

QUARTERLY
OF
APPLIED MATHEMATICS

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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.

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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,

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

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

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

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 nonabsorbent 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.

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Stopped Random Walks: Limit Theorems and Applications. By Allan Gut. Springer-Verlag, New York, 1988. pp. viii+199. \$44.00.

This is volume 5 of Applied Probability, a Series of the Applied Probability Trust. This book presents the theory of randomly indexed random walks, emphasizing both its applications and its intrinsic interest. It is its purpose to present the theory of limit theorems for randomly indexed random walks, to show how these results can be used to prove limit theorems for renewal counting processes, first passage time processes for random walks with positive drift and certain two-dimensional random walks and, finally, how these results, in turn, are useful in various kinds of applications. Chapter headings: 1. Limit theorems for stepped random walks. 2. Renewal processes and random walks. 3. Renewal theory for random walks with positive drift. 4. Generalizations and extensions. 5. Functional limit theorems.

Elements of Statistics for the Life and Social Sciences. By Braxton M. Alfred. Springer-Verlag, New York, 1987. pp. xiii+190. \$36.00.

This is a volume in the series Springer Texts in Statistics. In spite of its title, this is not the usual standard introductory statistics text for the life and social sciences. The main emphasis is on anthropology, the author's field of expertise. Counted data are exclusively the subject of analysis. Considerable attention is given to formal structured arguments. Concern is confined to statements which, by definition, are either true or false. After an introductory chapter, Chapter 2 considers formally the structure of arguments, and the propositional analysis of four common argumental structures is presented. Chapter 3 addresses the matters of inductive argument, the scientific program, and the conditions necessary for a good test of a hypothesis. In Chapter 4 the problem of deducing observation from hypothesis is considered, and in Chapter 5 are presented techniques for testing a variety of hypotheses with frequency (categorical) data. Chapter headings: 1. Introduction. 2. Some elementary principles of deductive argument. 3. The logic of scientific argument. 4. Generating predictions. 5. Topics in hypothesis testing. 6. Summary and conclusions.

Stationary Sequences and Random Fields. By Murray Rosenblatt. Birkhäuser, Boston, 1985. pp. i+258.

This book has the dual purpose of providing a text for a course in time series analysis covering both the finite parameter and the spectral approach, and to present topics of current research interest and some open questions. Among such topics are: higher-order spectral methods under broader conditions of validity; asymptotic behaviour of covariance and spectral estimates presented under the assumption of asymptotic independence or strong mixing; random fields and aspects of their structure, and concepts and statistical methods effective for them, such as those applied in the study of turbulence; estimates of phase appropriate for non-Gaussian linear processes with construction of procedures effective in the deconvolution of such processes; analysis of the problems of interpolation or prediction for random fields. Chapter headings: 1. Stationary processes. 2. Prediction and moments. 3. Quadratic forms, limit theorems and mixing conditions. 4. Estimation of parameters of finite-parameter models. 5. Spectral density estimates. 6. Cumulant spectral estimates. 7. Density and regression estimates. 8. Non-Gaussian linear processes.

Selected Papers on Algebra and Topology by Garrett Birkhoff. Edited by Gian-Carlo Rota and Joseph S. Oliveria. Birkhäuser, Boston, 1987. pp. xvii+608. \$78.00.

The present volume of reprints are what Professor Birkhoff considers to be his most interesting and influential papers on algebra and topology. To tie them together, and to place them in context, he has supplemented them by a series of brief essays sketching their historical background. In addition to these, he has listed some subsequent papers by others which have further developed some of his ideas. In the introduction to each part, Professor Birkhoff stated the most significant features of each paper reprinted there, and indicated later developments. There is also a bibliography of Birkhoff's books and papers from 1933 to 1986, and a list of his Ph.D. students. The papers are grouped under six headings: 1. Lattices. 2. Universal algebra. 3. Topology. 4. Lie groups and Lie algebras. 5. Lattice ordered algebraic structures. 6. History of algebra.

