# 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.

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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."

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**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 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

**Vol. XLIX, No. 3** **September 1991**

*Linear Operators in Spaces with an Indefinite Metric.* By T. Ya. Azizov and I. S. Iokhvidov. John Wiley & Sons, 1989. xi+304 pp., $82.95.

This is a volume in the series Pure and Applied Mathematics. It is a translation, by E. R. Dawson, of the Russian original published by Nauka Publishing House, Moscow. In it, the authors develop the foundations of the title subject on the basis of the geometry of spaces with an indefinite metric (chiefly Krein and Pontryagin spaces). After an introductory chapter, the book gives a full account of the theory of operators, including the theory of invariant subspaces, spectral questions, and the question of the extension of operators. Some applications are also described. Problems are provided at the end of each section, and there is an extensive bibliography. The subject has applications in differential equations, moment problems, damped oscillations of mechanical systems, representation theory of groups, geometry, theoretical physics, etc.

*A Course in Mathematics for Students of Physics, Vol.* I. By Paul Bamberg and Shlomo Sternberg. Cambridge University Press, 1988. xvii+405 pp., $49.50.

This book represents the text of a course the authors have been teaching at Harvard for the past eight years. It is aimed at students with an interest in Physics who have a good grounding in one-variable calculus. Some prior acquaintance with linear algebra is helpful but not necessary. The main topics of the course are the theory and physical application of linear algebra, and of the calculus of several variables, particularly the exterior calculus. Chapter headings: 1. Linear transformations of the plane; 2. Eigenvectors and eigenvalues; 3. Linear differential equations in the plane; 4. Scalar products; 5. Calculus in the plane; 6. Theorems of the differential calculus; 7. Differential forms and line integrals; 8. Double integrals; 9. Gaussian optics; 10. Vector spaces and linear transformations; 11. Determinants.

*Numerical Simulation and Optimal Control in Plasma Physics with Applications to Tokamaks.* By Jaques Blum. John Wiley & Sons, 1989. xvi+363 pp., $77.95.

This translation, by D. Chillingworth, from the French is a volume in the Wiley/Gauthier-Villars Series in Modern Applied Mathematics. The subject of this monograph is the modeling, numerical simulation, and optical control of equilibrium of the plasma in a Tokamak, an experimental device which confines plasma in a magnetic field in such a way as to control the nuclear fusion of atoms of low mass (hydrogen, deuterium, tritium). The equations which model the plasma are those of magnetohydrodynamics. The first five chapters of the book deal with the stationary problem of axisymmetric equilibrium of the plasma. The last two chapters trace the evolution of equilibrium on the time-scale of thermal diffusion in the plasma, studying the problem of stability and dynamic control of displacements of the plasma.

*Set-Value Analysis.* By Jean-Pierre Aubin and Helene Frankowska. Birkhäuser, Boston, 1990. xix+461 pp.

This is volume 2 in the series Systems and Control: Foundations and Applications. The authors quote as motivating applications for set-valued analysis: control theory and differential games, mathematical economics and game theory, biology and systems science, qualitative physics and viability theory, artificial intelligence. However, this book presents only the tools, not the applications themselves, for which references are given (the bibliography has 468 items!). The chapter headings indicate the scope of this monograph: 1. Continuity of set-valued maps; 2. Closed convex processes; 3. Existence and stability of an equilibrium; 4. Tangent cones; 5. Derivatives of set-valued maps; 6. Epiderivatives of extended functions; 7. Graphical and epigraphical convergence; 8. Measurability and integration of set-valued maps; 9. Selections and parametrizations; Differential inclusions.

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*Ordinary and Partial Differential Equations* II. Edited by B. D. Sleeman and R. J. Jarvis. John Wiley & Sons, 1989. 227 pp., $38.00.

This is volume 216 in the Pitman Research Notes in Mathematics Series. This volume arose from the tenth Dundee Conference, held at the University of Dundee in July 1988. Special emphasis is given to nonlinear wave propagation, continuum mechanics, and biology. The topics covered include reaction-diffusion equations, dynamical systems, waves in excitable media, bifurcation including pattern formation and nonlinear boundary value problems, limit cycles in polynomial systems and Hilbert's 16th problem, eigenvalue problems, the Weyl conjecture and fractal domains, Wiener-Hopf methods in scattering theory, and problems in elasticity.

