Centrum voor Wiskunde en Informatica
Centre for Mathematics and Computer Science

# Scientific Publications

# 1989

# CWI Scientific Publications



**Contents**




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# Introduction

CWI is the research institute of the Stichting Mathematisch Centrum, which was founded on February 11, 1946, as a nonprofit institution aiming at the promotion of mathematics, computer science, and their applications. It is sponsored by the Dutch Government through the Netherlands Organization for the Advancement of Research (NWO). At present about 100 researchers are employed at CWI.
CWI publishes, apart from the scientific reports, three series of publications through its own publication department: the Monographs, the Tracts and the Syllabi.

*CWI Monographs* is a hard cover series, which started in 1984. It contains monographs on a high level, as well as proceedings of symposia and lecture notes on a single, coherent subject. They are written or edited by (ex-)researchers of CWI. The series is published and distributed in cooperation with North-Holland Publishing Company.
*CWI Tracts* mainly contain theses and other scientific research, both by CWI staff members and by others. Proceedings of conferences organized by CWI are also published in this series. Of the Tracts published before 1986 no abstracts are given.
*CWI Syllabi* mainly contain reports of seminars, manuals to courses organized by CWI and revisions of lecture notes.

This booklet contains information on the titles published in these three series, as well as on some other publications. On the back cover you will find ordering information and an order form.
Further information can be obtained from our publication department: C.E. Thomson, telephone 31 - 20 592 4010.

Orders for CWI Monographs should be mailed to your supplier/bookseller, or to Elsevier Science Publishers, Book Order Department, P.O. Box 211, 1000 AE Amsterdam, The Netherlands. All other orders to be addressed to CWI. The Dutch Guilder (Dfl.) price is definitive. No extra costs will be added to prepaid orders.

# CWI Monographs

1. MATHEMATICS AND COMPUTER SCIENCE — Proceedings of the CWI Symposium, November 1983
*edited by J.W. de Bakker, M. Hazewinkel and J.K. Lenstra*
The rapid development of both mathematics and computer science has created many new interrelations at their interface. All of the topics covered in this volume are relevant to both disciplines.
Contents: Stochastic Geometry and Image Analysis (*A.J. Baddeley*). Systematic Program Development (*C.B. Jones*). Algorithmic Aspects of Some Notions in Classical Mathematics (*L. Lovász*). Problems and Perspectives in Robotics (*J.T. Schwartz*). Algebra of Communicating Processes (*J.A. Bergstra* and *J.W. Klop*). Relaxation Times for Queueing Systems (*J.P.C. Blanc* and *E.A. van Doorn*). Some Current Developments in Density Estimation (*P. Groeneboom*). Experimental Mathematics (*M. Hazewinkel*). Numerical Analysis of Shallow Water Equations (*P.J. van der Houwen, B.P. Sommeijer, J.G. Verwer* and *F.W. Wubs*). Primality Testing (*H.W. Lenstra, Jr.*). Algorithmics (*L.G.L.T. Meertens*). Uniform Asymptotic Expansions of Integrals (*N.M. Temme*).

1986 viii + 352 pages
ISBN 0-444-70024-2 US $73.25 / Dfl. 150.00

2. STABILITY OF RUNGE-KUTTA METHODS FOR STIFF NONLINEAR DIFFERENTIAL EQUATIONS
*by K. Dekker and J.G. Verwer*
The object of this monograph is to present a unified account of all developments concerning stability of Runge-Kutta methods for stiff nonlinear differential equations, which began in 1975 with Dahlquist's *G*-stability paper and Butcher's *B*-stability paper.
Designed for the reader with a background in numerical analysis, the book contains numerous theoretical and practical results aimed at giving insight into the treatment of nonlinear problems.
Contents: Survey. 1. Stiff Differential Equations. 2. Contractivity and Stability. 3. Runge-Kutta Methods. 4. Contractivity of Runge-Kutta Methods. 5. Solution of the Algebraic Equations in Runge-Kutta Schemes. 6. Contractivity of Explicit Methods. 7. The Concept of *B*-Convergence. 8. The Concept of *D*-Stability. 9. Runge-Kutta Rosenbrock Methods. 10. Applications to Partial Differential Equations. Bibliography and Author Index. Subject Index. Symbol Index.

1984 x + 308 pages
ISBN 0-444-87634-0 US $46.25 / Dfl. 95.00



3. THE NUMERICAL SOLUTION OF VOLTERRA EQUATIONS
*by H. Brunner and P.J. van der Houwen*
This monograph presents the theory and modern numerical analysis of Volterra integral and integro-differential equations, including equations with weakly singular kernels.
While the research worker will find an up-to-date account of recent developments of numerical methods for such equations, including an extensive bibliography, the authors have tried to make the book accessible to the non-specialist possessing only a limited knowledge of numerical analysis.
After an introduction to the theory of Volterra methods and to numerical integration, the book covers linear methods and Runge-Kutta methods, collocation methods based on polynomial spline functions, stability of numerical methods, and it surveys computer programs for Volterra integral and integro-differential equations.
Contents: 1. An Introduction to the Theory of Volterra Equations. 2. Numerical Quadrature. 3. Linear Methods for Volterra Equations. 4. Runge-Kutta Type Methods for Volterra Equations. 5. Collocation Methods for Volterra Equations with Regular Kernels. 6. Volterra Equations with Weakly Singular Kernels. 7. Numerical Stability. 8. Software and Test Examples. Index.