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Direct Methods for Sparse Matrices. By I. S. Duff, A. M. Erisman, and J. K. Reid. Oxford University Press, New York, 1987. pp. xiii+341. \$42.50.

This is a volume in the series Monographs on Numerical Analysis, in Oxford Science Publications. Large sparse matrices occur in many fields of application, such as management science, power systems analysis, surveying, circuit theory, and structural analysis. It has become apparent in recent years that systems containing such matrices can be solved even when the pattern is irregular, and it is primarily to the solutions of such problems that this book is devoted. The subject is practical, and this is recognized in the treatment given here. However, many aspects of the subject have an interest in their own right, and this is recognized in making the book suitable for a course. Chapter headings: 1. Introduction. 2. Sparse matrices: Storage schemes and simple operations. 3. Gaussian elimination for dense matrices: The algebraic problem. 4. Gaussian elimination for sparse matrices: Numerical considerations. 5. Gaussian elimination for sparse matrices: An introduction. 6. Reduction to block triangular form. 7. Local pivotal strategies for sparse matrices. 8. Ordering sparse matrices to special forms. 9. Implementing Gaussian elimination: ANALYSE with numerical values. 10. Implementing Gaussian elimination with symbolic ANALYSE. 11. Partitioning, matrix modification, and tearing. 12. Other sparsity-oriented issues.

Matrices for Statistics. By M. J. R. Healy. Oxford University Press, New York, 1987. pp. ix+89. \$22.50.

This is a volume in Oxford Science Publications. It is written from the perspective that statisticians and users of statistical methods require for their study of matrices something rather different from the standard mathematical textbook; it is the author's hope that the treatment given here will enable such readers to obtain a deeper insight into the mathematical underpinning of the techniques on which they rely. Chapter headings: 1. Introducing matrices. 2. Determinants. 3. Inverse matrices. 4. Linear dependence and rank. 5. Simultaneous equations and generalized inverses. 6. Linear spaces. 7. Quadratic forms and eigensystems. 8. Matrix calculations.

Design, Data and Analysis: by some friends of Cuthbert Daniel. Edited by Colin L. Mallows. John Wiley & Sons, New York, 1987. pp. xix+380. \$29.95.

This is a volume in the Wiley Series in Probability and Mathematical Statistics. It is a compilation by prominent statisticians in recognition of Cuthbert Daniel's long career and significant contributions to statistics. There are seventeen chapters, devoted to topics in the analysis of data, including techniques for selecting a subset of variables, experiments and analysis in biology, the use of accounting data to measure productivity, analysis of psychometric data, etc. The expository material includes factorial and fractional factorial experiments, blocking, response surface analysis, Evolutionary Operation, components-of-variance models and nested experiments, and an introduction to Taguchi's ideas in process design. Two chapters address design issues, looking into the use of latin squares for the three factor case, and describing how a two-stage procedure can be used to ensure that certain calibration standards conform to desired tolerances. Experiments are presented with full data and analyses performed by the people directly responsible. Contributors include George Box, John Tukey, Frank Hampel, J. Stuart Hunter, Barry Margolin, Lincoln Moses, and other prominent practitioners of the art and science of data analysis.

Machine Intelligence and Knowledge Engineering for Robotic Applications. Edited by Andrew K. C. Wong and Alan Pugh. Springer-Verlag, New York, 1987. pp. xiv+486. \$79.00.

This is volume 33 of Series F: Computer and Systems Sciences, of the NATO Advanced Science Institute Series. The NATO Advanced Research Workshop on Machine Intelligence, of which these are the Proceedings, was held at Marata, Italy, May 12-16, 1986. The nineteen papers are grouped into five sections, entitled: 1. Robot vision. 2. Knowledge representation and image understanding. 3. Robot control and inference systems. 4. Task planning and expert systems. 5. Software/hardware systems.

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Classic Papers in Combinatorics. Edited by Ira Gessel and Gian-Carlo Rota. Birkhäuser, Boston, 1987. pp. x+489. \$60.00.