*Volterra Integrodifferential Equations in Banach Spaces and Applications.* Edited by G. Da Prato and M. Iannelli. John Wiley & Sons, 1989. 404 pp., $49.00.

This is volume 190 in the Pitman Research Notes in Mathematics Series. It collects 33 contributions to a conference held in Trento, Italy, February 2–7, 1987. Many are devoted to abstract equations, and questions such as existence, regularity, and well-posedness. Others are concerned with applications, principally to viscoelasticity theory.

*Radical Theory.* By B. J. Gardner. John Wiley & Sons, 1989. 198 pp., $49.95.

This is volume 198 in the Pitman Research Notes in Mathematics Series. The origin of this subject, now known as Kurosh-Amitsur radical theory, is seen in earlier work on structure theory for rings and algebras, but has now evolved into an autonomous algebraic sub-discipline. This book is an introduction to the subject.

*Riemannian Geometry and Holonomy Groups.* By Simon Salamon. John Wiley & Sons, 1989. 201 pp., $47.95.

This is volume 201 in the Pitman Research Notes in Mathematics Series. This research note gives a self-contained account of various aspects of Riemannian geometry arising from the definition of holonomy group. It provides an introduction to topics such as torsion, curvature, and homogeneous spaces, emphasizing the role played by representations of Lie groups and Lie algebras. These notes represent an expanded version of a 1986 lecture course at Oxford.

*Strong Asymptotics for Extremal Errors and Polynomials Associated with Erdös-type Weights.* By D. S. Lubinsky. John Wiley & Sons, 1989. 240 pp.

This is volume 202 in the Pitman Research Notes in Mathematics Series. Orthogonal polynomials are widely applied in approximation theory, numerical analysis, combinatorics, statistics, and mathematical physics. In recent years, there has been an extensive program to determine the asymptotic behavior (as the degree of the polynomial approaches infinity) of orthogonal polynomials associated with weights on the whole real line. This research note forms part of this program.

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*Complex Analysis: Articles Dedicated to Albert Pfluger on the Occasion of his 80th Birthday.* Edited by Joseph Hersch and Alfred Huber. Birkhäuser Verlag AG, 1988. xii+245 pp., $72.50.

This volume contains 22 articles pertaining to subjects such as conformal and quasiconformal mappings and related extremal problem, Riemann surfaces, meromorphic functions, subharmonic functions, approximation and interpolation, and other questions of complex analysis. There is also a bibliography of Pfluger's publications and a sketch of his career (he was Polya's successor at the ETH, Zurich).

*Mechanics, Boundary Layers, and Function Spaces.* By Diarmuid O. Mathuna. Birkhäuser, Boston, 1989. 215 pp., $42.50.

In the theory of elastic plates and shells, many features of the contraction from a three- to a two-dimensional theory remain obscure. The present work is aimed at clarifying for the static case, within the framework of the linearized theory of elasticity, the precise significance of the simpler theory, by means of an equally precise formulation of the complementary problem. This is effected through a complete and systematic integration, with respect to the thickness coordinate, of the full three-dimensional equations; this integration is facilitated by the recursion relations associated with the Legendre polynomials. There are three chapters: 1. Beam theory and the residual effects in the elastic strip; 2. Plate theory and the edge effects; 3. Shell theory—a first approximation.

*An Introduction to Operator Polynomials.* By Leiba Rodman. Birkhäuser, Boston, 1989. xii+398 pp., $95.00.

This is volume 38 in the series Operator Theory: Advances and Applications. It provides an introduction to the modern theory of polynomials whose coefficients are linear bounded operators in a Banach space—operator polynomials. This theory has its roots and applications in partial differential equations, mechanics and linear systems, as well as in modern operator theory and linear algebra.

*Lectures on Hyponormal Operators.* By Mircea Martin and Mihai Putinar. Birkhäuser, Boston, 1989. 297 pp., $80.00.