1986 xvi + 588 pages
ISBN 0-444-70073-0 US $73.25 / Dfl. 150.00

4. MATHEMATICS AND COMPUTER SCIENCE II — Fundamental Contributions in The Netherlands since 1945
*edited by M. Hazewinkel, J.K. Lenstra and L.G.L.T. Meertens*
Showing the breadth and depth of fundamental research at CWI, these papers were presented at a symposium in October 1986, marking the fortieth anniversary of the Amsterdam Mathematical Centre.
Contents: The Numerical Solution of Partial Differential Equations (*A.O.H. Axelsson*). Dynamics in Bio-Mathematical Perspective (*O. Diekmann*). The Arch-Enemy Attacked Mathematically (*L. de Haan*). Process Algebra: Specification and Verification in Bisimulation Semantics (*J.A. Bergstra* and *J.W. Klop*). Codes from Algebraic Number Fields (*H.W. Lenstra, Jr.*). Infinite-Dimensional Normed Linear Spaces and Domain Invariance (*J. van Mill*). Geometric Methods in Discrete Optimization (*A. Schrijver*). Archirithmics or Algotecture? (*P.M.B. Vitányi*).

1986 x + 162 pages
ISBN 0-444-70122-2 US $34.25 / Dfl. 70.00

5. ONE-PARAMETER SEMIGROUPS
*by Ph. Clément, H.J.A.M. Heijmans, S. Angenent, C.J. van Duijn and B. de Pagter*
The purpose of this book is to illustrate the richness of the theory of one-parameter semigroups by examining some of its various aspects. The main subjects are: semigroups of linear and nonlinear contractions, analytic semigroups and maximal regularity, positive semigroups including spectral theory and asymptotic behaviour. Two whole chapters are devoted to applications, the one to nonlinear diffusion and the other to structured population dynamics.

1987 x + 312 pages
ISBN 0-444-70284-9 US $51.25 / Dfl. 105.00

6. PROGRAM CORRECTNESS OVER ABSTRACT DATA TYPES, WITH ERROR STATE SEMANTICS
*by J.V. Tucker and J.I. Zucker*
This research monograph is about proof systems, in the style of Floyd and Hoare, for proving the correctness of programs interpreted over abstract data types. In addition, the proof systems are designed to operate on programs with the semantic feature that using an uninitialised variable leads to an error message. Designed for the computer scientist, or mathematician interested in the theory of programming languages, the book discusses established and new tools necessary for proving the soundness and completeness of logics for partial and total correctness in an abstract setting. The new tools include classes of many-sorted structures, weak second order assertion languages, and, in particular, a full generalization of the theory of computable functions from the natural numbers to many-sorted abstract structures. Some new generalizations of the Church-Turing Thesis are discussed in detail.

1988 viii + 212 pages
ISBN 0-444-70340-3 US $58.00 / Dfl. 110.00

7. QUEUEING THEORY AND ITS APPLICATIONS
*by O.J. Boxma and R. Syski*
This Liber Amicorum honors a man whose ideas and results have to a large extent shaped queueing theory in its present form. Wim Cohen has made important contributions to the theory of stochastic processes, queueing theory, teletraffic and performance evaluation. The twenty invited papers, from his friends and colleagues, are grouped into five parts. Part I consists of survey papers which present a broad picture of the developments in several areas of queueing theory and performance evaluation. Parts II-V contain research papers dealing with problems of current interest - the Single Server Queue, analytic methods, queueing networks and their applications to communication and computer systems, and various topics in probability and statistics with implications for queueing theory.