This volume surveys the development of combinatorics since 1930 by presenting in chronological order the fundamental results of the subject proved in the original papers, beginning with the celebrated theorem of Ramsey, originally developed in the context of the problem of finding a regular procedure to determine the truth or falsity of any given logical formula (the "Entscheidungsproblem"), and ending with Geissinger's definitive three 1973 papers on the theory of Möbius functions. In all, there are 39 papers reprinted.

A First Look at Perturbation Theory. By James G. Simmonds and James E. Mann, Jr., Robert E. Krieger Publishing Co., Malibar, Florida, 1986. pp. vii+136. \$12.50.

This book, written in an informal style and emphasizing heuristics and based on class notes, expects from the reader a background consisting only of two semesters of one-variable calculus and one semester of ordinary differential equations. Chapter headings: 1. Introduction and overview. 2. Roots of polynomials. 3. Singular perturbations in ordinary differential equations. 4. Periodic solutions of the simplest nonlinear differential equations. Poincaré's method. 5. Introduction to the two-scale method. 6. The WKB(J) approximation. 7. Transition point problems and Langer's method of uniform approximation. 8. Introduction to boundary layer theory. 9. Cables and cells: Ancient and modern problems.

Stochastic Differential Systems: Analysis and Filtering. V. S. Pugachev and I. N. Sinityn. John Wiley & Sons, New York, 1987. pp. xx+549. \$95.00.

This work, first published in Russian, was translated by the second author and edited by the first. The original was based on lectures delivered by the two authors to students of the Moscow Aviation Institute and of the Moscow High Technical School, respectively. It is principally addressed to applied mathematicians. Applied methods are given for studying stochastic differential systems, in particular methods for finding finite-dimensional distributions of the state vector and of the output of such systems and also estimation methods of the state and of the parameters of differential systems based on observations (filtering and extrapolation theory). Chapter headings: 1. Differential systems. 2. Random functions. 3. Stochastic integrals, differentials and differential equations. 4. Stationary random functions. 5. Theory of stochastic differential systems. Linear systems. 6. Nonlinear stochastic differential systems. 7. Theory of optimal filtering. Linear filtering. 8. Suboptimal filtering. 9. Conditionally optimal filtering and extrapolation.

The Beauty of Fractals: Images of Complex Dynamical Systems. By H.-O. Peitgen and P. H. Richter. Springer-Verlag, New York, 1986. pp. xii + 199. \$35.00.

This beautiful and original book, translated from the German by Howard and Irene Schultens, has its origin in an exhibition "Beauty in Chaos/Frontiers of Chaos" held in Bremen, Germany, in collaboration with the Goethe Institute. Two essays, "Frontiers of Chaos" and "Magnetism and Complex-Boundaries", explain the background to the nonspecialist. There are four invited contributions: Benoit B. Mandelbrot reports his discovery of the Mandelbrot set that plays such a central role in the exhibition. He also gives a rather personal account of fractal geometry. Adrien Douady recounts what is known and what is mysterious about the Mandelbrot set. Gert Eilenberger, a physicist, describes the symbolic meaning that the pictures may have within the changing comprehension of nature. Herbert W. Frank, one of the pioneers of computer graphics, reports on his own experiences and draws a number of inferences from them. The pictures selected for this volume are essentially those in the exhibition. They were chosen from several hundred experiments carried out in the authors' laboratory in Bremen. There are eight more technical papers, entitled: 1. Verhulst dynamics; 2. Julia sets and their computergraphical generation; 3. Sullivan's classification of critical points; 4. The Mandelbrot set; 5. External angles and Hubbard trees; 6. Newton's method for complex polynomials; 7. Newton's method for real equations; 8. A discrete Volterra-Lotka system.

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Methods of Representation Theory, with Applications to Finite Groups and Orders, Volume II. By Charles W. Curtis and Irving Reiner. John Wiley & Sons, New York, 1987. pp. xv+949. \$95.00.