This is volume 39 in the series Operator Theory: Advances and Applications. The authors' purpose is to provide the reader with a straightforward access to an active field of research which is strongly related to the spectral and perturbation theories of Hilbert space operators, singular integral equations, and scattering theory.

*Toeplitz Operators and Spectral Function Theory: Essays from the Leningrad Seminar on Operator Theory.* Edited by N. K. Nikolskiĭ. Birkhäuser, Boston, 1989. vii+425 pp., $86.50.

This is volume 42 in the series Operator Theory: Advances and Applications. This volume contains seven papers of the Spectral Function Theory seminar, Leningrad Branch of the Steklov Mathematical Institute.

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*Distributions and Analytic Functions.* By Richard D. Carmichael and Dragisa Mitrovic. John Wiley & Sons, 1989. 347 pp., $42.00.

This is volume 206 in the Pitman Research Notes in Mathematics Series. The authors present a survey of distributions and complex variables and give detailed proofs and examples of their analysis. Areas which are examined include the representation of distributions as boundary values of analytic functions in one and several variables; the development of the one-dimensional boundary value analysis; and the application of results from the one-dimensional distributional boundary value to produce solutions to boundary value problems and convolution equations.

*Brauer Groups and the Cohomology of Graded Rings.* By Stefaan Caenepeel and Freddy Van Oystaeyen. Marcel Dekker, 1988. 280 pp., $107.50.

This is volume 121 of Pure and Applied Mathematics: A Series of Monographs and Textbooks. It uses Galois, Amitsur, and etale cohomological methods as well as a cohomology on suitably chosen sites, applying them to gradations by finite groups. These new methods yield new facts concerning the Brauer-Wall and Brauer-Long groups.

*Numerical Methods, with Applications in the Biomedical Sciences.* By E. H. Twizell. John Wiley & Sons, 1988. 339 pages.

This is a volume in the Ellis Horwood Series in Mathematics and its Applications. It is designed to be used as a text for a first numerical methods course, and also for researchers who need to know how to solve the nonlinear algebraic and the ordinary and partial differential equations that arise from the mathematical modeling of biomedical systems.

*New Methods in Optimization and their Industrial Use: State of the Art, Recent Advances, Perspectives.* Edited by Jean-Paul Penot. Birkhäuser, Boston, 1988. ix+227 pp., $55.00.

This is volume 87 in the International Series of Numerical Mathematics. This is the Proceedings of the Symposium held in Pau, October 19–29, 1987, and Paris, November 19, 1987. The topics discussed in the 14 papers include: global optimization methods, classical and less classical algorithms, Karmarkar's algorithm, connections with computer science; applications include: large scale problems in the smelting industries, optimal planning of compound medicines, management of mixtures.

*Mathematical Models for Phase Change Problems.* Edited by Jose Francisco Rodrigues. Birkhäuser, Boston, 1989. x+410 pp., $76.00.

This is volume 88 in the International Series of Numerical Mathematics. It is the Proceedings of the European Workshop held at Obidos, Portugal, October 1–3, 1988. The underlying idea of the workshop was to study the mathematical models arising in problems with free boundaries in a broad sense, namely in melting and freezing problems, diffusion-reaction processes, solid-solid phase transitions, hysteresis phenomena, "mushy region" descriptions, contact problems with friction and/or adhesion, elastoplastic deformations, etc.

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*The Interacting Boson Model.* By F. Iachello and A. Arima. Cambridge University Press, New York, 1987. x+250 pp., $59.50.

This is a volume in the series Cambridge Monographs on Mathematical Physics. In 1974 a new model, the interacting boson model, was introduced in an attempt to describe in a unified way collective properties of nuclei. This model is rooted in the spherical shell model developed by Jensen and Mayer, which is the fundamental model for describing properties similar, and in many cases identical, to the collective model developed by Bohr and Mottelson and based on the concept of shape variables. Since 1974, the interacting boson model has been the subject of many investigations and it has been extended to cover most aspects of nuclear structure. In this book, which is intended to be the first in a series of three, the authors give an account of some properties of the interacting boson model. The nine chapters are divided into three parts: 1. The interacting boson model-1. 2. The interacting boson model-2. 3. The interacting boson model-$k$ .