Contents: J.W. Cohen: His Scientific Career and Publications. **Surveys:** Performance Evaluation of Distributed Computer Communication Systems *(L. Kleinrock).* A Perspective on Queueing Models of Computer Performance *(S.S. Lavenberg).* Markov Processes and Teletraffic *(R. Syski).* Computational Methods for Queueing Models: A Review *(H.C. Tijms).* **The Single Server Queue:** Approximations for the M/M/1 Busy-Period Distribution *(J. Abate, W. Whitt).* Storage of the Single-Server Queue *(E.G. Coffmann, Jr., I. Mitrani).* Sojourn Time in an M/G/1 Queue with Bernoulli Feedback *(B.T. Doshi, J.S. Kaufman).* **Analytic Methods in Queueing Theory:** On the Relaxation Times of Open Queueing Networks *(J.P.C. Blanc).* Two Queues with Alternating Service and Switching Times *(O.J. Boxma, W.P. Groenendijk).* On a System with Impatience and Repeated Calls *(G. Fayolle, M.A. Brun).* Some Comments on the Work of J.W. Cohen and New Results in the Theory of Queueing Networks *(P. Le Gall).* **Networks and Computers:** A Recursive Aggregation-Disaggregation Method to Approximate Large-Scale Closed Queueing Networks with Multiple Job Types *(J.B.M. van Doremalen, J. Wessels).* Reduced State-Space Heuristics for Symmetric Markovian Queueing Systems *(M. Hofri).* Insensitivity, Sensitivity and Partial Insensitivity for Some Queueing Models *(A. Hordijk).* The Optimization of Queueing and Loss Networks *(F.P. Kelly).* **Queueing Models and Related Topics:** A Note on the Random Walk for the Transport and Deposition of Particles *(J. Gani).* Asymptotic Efficiency Results for the Method of Moments with Application to Estimation for Queueing Processes *(C.C. Heyde).* Regenerative Sets and their Applications to Markov Storage Systems *(H. Kaspi, M. Rubinovitch).* Estimation from an Infinite Server Queueing System with Two Demands *(M.J. Phelan, N.U. Prabhu).* **Epilogue:** Art and Science: The Greatness and Tragedy of Applied Science *(A. Jensen).*

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22. Topological Dynamix
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The main theme of this tract is the structure theory for minimal flows, following the works of Auslander, Ellis, Furstenberg, Glasner, Veech and others. The central notions are: quasifactors of minimal flows, (weak) disjointness of flow homomorphisms, and the equicontinuous structure relation.

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23. Methods, Concepts and Ideas in Mathematics — Aspects of an Evolution
*by A.F. Monna*
This tract consists of three parts which are basically a revised version - in English - of three papers published earlier in French by the same author in the series: 'Communication of the Mathematical Institute Rijksuniversiteit Utrecht', scil.: 'L'algébrisation de la Mathématique' (1977), 'Evolutions de problèmes d'existence en Analyse' (1979) and 'Evolutions en Mathématique' (1981). An extensive bibliography (160 titles) and an index of mathematicians are included.

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24. Filters and Ultrafilters over Definable Subsets of Admissible Ordinals
*by J.C.M. Baeten*
The search for a recursive analogue of a measurable cardinal leads to a study of ordinals that have a filter, which is complete, normal or an ultrafilter on a Boolean algebra of definable subsets. Techniques from definability theory, set theory and recursion theory are combined and the hierarchy of constructible sets is used. The existence of these so-called definable filters is related to admissibility, and we find that the existence of a definable normal (ultra)filter is not equivalent to the existence of a definable (ultra)filter. We look at the analogues of certain classical filters, and prove that on a countable ordinal, we can extend a definable filter to a definable ultrafilter, and a definable normal filter to a definable normal ultrafilter.

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25. Tree Network and Planar Rectilinear Location Theory
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It is shown that chordal graphs and totally-balanced matrices are useful tools in finding strong duality results and polynomial time algorithms for tree networks location problems.

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This tract deals with three subjects: dataflow machines, analysis of imperative programs and the use of analysis to make programming of dataflow machines possible. Chapter two contains a comprehensive survey of dataflow machines, while chapter three elaborates on the differences between applicative languages and imperative languages, especially in relation to dataflow machines. Chapter four discusses the area of flow analysis and compares some existing methods. The general analysis method is described in chapter five; it subsequently treats syntactic analysis, demand graph construction, demand propagation and extraction. Chapter six contains a detailed description of the crucial part of the analysis method: the construction of the demand graph. Chapter seven gives examples of the application specific propagation of demands and chapter eight describes the generation of code for the Dataflow Machine. Finally, in chapter nine the compiler is evaluated.

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27. HOMOGENEOUS ZERO-DIMENSIONAL ABSOLUTE BOREL SETS
*by A.J.M. van Engelen*
In this tract, topological characterizations are given of all homogeneous zero-dimensional absolute Borel sets; there turn out to be $\omega_1$ topological types of such spaces. They mainly consist of a description of the level in the Borel hierarchy of the spaces under consideration. For this purpose we use the hierarchy of small Borel classes (Kuratowski), and the Wadge hierarchy (Wadge). As an application of our results, we prove that non-trivial *rigid* zero-dimensional absolute Borel sets do not exist, answering a question of Van Douwen.

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28. FOUNDATIONS AND APPLICATIONS OF MONTAGUE GRAMMAR — Part 2: Applications to Natural Languages
*by T.M.V. Janssen*
See CWI Tract 19.