This is a volume in the series Pure and Applied Mathematics, founded by Richard Courant. The authors' main objective has been to present an accessible, self-contained, and detailed introduction to the contributions of R. Brauer, J. A. Green, G. Lusztig and R. G. Swan, which not only have set the foundations but have also established close ties between representation theory and the theory of finite groups, algebraic number theory, and algebraic geometry and topology. Chapter headings: 5. Algebraic K -theory. 6. Class groups of integral group ring orders. 7. The theory of blocks. 8. The representation theory of finite groups of Lie type. 9. Rationality theory. 10. Indecomposable modules. 11. The Burnside ring and the representation ring of a finite group.

Nonlinear Approximation Theory. By Dietrich Braess. Springer-Verlag, New York, 1986. pp. xiv+290.

This is volume 7 in the Springer Series in Computational Mathematics. Although this monograph is directed to researchers, it is also the author's intention for it to be used as a text for students. It grew out of lectures which the author gave to fourth-year students at German universities, where the background consisted of a good basic knowledge of analysis and functional analysis. Chapter headings: 1. Preliminaries. 2. Nonlinear approximation: The functional analytic approach. 3. Methods of local analysis. 4. Methods of global analysis. 5. Rational approximation. 6. Approximation by exponential sums. 7. Chebyshev approximation by γ -polynomials. 8. Approximation by Spline functions with free nodes.

A Diary on Information Theory. By Alfréd Rényi. John Wiley & Sons, New York, 1987. pp. ix+125.

This is a volume in the Wiley Series in Probability and Mathematical Statistics. It may be looked upon as a continuation of the late author's books, *Dialogues in Mathematics*, and *Letters on Probability*. It consists of five essays: 1. On the mathematical notion of information. 2. Games of chance and probability theory. 3. Notes on the teaching of probability theory. 4. Variations on a theme by Fibonacci. 5. The mathematical theory of trees. It, too, was not written with the aim of teaching a particular field of mathematics. Its intent is to explain what mathematics is, what it can contribute to our everyday lives, how it can further the development of how we think, and how we can enjoy its beauty.

A Handbook of Fourier Theorems. By D. C. Champeney. Cambridge University Press, New York, 1987. pp. xi + 185. \$39.50.

This handbook is intended to assist those scientists, engineers, and applied mathematicians who are already familiar with Fourier theory and its applications in a nonrigorous way, but who wish to find out the exact mathematical conditions under which particular results can be used. The core of the book consists of rigorous statements of the most important theorems in Fourier theory, together with explanatory comments and examples, and this occupies Chapters 6–16. This is preceded, in Chapters 1–5, by an introduction to the terminology and the necessary ideas in mathematical analysis including, for instance, the interpretation of Lebesgue integrals. Chapter headings: 1. Introduction. 2. Lebesgue integration. 3. Some useful theorems. 4. Convergence of sequences of functions. 5. Local averages and convolution kernels. 6. Some general remarks on Fourier transformations. 7. Fourier theorems for good functions. 8. Fourier theorems in L^p . 9. Fourier theorems for functions outside L^p . 10. Miscellaneous theorems. 11. Power spectra and Wiener's theorems. 12. Generalized functions. 13. Fourier transformations of generalized functions I. 14. Fourier transformations of generalized functions II. 15. Fourier series. 16. Generalized Fourier series.

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An Introduction to the Theory of the Riemann Zeta-Function. By S. J. Patterson. Cambridge University Press, New York, 1988. pp. xiii + 156. \$34.50.

This is volume 14 in Cambridge Studies in Advanced Mathematics. It is the purpose of the book to explain the striking connection of the continuous and the discrete through the example of the Riemann zeta-function—a meromorphic function whose properties can on the one hand be investigated by the techniques of complex analysis (the continuous), and on the other hand yield difficult theorems concerning the integers (the discrete). The book is intended to be an introduction to this beautiful subject. It consists of a main part and seven appendices which serve to summarize the background mathematics needed. Chapter headings: 1. Historical introduction. 2. The Poisson summation formula and the functional equation. 3. The Hadamard product formula and ‘explicit formulae’ of prime number theory. 4. The zeros of the zeta-function and the prime number theorem. 5. The Riemann hypothesis and the Lindelöf hypothesis. 6. The approximate functional equation.