*Majorization of the Lorenz Order: A Brief Introduction.* By Barry C. Arnold. Springer-Verlag, New York, 1987. i+122 pp., $18.00.

This is Volume 43 of Lecture Notes in Statistics. In the early accessible English language literature on the subject of majorization the names of Muirhead, Lorenz, Dalton and Hardy, Littlewood and Polya stand out. Majorization or Lorenz ordering is the name attached to the partial order implicitly or explicitly described by these authors. This set of notes is designed for a one quarter course introducing majorization and the Lorenz order. The inequality principle of Hugh Dalton is given prominence. Chapter headings: 1. Introduction. 2. Majorization in IR functions. 3. The Lorenz order in the space of distribution functions. 4. Transformations and their effects. 5. Multivariate and stochastic majorization. 6. Some related orderings. 7. Some applications.

*Harmonic Analysis on the Heisenberg Nilpotent Lie Group.* By W. Schempp. Longman Scientific & Technical, and John Wiley & Sons, New York, 1986. i+199 pp., $39.95.

This is Volume 147 in the Pitman Research Notes in Mathematics Series. Chapter headings: 0. Basic notations and conventions. 1. Basic facts on linear group representations. 2. The unitary inducing procedure. 3. Square integrable linear group representations. 4. Basic facts on real nilpotent Lie groups. 5. The real Heisenberg nilpotent Lie group. Part I. 6. The coadjoint orbit picture. 7. The real Heisenberg nilpotent Lie group. Part II. 8. Applications to signal theory.

*Mathematical Modeling and Digital Simulation for Engineers and Scientists.* By Jon Michael Smith. John Wiley & Sons, New York, 1987. xiv+430 pp., $42.95.

This is the second edition of a book first published in 1976. There are two new sections: Part 4, dedicated to the use of modern numerical methods for generating chaos and simulating random processes on a digital computer, and Part 5, dealing with simulator verification. The headings of the six parts are: 1. Mathematical modeling preliminaries. 2. Numerical methods for simulating linear systems on a digital computer. 3. Numerical methods for simulating nonlinear systems on a digital computer. 4. Simulating continuous random processes on a digital computer. 5. Simulator verification. 6. Fast function evaluation techniques.

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*Combinatorial Geometries.* Edited by Neil White. Cambridge University Press, New York, 1987. xii+212 pp., $39.50.

This is Volume 29 of the Encyclopedia of Mathematics and its Applications, a series edited by G.-C. Rota. It is the second in a three volume series, the first of which is Theory of Matroids, and the third of which will be called Combinatorial Geometries: Advanced Theory. The three volumes together aim to constitute a fairly complete survey of the current knowledge of matroids and combinatorial geometries.

*Differential Equations: An Introduction with Applications.* By Lothar Collatz. John Wiley & Sons, New York, 1986. xv+372 pp., $64.95.

This is a translation by E. R. Dawson of the 6th German edition of 1980, with additional material by the author, for instance on Laplace and Fourier transforms. Chapter headings: 1. Ordinary differential equations of the first order. 2. Ordinary differential equations of a higher order. 3. Boundary-value problems and, in particular, eigenvalue problems. 4. Particular differential equations. 5. An excursion into partial differential equations. 6. Appendix. Some methods for approximation and further examples for practice.

*Economic Choice Under Uncertainty : A Perspective Theory Approach.* By J. L. Ford. St. Martin's Press, New York, 1987. ix+146 pp., $39.95.

This book provides a new theory of decision-making under uncertainty and also proposes a new measure of uncertainty. Perspective Theory is developed on the basis of both that measure and of the conventional measure, namely, probability. It departs from handling choice over probability distributions of outcomes by means of the "expectation" principle. It produces results consistent with surveys of actual choices made between competing probability distributions and relies on a plausible or recognizable mental process. Accordingly, it presents a coherent alternative to Expected Utility Theory.

*Jack Carl Kiefer Collected Papers: Supplementary Volume.* Edited by Lawrence D. Brown, Ingram Olkin, Jerome Sacks, and Henry P. Wynn. Springer-Verlag, New York, 1986. pp. vi + 56. $20.00.