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29. ALMOST INVARIANT SUBSPACES AND HIGH GAIN FEEDBACK
*by H.L. Trentelman*
In this tract a theory is developed around the notion of 'almost controlled invariance'. The theory presented mainly falls within the area of research commonly known as the 'geometric approach' to linear systems, but also more 'frequency domain oriented' methods are used. The work consists of five chapters. In chapter one the basic concepts of controlled invariance and almost controlled invariance are introduced. Chapter two provides characterizations in terms of distributional inputs. As a first application, the $L_p/L_q$-almost disturbance decoupling problem is discussed. In chapter three the notion of $L_p$-almost invariance is treated. The $L_p$-almost disturbance decoupling problem is discussed and results are provided in the context of pole placement by low-order dynamic output feedback. Chapter four treats the $L_p$-almost disturbance decoupling problem with bounded peaking. Finally, in chapter five, a theory around the dual concept of almost conditionally invariant subspaces is developed.

1986 239 pages
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30. PRODUCTION-INVENTORY CONTROL MODELS — Approximations and Algorithms
*by A.G. de Kok*
This tract concerns the probabilistic analysis of a variety of one-product production-inventory models in which the central problem is to coordinate the production rate with the inventory level in order to cope with random fluctuations in demand. Here the main goal is to meet service level constraints corresponding to service measures such as the long-run fraction of the demand to be met directly from stock on hand, while minimizing the average costs. Here we account for linear holding costs and a fixed cost for changing the production rate. The control of the inventory is governed by a so-called *(m,M)*-rule. Using results from random walk theory and renewal theory accurate and practically useful approximations are obtained for all performance characteristics, from which the optimal control levels $m$ and $M$ can be computed.

1987 211 pages
ISBN 90-6196-310-9 Dfl. 38.00

31. OPTIMAL PAIRED COMPARISON DESIGN FOR FACTORIAL EXPERIMENTS
*by E.E.M. van Berkum*

In paired comparison experiments observations are made by presenting pairs of objects to one or more judges. When all pairs are presented to each of $n$ judges (round robin), then the number of paired comparison is $n\binom{t}{2}$, where $t$ is the number of objects. This number is often too large for practical purposes. Bradley and Terry postulate the existence of parameters, $\pi_i$ for $T_i$, where $T_i$ is the $i$-th object or treatment. In many cases these parameters are functions of quantities determining the objects and a linear model can be formulated. The information from this model is used to construct designs, that are more efficient than the round robin design book is.

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32. MULTIVARIATE EMPIRICAL PROCESSES
*by J.H.J. Einmahl*
Multivariate empirical processes based on a sequence of independent and identically distributed random vectors are considered. As indexing sets either quadrants, which are identified with points, or rectangles with sides parallel to the coordinate axes are used. With the aid of sharp probability inequalities optimal results are obtained concerning weak convergence and strong limit theorems for the weighted case and the behaviour of two oscillation moduli of the empirical processes for the unweighted case. It turns out that in some situations there is a remarkable difference between dimension one and higher dimensions.

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33. STOCHASTIC GAMES WITH FINITE STATE AND ACTION SPACES
*by O.J. Vrieze*
Two-person zero sum stochastic games with finite state and action spaces are treated. A new proof of the existence of the value is given, based on mathematical programming techniques. Structural properties of the solution sets are elaborated. Besides a review of existing algorithms, a new algorithm, built up by 'fictitious' play is presented. Games where the value is independent of the initial state are treated rigorously. Furthermore it is shown that for every stochastic game both players possess 'easy' states. Also for this class of games a review of existing algorithms is given and for two subclasses (one-player-control and switching control) new finite step algorithms are presented. Finally, preliminary facts on matrix games and Markov decision problems are stated.

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34. INFINITESIMAL SYMMETRIES: A COMPUTATIONAL APPROACH
*by P.H.M. Kersten*
This tract deals with computational aspects in the determination of infinitesimal symmetries and Lie-Bäcklund transformations of differential equations. After a brief introduction to some theoretical concepts the mathematical formalism is shortly reviewed. The jet bundle formulation is chosen, in which, objects can be described very precisely. A number of procedures are discussed, which enable one to carry through computations with the help of a computer. These computations are very extensive in practice. The Lie algebras of infinitesimal symmetries of a number of differential equations in mathematical physics are established and some of their applications are discussed. Moreover Lie-Bäcklund transformations of some equations are determined.

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*by M.L. Eaton*
These lectures, given at the University of Amsterdam highlight the following topics: i) majorization results and their extensions to reflection groups; ii) association and the FKG inequality; iii) log concavity, Anderson's theorem and related topics. To a large extent the treatment of the material is mathematically self-contained, although the examples sometimes require a bit of specialized statistical knowledge.

1987 197 pages
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36. PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON INDUSTRIAL AND APPLIED MATHEMATICS (ICIAM 87) — CONTRIBUTIONS FROM THE NETHERLANDS
*edited by A.H.P. van der Burgh and R.M.M. Mattheij*
This tract contains the contributions from the Netherlands to the First International Conference on Industrial and Applied Mathematics (ICIAM 87). The papers cover the following topics: applied mathematical analysis, scientific computing, control theory and signal processing, computational geometry, applied probability and statistics, mathematics of natural sciences, software and hardware aspects.