Real-Variable Methods in Harmonic Analysis. By Alberto Torchinski. Academic Press, New York, 1986. pp. xii + 462. \$89.00.

This is volume 123 in Pure and Applied Mathematics, A Series of Monographs and Textbooks. It is based on a set of notes from a course the author gave at Indiana University during the academic year 1984–1985. His purpose in these lectures was to present some recent topics in harmonic analysis to graduate students with varied backgrounds and interests, ranging from operator theory to partial differential equations. The book is an exploration of the unity of several areas in harmonic analysis, emphasizing real-variable methods, and leading to active areas of research including the Calderón–Zygmund theory of singular integral operators, the Muckenhoupt theory of A_p weights, the Fefferman–Stein theory of H^p spaces, the Burkholder–Gundy theory of good λ inequalities, and the Calderón theory of commutators.

The Complexity of Boolean Functions. By Ingo Wegner. John Wiley & Sons, New York, 1987. pp. xi + 457. \$44.95.

This is a volume in the Wiley–Teubner Series in Computer Science; in it, the author describes the latest state of research concerning results and methods in the field. Apart from the classic circuit model and the parameters of complexity, circuit size and depth, providing the basis for sequential and parallel computations, numerous other models are analyzed, among them monotone circuits, Boolean formulas, synchronous circuits, probabilistic circuits, programmable (universal) circuits, bounded depth circuits, parallel random access machines and branching programs. Relationships between various models are studied, and also the relationship to the theory of complexity and uniform computation models.

Lectures on Bochner-Riesz Means. By Katherine Michelle Davis and Yang-Chung Chang. Cambridge University Press, New York, 1987. pp. ix + 150.

This is volume 114 of the London Mathematical Society Lecture Notes Series. The purpose of the book is to give a self-contained exposition of the geometric theory of Bochner-Riesz means. The subject deals with the question of when a Fourier series converges to its original function. Substantial progress was made in the mid 1970’s, but the techniques are still available only in the technical literature. The authors’ intent is to present an account accessible to graduate students. They have assumed that the reader is familiar with real analysis at a graduate level, and with basic facts about distributions and the Fourier transform. Chapter headings: 1. Multiplier theory. 2. The Hilbert transform. 3. Good lambda and weighted norm inequalities. 4. Multipliers with singularities. 5. Singularities along curves. 6. Restriction theorems. 7. The multiplier theorem for the disc. 8. The Cordoba multiplier theorem.

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Riemann, Topology, and Physics. By Michael Monastyrsky. Birkhäuser, Boston, 1987. pp. xiii + 158. \$39.50.

This is a translation from the Russian by James and Victoria King and was edited by R. O. Wells, Jr. It consists of two independent parts: "Bernhard Riemann" and "Topological Themes in Contemporary Physics". There is a foreword by Freeman J. Dyson, elucidating the background of the author and his themes. The book represents a historical as well as contemporary perspective on the relationship between topology and physics, with the person of Riemann being a key historical link. The first part deals with the life and research activity of Bernhard Riemann. The second part of the book discusses various applications of topology to contemporary physics, mainly pertaining to two of its branches: field theory and condensed matter, including liquid crystals and superfluid liquids.

Heat Conduction. By James M. Hill and Jeffrey N. Dewynne. Blackwell Scientific Publications, Inc., Palo Alto, Ca., 1987. pp. xvi + 334. \$39.95.