The commentaries in this volume provide the reviews of selected papers from the three-volume Collected Papers of Jack Carl Kiefer (Springer-Verlag, 1985).

*Defect Minimization in Operator Equations: Theory and Applications.* By R. Reemtsen. Longman Scientific & Technical, and John Wiley & Sons, New York, 1987. pp. 1 + 106. $36.95.

This is volume 163 in the Pitman Research Notes in Mathematics Series. The first chapter (Theory) has ten sections, and the second chapter (Applications) discusses ordinary differential equations, and well-posed and ill-posed problems for the heat equation. There is an appendix on stability theorems and the Stefan Problem.

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*Principles of Applied Mathematics: Transformation and Approximation.* By James P. Keener. Addison-Wesley Publishing Co., New York, 1988. xv+560 pp., $48.50.

This text for beginning graduate students in applied mathematics has a unifying theme: it shows how developments of the past twenty years are useful in solving a whole variety of problems in applied science. More particularly, it concentrates on showing how the spectral theory of operators and asymptotic analysis are used to solve integral, differential, and difference equations. The emphasis of the book is a working, systematic understanding of classical techniques in a modern setting, illustrated by models from a variety of disciplines. The following is a brief resumé of the chapters. Chapter one reviews the basics of spectral theory for matrices with the goal of understanding the geometry of the solution process, and the critical role played by eigenvalues and eigenvectors in finding useful changes of coordinate systems. Chapter two extends many of the notions of finite-dimensional vector spaces to function spaces. Hilbert spaces and representation of functions in a Hilbert space are studied. Chapter three explores the strong analogy between integral equations and matrix equations, and examines again the consequences of spectral theory. Chapter four develops the tools necessary to use spectral decompositions to solve differential equations. Chapter five is devoted to showing how many differential equations can be derived from a variational principle, and how the eigenvalues of a differential operator vary as the operator is changed. Chapter six reviews analytic function theory required in all the subsequent chapters. Chapter seven continues the development of transformation theory, shows that eigenvalues and eigenfunctions are not always sufficient to build a transform, and that operators having a continuous spectrum require a generalized construction. It is in this context that Fourier, Mellin, Hankel, and $Z$ transforms, as well as scattering theory for the Schrödinger operator are studied. Chapter eight shows how to solve linear partial differential and difference equations, with special emphasis on transform theory. Chapter nine shows how transform theory has recently been used to solve certain nonlinear evolution equations, illustrating the inverse scattering transform on the Korteweg-de Vries equation and the Toda lattice. Chapter ten shows how asymptotic methods can be used to approximate the integral expressions that so often result from transformation techniques. Chapter eleven shows how perturbation theory and especially the study of nonlinear eigenvalue problems uses knowledge of the spectrum of a linear operator in a fundamental way. Chapter twelve gives a survey of the three basic singular perturbation problems (slowly varying oscillations, initial value problems with vastly different time scales, and boundary value problems with boundary layers).

*Information Mechanics: Transformation of Information in Management, Command, Control and Communication.* By Brian Conolly and John G. Pierce. John Wiley & Sons, 1988. 174 pp., $44.95.

The studies in this book are intended to illuminate some of the processes of concern in military command, control, and communication ($C^3$): search; occasional observation and surveillance; transmission of information over possibly faulty channels; aspects of priority in message traffic; interaction between competitors who gain access to new information. Chapter 1 discusses the relationship of information theory and search when false targets are present. Chapter 2 develops a mathematical description of the information generated by periodic surveillance of a moving target, in which detection of the target is not an issue. Chapter 3 treats the merger, in a filter center, of data about the same situation from various sources. Chapters 4 and 5 examine, in terms of the formalism of queueing theory, the effects of assigning priority to one class of information to be transmitted over a link with finite capacity. Chapter 6 has its roots in models created by F. W. Lanchester in 1916 to describe the evolution in deterministic terms of what he called ancient and modern warfare. Chapter headings: 1. Simple models for search in the presence of false targets; 2. Information provided by regular surveillance of a moving target; 3. Merger of data in a filter centre; 4. Management of an information channel with a priority facility; 5. Single-channel service with alternating priority; 6. Modified Lanchester equations incorporating effects of information.