1987 433 pages
ISBN 90-6196-318-4 Dfl. 61.80

37. DESIGN AND ANALYSIS OF ALGORITHMS FOR STOCHASTIC INTEGER PROGRAMMING
*by L. Stougie*
In stochastic programming problems some of the parameters are modeled as random variables to represent uncertainty

about their value. Integrality constraints imposed on some of the decision variables lead us into the field of stochastic integer programming. Due to the stochasticity and the combinatorial nature, the problems are extremely hard to solve and therefore an approximation of the optimal solution is settled for. A framework for the theoretical analysis of the quality of approximations is presented. For various specific stochastic integer programming problems approximation algorithms are designed and analyzed. For some specific problems of small size dynamic programming algorithms are presented to obtain an optimal solution.

1987 92 pages
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38. On Banach Algebras, Renewal Measures and Regenerative Processes
*by J.B.G. Frenk*
For a sequence of independent and identically distributed random variables with probabilty distribution $F$ a *renewal* measure can be defined, which plays an important role in the analysis of regenerative processes. In this tract a self-contained treatment of the asymptotic behaviour of the renewal measure under various assumptions on the probability distribution $F$ is given, using Fourier analysis and the theory of commutative Banach algebras.

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39. Surveys in Game Theory and Related Topics
*edited by H.J.M. Peters and O.J. Vrieze*
This book consists of eleven surveys in game theory and two on related topics. Each chapter is self-contained. The authors are specialists in the respective fields and in the last section of each chapter they discuss some of their latest results. The whole field of game theory is covered. We mention: Refinements of equilibrium concepts, Games with incomplete information, Stochastic games, Combinatorial games, Games of linear optimization problems, Simple games, Solution concepts for cooperative games, Bargaining solutions. The 'related topics' are concerned with social choice theory and the relation between decision theory and game theory.

1987 330 pages
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40. Regular Variation, Extensions and Tauberian Theorems
*by J.L. Geluk and L. de Haan*
This tract gives a self-contained, smooth and coherent introduction to the theory of functions of regular variation and its main extensions. We show how these classes of functions are a natural setting for Tauberian theorems of the Laplace type. Also some results are given for general kernel transforms. Little emphasis is put on various refinements, minimality of conditions and other specialized topics. After a full treatment of regularly varying (RV) functions sections on the function classes $\Pi$ and $\Gamma$ follow. The theory of these function classes parallels closely the theory of regular variation. Next Tauberian theorems for Laplace transforms are treated in which these function classes (RV, $\Pi$ and $\Gamma$) play a central role. Finally, limits are replaced by upper and lower bounds and further generalizations of regular variation are given, together with some Tauberian theorems.

1987 132 pages
ISBN 90-6196-324-9 Dfl. 25.30



41. The Amoeba Distributed Operating System: Selected Papers 1984-1987
*edited by S.J. Mullender*
This tract contains selected papers relating to the Amoeba Distributed Operating System which were published between 1984 and 1987. The papers reflect a joint effort between CWI and the Vrije Universiteit at Amsterdam.

1987 308 pages
ISBN 90-6196-325-7 Dfl. 51.70

42. Essays on Concepts, Formalisms, and Tools
*edited by P.R.J. Asveld and A. Nijholt*
Most papers in this volume deal with 'artificial' situations. Their subject matters are human-defined or human-constructed languages and systems. The authors introduce and study formalisms, show how a subject matter can be modeled, or discuss the building and usefulness of tools for the generation of programs that facilitate the writing or processing of user programs. Ultimately, the introduction and study of the formalisms that are discussed in these papers have been inspired by practical considerations.

1987 278 pages
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43. Distributed Computing: Structure and Complexity
*by H.L. Bodlaender*
By connecting several processors or computer systems, for instance in a network, one obtains a distributed system. Distributed systems have important advantage over conventional (mainly) sequential computer systems. In this book some fundamental problems in the area of distributed computing are analyzed. An extensive analysis is made of the concept of uniform emulation: a method for obtaining structure-

preserving, efficient simulations of (large) processor-networks on smaller processor-networks. Several new lower bounds and upper bounds are obtained for extreme finding (or election) on rings of processors. An analysis is made of a fundamental load-balancing problem on rings of processors. A large class of controllers is introduced, that avoid store-and-forward deadlock and use only 'local information'.

1987 294 pages
ISBN 90-6196-327-3 Dfl. 50.40

44. Statistical Estimation in Large Parameter Spaces
*by A.W. van der Vaart*

The manuscript treats estimation problems in models which are typically parametrized by an 'infinite dimensional' parameter. Generalizations and extensions of the convolution and the local asymptotic minimax theorem are obtained for estimators with values in a Euclidean space, as well as for possibly infinite dimensional vector spaces. Based on these results a concept of asymptotic efficiency is defined and it is shown, that Hadamard differentiable functionals of efficient estimators are again efficient. The latter result is applied to the censoring problem. Finally, efficient estimators are constructed by the method of adaptation, in a special type of semi-parametric model, characterized by the existence of a sufficient statistic for the nuisance parameter.