This is the first volume in the series Applied Mathematics and Engineering Science Texts. It is intended as a modern undergraduate text which reflects the importance of the heat equation in applied mathematics and mathematical modelling, and which also is intermediate to the classical treatise of H. S. Carslaw and J. C. Jaeger. The authors have attempted to provide a balanced account of solutions and results for the heat equation. They have adopted the strategy of bringing together the simplest and most useful results from many diverse areas of mathematics. More complicated results are summarized as problems at the end of each chapter. The first two chapters of the book are introductory and serve to summarize the essential elements of heat flow and to a certain extent diffusion and the mathematical formulation and simple general results. The next two chapters develop exact analytical solutions, obtained by Laplace transforms and Fourier series, for infinite and finite media problems, respectively. The chapter thereafter deals with approximate analytical solutions based on the heat-balance integral method. The final two chapters of the book deal, respectively, with numerical methods for the heat equation and simple heat conditions moving boundary problems. Chapter headings: 1. Introduction. 2. Mathematical preliminaries. 3. Exact analytical solutions for semi-infinite media. 4. Exact analytical solutions by Fourier series. 5. Approximate analytical solutions by heat-balance. 6. Numerical solutions. 7. Melting or freezing moving boundary problems.

Computational Fluid Dynamics and Reacting Gas Flows. Edited by B. Engquist, M. Luskin, and A. Majda. Springer-Verlag, New York, 1988. pp. 1 + 346. \$33.50.

This is volume 12 of the IMA Volumes in Mathematics and its Applications. It is in part the proceedings of a workshop held at the Institute of Mathematics and its Applications at the University of Minnesota during September, 1986. It contains 15 papers. In the workshop, more traditional fields were mixed with fields of emerging importance such as reacting gas flows and non-Newtonian flows.

Mathematical Aspects of Scientific Software. Edited by J. R. Rice. Springer-Verlag, New York, 1988. pp. xi + 208. \$21.00.

This is volume 14 in the IMA Volumes in Mathematics and its Applications. It is in part the proceedings of a workshop held at the Institute of Mathematics and its Applications at the University of Minnesota. The focus is on five topics, viz., the new subfields of parallel and geometric computations, the emergence of symbolic computation systems into general use, the potential emergence of new, high-level mathematical systems, and the crucial question of how to measure the performance of mathematical problem-solving tools. There are nine papers, including a survey paper by the editor.

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An Introduction to Independence for Analysis. By H. G. Dales and W. H. Woodin. Cambridge University Press, New York, 1987. pp. xiii + 241. \$29.95.

This is volume 115 of the London Mathematical Society Lecture Notes Series. The purpose of this book is to explain what it means for a proposition to be independent of set theory, and to describe how independence results can be proved by the technique of forcing. Chapter headings: 1. Homomorphisms from algebras of continuous functions. 2. Partial orders, Boolean algebras, and ultraproducts. 3. Woodin's condition. 4. Independence in set theory. 5. Martin's axiom. 6. Gaps in ordered sets. 7. Forcing. 8. Iterated forcing.

Homotopy Theory. Edited by E. Rees and J. D. S. Jones. Cambridge University Press, New York, 1987. pp. vii + 247. \$29.95.

This is volume 117 in the London Mathematical Society Lecture Notes Series. It is the proceedings of a symposium held at Durham University in August 1985. There are ten lectures.

Skew Linear Groups. By M. Shirvani and B. A. F. Wehrfritz. Cambridge University Press, New York, 1987. pp. 1 + 253. \$22.98.

This is volume 118 in the London Mathematical Society Lecture Notes Series. It is concerned with subgroups of groups of the form $GL(n, D)$ for some division ring D . In it the authors bring together many of the recent advances in the theory of skew linear groups. Some aspects of skew linear groups are similar to those for linear groups. However, there are often significant differences either in the method of proof or the results themselves. Topics covered in this volume include irreducibility, unipotency, locally finite-dimensional division algebras, and division algebras associated with polycyclic groups.

Non-Classical Continuum Mechanics. Edited by R. J. Knops and A. A. Lacey. Cambridge University Press, New York, 1987. pp. xii + 335. \$37.50.

