Rasband. John Wiley & Sons, Inc., New York, 1983. 1 + 259. $32.95

This text presents classical dynamics from a modern geometrical viewpoint, uniting this new perspective with the totality of knowledge in the field and introducing mathematical techniques gradually as the reader studies the standard topics. While it treats traditional topics in a general way, it frequently adds a non-traditional approach through the new geometrical methods—for instance, recent developments in the variance of mechanical systems under perturbation and Lie algebra techniques are introduced. Chapter headings: 1. Kinematics, 2. Newtonian Dynamics, 3. Lagrangian Dynamics, 4. The Dynamics of Rigid Bodies, 5. The Dynamics of Small Oscillations, 6. Invariants of the Motion, 7. Hamiltonian Dynamics, 8. Dynamics on Phase Space, 9. Action-Angle Variables, 10d. Algebraic Aspects of Motion.

Semi-Riemannian Geometry. By Barrett O'Neill. Academic Press, New York, 1983. 1 + 439 pp. $45.00

This book is an exposition of semi-Riemannian geometry—the study of a smooth manifold furnished with a metric tensor of arbitrary signature. The principal special cases are Riemannian geometry, where the metric is positive definite, and Lorentz geometry. After establishing the requisite language of manifolds and tensors (Chapters 1 and 2), the plan of the book is to develop the foundations of semi-Riemannian geometry in the simplest way and without regard to signature, allowing the Riemannian and Lorentz cases to appear as needed (Chapter 3–4 and 7). In the latter half of the book two threads are followed. One uses the notion of isometry to develop algebraic aspects of semi-Riemannian geometry: manifolds of constant curvature, symmetric spaces, and homogeneous spaces (Chapters 8, 9, and 11): the other thread applies Lorentz geometry to special and general relativity (Chapters 6, 12, and 13). The tendency of the spacetimes in Chapters 12 and 13 to have singularities (big bang and black holes) is accounted for in abstract Lorentz terms by two theorems, due respectively to S. W. Hawking and R. Penrose; these are the goals of Chapter 14. The basis prerequisites for the book are a good working knowledge of multivariable differentiall calculus and ordinary differential equations, an acquaintance with the fundamentals of point set topology and algebra, a knowledge of fundamental groups, covering spaces, and Lie groups; the necessary background in these latter topics is outlined briefly in Appendixes A and B. A college course in physics (particularly Newtonian mechanics) is required to appreciate the transformation and unification of Newtonian concepts effected by Einstein's relativistic geometry.