1988 205 pages
ISBN 90-6196-329-X Dfl. 36.60

45. Regression Analysis and Empirical Processes
*by S.A. van de Geer*

The regression model $y_k = g(x_k) + \epsilon_k$, $k = 1,...,n$ is tackled using concepts and ideas from empirical process theory. The study is confined to the investigation of the asymptotic properties of the least squares estimator given that $g$ is a member of a class $G$ of regression functions. Consistency is established with the help of uniform laws of large numbers and rates of convergence are obtained. Various examples with a particular $G$ (e.g. the class of all monotone functions) are provided. The results are also applied to two-phase regression, and furthermore, it is illustrated that the proof of asymptotic normality can benefit from empirical process theory. Closely related with the two-phase regression model is the change-point model, which is treated in a separate chapter.

1988 153 pages
ISBN 90-6196-330-3 Dfl. 29.20



46. Multigrid Solution of the Steady Euler Equations
*by S.P. Spekreijse*

A first- and second-order accurate upwind discretization of the 2D steady Euler equations is studied and a robust and efficient multigrid solution method is developed. The discretizations are based on cell centered finite volume schemes. In the first-order discretization, the numerical approximations are assumed to be uniformly constant in each volume. Second-order accuracy is obtained by using piecewise linear interpolation. In the second-order discretization, a limiting procedure is used to prevent spurious oscillations in the neighbourhood of discontinuities. It is shown that monotonicity and second-order accuracy can be obtained simultaneously, even in more than one dimension. The solution of the first-order discretization is obtained by a straightforward nonlinear multigrid solution method (FMG-FAS). A Defect Correction (DeC) iteration method is used to improve the accuracy of the first-order solutions. Particularly with respect to efficiency the method contributes to the state of the art in computing steady Euler flows with discontinuities.

1988 153 pages
ISBN 90-6196-346-X Dfl. 29.20

47. Analysis of Means in Some Non-standard Situations
*by J.B. Dijkstra*

This is a study on methods for comparing several mean values when the assumptions for a classical test are not fulfilled. For normal distributions with unequal and unknown population variances some tests for the hypothesis of equal location parameters are compared. For symmetric distributions two non-parametric methods are considered that adapt themselves to the estimated tail-weights. These tests have more power than some non-adaptive tests for a representative mixture of distributions. Several approaches are considered for dealing with the possible occurrence of some extreme outliers. This is done for normal distributions and equal variances. Outliers are represented by symmetric and one-sided contamination. For almost every well-known classical Multiple Comparisons Test alternatives are given that can deal with variance heterogeneity or with some extreme outliers. These modifications are compared and some recommendations are given.

1988 138 pages
ISBN 90-6196-347-8 Dfl. 26.60

48. Asymptotics for Generalized Chi-square Goodness-of-fit Tests
*by F.C. Drost*

This monograph considers the behaviour of various types of

chi-square goodness-of-fit test statistics. The influence of the number of classes $k$ in the presence of a location-scale nuisance parameter is investigated. When $k \to \infty$, we prove the asymptotic normality of the Moore-Spruill class of $\chi^2$ statistics. Criteria are developed on whether to choose a large or a small number of classes. It turns out that non-robust estimation is best: in that case general EDF tests, including generalized $\chi^2$ tests, are consistent while the asymptotic local power remains bounded. Complementary results are given for $\sqrt{n}$-consistent estimators having a relatively large bias or variance under local alternatives. The last chapter deals with power approximations for the Cressie-Read class of $\chi^2$ statistics when no nuisance parameters are present. A non-local Taylor expansion of the test statistic yields a new, and very good approximation based on a weighted sum of independent non-central $\chi^2$ distributions.

1988 104 pages
ISBN 90-6196-348-6 Dfl. 21.50

49. NUMERICAL SOLUTION OF THE SHALLOW-WATER EQUATIONS
*by F.W. Wubs*

Shallow-water equations play an important role in hydraulic engineering. In this book a numerical method is described to solve these equations efficiently. This method exploits the facilities of the vector computer CYBER 205. Details are given about the space and time discretizations, the stabilization of the time integration, vectorization aspects, description of the code and numerical results for real engineering problems. Theoretical aspects of the developed stabilization technique for the numerical integration of partial differential equations are described. For vectorization reasons finite differences and explicit time stepping methods are to be preferred. However, explicit methods have the undesirable property that the time step is often more restricted by stability considerations than by accuracy considerations. Therefore, we have designed an explicit technique by which the time step restriction is relaxed considerably. This technique allowed us to construct a very efficient method on the CYBER 205.