This is volume 122 in the London Mathematical Society Lecture Notes Series. It contains most of the invited lectures of the London Mathematical Society Symposium in Dublin, July, 1986. One objective of the Symposium was to provide the opportunity of interaction between two broad trends now discernible in continuum mechanics which respectively emphasize applications and rigorous mathematical analysis. Part I contains six Principal Lectures and Part II fourteen Single Invited Lectures.

Commutator Theory for Congruence Modular Varieties. By Ralph Freese and Ralph McKenzie. Cambridge University Press, New York, 1987. pp. 1 + 227. \$27.95.

This is volume 125 in the London Mathematical Society Lecture Notes Series.

New Directions in Dynamical Systems, Edited by T. Bedford and J. Swift. Cambridge University Press, New York, 1988. pp. xiii + 283. \$34.50.

This is volume 127 in the London Mathematical Society Lecture Notes Series. It is associated with the conference on "Theoretical and Numerical Problems in the Study of Chaotic Ordinary Differential Equations" held at King's College, Cambridge in June and July, 1986, and contains the following lectures: Universality and renormalization in dynamical systems, by David Rand; Smooth dynamics on the interval (with an emphasis on quadratic-like maps), by Sebastian van Strien; Global bifurcation flows, by Paul Glendinning; Knots and orbit genealogies in nonlinear oscillators, by Philip Holmes; Limit cycles of polynomial systems—some recent developments, by N. G. Lloyd; Bifurcations with symmetry, by Ian Stewart.

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Numerical Treatments of Eigenvalue Problems, vol. 4. Edited by J. Albrecht, L. Collatz, W. Velte, and W. Wunderlich. Birkhäuser, Boston, 1987. pp. 1 + 242.

This is volume 83 of the International Series of Numerical Mathematics. It is the proceedings of a conference held at the Mathematical Research Institute in Oberwolfach in December, 1986. Focal points during the meeting were eigenvalue problems in the engineering sciences and in industry, methods for calculating bounds for eigenvalues, and matrix eigenvalue problems. Central to the lectures on eigenvalue problems were oscillation and stability problems; for these, numerical treatment drew mainly on finite-element methods, questions concerning the quality of the mathematical models applied, and the choice of appropriate finite elements. Other lectures addressed new research results in the calculation of (primarily lower) bounds of eigenvalues. The extensive use of finite-element methods has led to new research in matrix eigenvalue problems, and several lectures reported on results which have been achieved in this area. There are 19 lectures.

Introduction to the Analysis of Metric Spaces. By J. R. Giles. Cambridge University Press, New York, 1987. pp. xiv + 257. \$49.50 hardcover, \$16.95 paperback.

This is volume 3 in the Australian Mathematical Society Lecture Series. It is designed as a basic introductory course in the analysis of metric and normed linear spaces for undergraduate students. It is aimed at providing the abstract analysis components for the degree course of a student majoring in mathematics or an honors student majoring in science or engineering. Chapter headings: 1. Metric spaces and normed linear spaces. 2. Limit processes. 3. Continuity. 4. Compactness. 5. The metric topology.

Fuzzy Sets and Applications: Selected Papers by L. A. Zadeh. Edited by R. R. Yager, S. Ovchinnikov, R. M. Tong, and H. T. Nguyen. John Wiley & Sons, New York, 1987, pp. 1 + 684. \$49.95.

This volume celebrated the 20th anniversary (in 1985) of the publication of the first paper on fuzzy sets. There is also a text of an interview with Lofti A. Zadeh entitled "Coping with the Imprecision of the Real World."

Whitehead Groups of Finite Groups. By Robert Oliver. Cambridge University Press, New York, 1988. pp. 1 + 349. \$34.50.

This is volume 132 in the London Mathematical Society Lecture Notes Series. This book aims to make accessible techniques for studying Whitehead groups of finite groups, as well as a variety of related topics such as induction theory and p -adic logarithms. The author has included a lengthy introduction to set the scene for nonspecialists who want an overview of the field, its history and its applications. The rest of the book consists of three parts: general theory, group rings of p -groups and general finite groups.