1988 115 pages
ISBN 90-6196-349-4 Dfl. 22.80

50. ASYMPTOTIC ANALYSIS OF A CLASS OF PERTURBED KORTEWEG-DE VRIES INITIAL VALUE PROBLEMS
*by F. de Kerf*

We consider a perturbed Korteweg-de Vries initial value problem (pKdV),

$$\begin{cases} u_t - 6uu_x + u_{xxx} = \epsilon f(u) \\ u(x,0) = U(x) \end{cases}$$



with a quite general perturbation, namely: $f(u)$ is a polynomial in $u$ and $x$-derivatives up to arbitrary order of $u$. We show that on $\delta^{-1}(\epsilon)$-timescales with $\delta(\epsilon)=o(1)$ and $\epsilon\delta^{-1}(\epsilon)=O(1)$, the solutions of the pKdV display a behaviour similar to that of solutions of the KdV. That is, emergence of solitons takes place and on right half lines the solutions can be approximated by these solutions. Moreover, we give explicit approximations of the solitons.

1988 180 pages
ISBN 90-6196-351-6 Dfl. 32.80

51. THEORETICAL AND COMPUTATIONAL ASPECTS OF SIMULATED ANNEALING
*by P.J. van Laarhoven*

Simulated annealing is a new approach to the approximate solution of large combinatorial optimization problems, using ideas from statistical physics. After an informal introduction a mathematical description of the simulated annealing algorithm is given in terms of Markov chains. Necessary and sufficient conditions are derived to ensure that asymptotically the algorithm finds a globally minimal configuration with probability 1. A cooling schedule which ensures that near-optimal configurations are returned in finite time by closely imitating the aforementioned asymptotic behaviour, is described and compared with other schedules from the literature. Numerical tests of the quality of the algorithm are described. Results are presented obtained by running simulated annealing on instances of the *travelling salesman*, the *job shop scheduling* and the *football pool* problem. Finally we consider simulated annealing from a *Bayesian* point of view. Numerical experiments are described in which the *posterior distribution* firstly is shown to predict accurately the behaviour of the algorithm during the next Markov chain and secondly is used to compute the (a posteriori) expectation of the minimum value of the cost function.

1988 168 pages
ISBN 90-6196-352-4 Dfl. 31.70

52. CONTINUOUS DECOUPLING TRANSFORMATIONS FOR LINEAR BOUNDARY VALUE PROBLEMS
*by P.M. van Loon*

In this tract a class of solution methods for systems of linear boundary value problems (BVPs) for ordinary differential equations is examined. The class consists of methods that (i) use the integration of initial value problems, (ii) are founded on fundamental concepts like dichotomy, consistency and conditioning, (iii) are applicable to both non-stiff and stiff (turning point) problems, (iv) decouple the (fast) increasing and the (fast) decreasing modes in a continuous way (this in

contrast to (multiple) shooting techniques), (v) don't have excessive demands on computer memory (implying integration in one direction), (vi) can directly be generalized to solution methods for singular BVPs. The most familiar method within this class is the so-called Riccati method, a combination of the Riccati transformation and an invariant imbedding technique. It is proven that the method has to be numerically stable, which is illustrated by a set of examples.

1988 198 pages
ISBN 90-6196-353-2 Dfl. 35.40

53. Numerical Solution of Optimal Control Problems with State Constraints by Sequential Quadratic Programming in Function Space
*by K.C.P. Machielsen*
In the first instance, optimization problems are considered in an abstract setting and a number of results on optimality conditions are reviewed. The abstract theory is directly applicable to state constrained optimal control problems. When the optimality conditions for the abstract problems are expressed in terms of the optimal control problems, the well-known minimum principle for state constrained optimal control problems follows. The method proposed for the numerical solution of the optimal control problems is analogous to a sequential quadratic programming method for the numerical solution of finite-dimensional nonlinear programming problems. The numerical implementation of the method essentially comes down to the numerical solution of a linear multipoint boundary value problem, for which the collocation method was chosen. Numerical results of the program for some practical problems are given.

1988 214 pages
ISBN 90-6196-354-0 Dfl. 38.00

54. Computational Aspects of Survey Data Processing
*by L.C.R.J. Willenborg*
A theoretical framework is developed for the description of survey data production processes, as applied in statistical offices. Of central importance is the logical structure of a questionnaire, which comprises its routing and edit structure. After a brief sketch of the possible organization of a survey data production process, the logical structure of questionnaires is formally defined and investigated. In particular several tests as to the formal correctness of the logical structure of a questionnaire are investigated with respect to their computational complexity. Furthermore the computational complexity of certain data editing problems is considered. The final major topic treated centers around missing data: how to cope with files containing missing information from a data processing point of view, the problem of estimation in the presence of missing data (interpreted as item non-response) and the completion of files containing missing information (imputation).