Model Theory and Modules. By Mike Prest. Cambridge University Press, New York, 1988. pp. xviii + 380. \$37.50.

This is volume 130 in the London Mathematical Society Lecture Notes Series. In this book, the theme is the interplay between model theory and the theory of modules. It is intended to be a self-contained introduction to the subject and introduces the requisite model theory and the module theory as it is needed. The author develops the basic ideas concerning what can be said about modules using the information which may be expressed in a first-order language. Later chapters discuss stability-theoretic aspects of modules, and the structure and classification theorems over various types of rings and for certain classes of modules.

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Iterative Aggression Theory: Mathematical Methods of Coordinating Detailed and Aggregate problems in Large Control Systems. By Lev M. Dudkin, Ilya Rabinovich, and Ilya Vakutinsky. Marcel Dekker, New York, 1987. \$89.75.

This is volume 111 in the series Pure and Applied Mathematics. Iterative aggression methods are a new class of iterative mathematical models which appeared as a result of research into the problem of rigorously coordinating aggregated calculations at higher levels of planning systems with detailed calculations at lower levels of the systems. They can be used to describe the functioning of existing or projected hierarchical systems, where the task of coordinating problems with different levels of aggregation of information appears. The six chapters are divided into three parts, two chapters each: 1. Review of contemporary methods of mathematical programming. 2. Iterative aggregation algorithms for solving systems of equations. 3. Iterative aggregation algorithms for solving extremum problems.

Methods of Complex Analysis in Partial Differential Equations with Applications. By Manfred Kracht and Erwin Kreyszig. John Wiley & Sons, New York, 1988. pp. xiv + 394. \$54.95.

This is a volume in the Canadian Mathematical Society Series of Monographs and Advanced Texts. The book is devoted to the development of complex function theoretic methods in partial differential equations and to the study of the analytic behavior of solutions. The main purpose of the book is the presentation of some basic facts and recent results, emphasizing the method of integral operators. The book may be divided into three parts as follows. First, it investigates the existence and representation theory of integral operators and differential operators that transform analytic functions of one complex variable into solutions of linear second-order partial differential equations (Chapters 2–7). Second, the results of the preceding chapters are applied to exploit the theory of analytic functions of one complex variable in the study of solutions of partial differential equations (Chapters 8–10). Third, it discusses applications of the theory in the case of three classes of equations that are of special significance in mathematical physics (Chapters 11–13). Chapter headings: 1. Introduction. 2. Bergman operators: general theory. 3. Integral operators with polynomial kernels and differential operators. 4. Polynomial kernels: existence and construction. 5. Further closed-form kernels. 6. Riemann–Vekua representation and further methods related to Bergman kernels. 7. Determination of Riemann functions. 8. Coefficient problem and singularities of solutions. 9. Approximation of solutions. 10. Value distribution theory of solutions. 11. Applications of class P operators. Function theory of the Bauer–Peschl equation. 12. Application to compressible fluid flow. 13. Integral operators applied to transonic flow. Tricomi equation.

Surveys in Combinatorics, 1987. Edited by C. Whitehead. Cambridge University Press, New York, 1987. pp. 1 + 226. \$27.95.

This is volume 123 in the London Mathematical Society Lecture Notes Series. It is the proceedings of the Eleventh British Combinatorial Conference, held at the University of London's Goldsmiths' College in July, 1987. There are nine lectures.

Trigonometric Series: Second Edition—Volumes I and II Combined. By A. Zygmund. Cambridge University Press, New York, 1988. pp. Vol I: ix + 383, Vol II: 1 + 364. \$44.50.

This is a volume in the Cambridge Mathematical Library, and is an unabridged reprint of the greatly enlarged 1959 two-volume edition of this famous classic, first published in Warsaw in 1935. The two volumes here are bound together.