1988 154 pages
ISBN 90-6196-356-7 Dfl. 29.20



55. A Program Generator for Recognition, Parsing and Transduction with Syntactic Patterns
*by G.J. van der Steen*
A program-generator for linguistic purposes is described with the following properties. (i) The formalism unifies weak equivalent formalisms for Chomsky type-0 grammars, cascaded transduction grammars, pattern matching, augmented transition networks and attribute grammars. (ii) In the compiler new extensions for the LR-table generation technique are implemented. (iii) The generated code runs on a formal machine which makes use of two dag-structured stacks and which maintains a parse forest for the efficient storage of parses of ambiguous grammars. (iv) Parsing is done on-line, transduction is done with a finite delay. (v) New bounds are obtained for the runtime of some pattern matching problems. A number of applications is shown, e.g. syntactic pattern recognition in enriched corpora of text, music, historical and bibliographical records, parsing with an apsg-grammar and a transformational grammar, and translation with a transduction grammar for grapheme-phoneme conversion.

1988 284 pages
ISBN 90-6196-361-3 Dfl. 47.90

56. Translating Programs into Delay-insensitive Circuits
*by J.C. Ebergen*
Delay-insensitive circuits are particularly attractive for avoiding many timing problems. It is shown that the design of delay-insensitive circuits can be reduced to the design of programs. This is done by presenting a syntax-directed translation of programs into delay-insensitive connections of basic elements. The program notation is a generalization of regular expressions and includes operations to express parallelism, tail recursion, and the introduction of internal symbols. Many components can now be expressed in a clear and concise way. The translation method presented yields delay-insensitive connections of circuit elements chosen from a finite basis. The notion 'delay-insensitive' is rigourously formalized. The translation is syntax-directed and can be carried out in such a way that the number of basic elements in the connection is proportional to the length of the program. Many examples, including counters, buffers, finite state machines and token-ring interfaces, are discussed.

1989 216 pages
ISBN 90-6196-363-X Dfl. 38.00

57. EXPONENTIAL TYPE CALCULUS FOR LINEAR DELAY EQUATIONS
*by S.M. Verduyn Lunel*
Retarded functional differential equations possess an infinite number of linearly independent characteristic solutions $p_j(t)e^{\lambda_j t}$, where $\lambda_j$ denotes a zero of a transcendental equation and $p_j$ a polynomial. In this monograph the asymptotic behaviour of the solutions of this type of differential equations is studied using Laplace transform methods. Furthermore, we will present necessary conditions such that a solution can be represented as a series of characteristic solutions. With these results we then study the geometric structure of the strongly continuous semigroup $T(t)$ associated with a retarded functional differential equation. The main result is a characterization of the closure of the system of generalized eigenfunctions of the infinitesimal generator $A$ of $T(t)$.

1989 126 pages
ISBN 90-6196-364-8 Dfl. 25.30

58. A RANDOM MODEL FOR PLANT CELL POPULATION GROWTH
*by M.C.M. de Gunst*
A stochastic model for the cell cycle of plant cells during batch culture is presented and its consequences for the total cell population growth are studied. The model combines the ideas of the transition probability model of Smith and Martin, and Monod-kinetics. The cell cycle duration is assumed to depend on the substrate concentration in the medium, whereas the number of newly born cells which will again divide, is supposed to depend on the hormone concentration in the medium. Based on this model the total cell population growth is described by means of non-Markovian point process. Experiments which were performed in order to test the model against actual data are described. The results are discussed and statistically analyzed.

1989 152 pages
ISBN 90-6196-365-6 Dfl. 29.20

59. CHARACTERIZATION OF BANACH SPACES NOT CONTAINING $l^1$
*by D. van Dulst*
This tract contains the lectures the author gave on the subject at the Indian Statistical Institute in 1988. It surveys the main developments on $l^1$-embeddability since 1974, including a discussion of the Pettis integral and the weak Radon-Nikodym property, and ending with Schachermeyer's recent results on strong regularity. This book is intended for non-specialists: details from topology and measure theory are presented with full proofs, either in the main text or in several appendices. There is also an introductory chapter summarizing the standard results from Banach space theory that are needed.

1989 163 pages
ISBN 90-6196-366-4 Dfl. 30.30



60. VACILLATION AND PREDICTABILITY PROPERTIES OF LOW-ORDER ATMOSPHERIC SPECTRAL MODELS
*by H.E. de Swart*
The atmospheric circulation fluctuates irregularly between three different weather regimes. A contribution is made to a better understanding of the vacillation and predictability properties of the atmosphere by considering three simplified spectral models of the barotropic vorticity equation, which consist of three, six and ten components, respectively. It appears that the internal dynamics of the three-component model already explains the presence of three weather regimes. The nontransient solutions are always stationary, while those of the six-component model can also be periodic, quasi-periodic and chaotic. The ten-component model can be considered as a minimum-order quasi-geostrophic model representing a flow with a finite predictability and vacillatory behaviour. Again three weather regimes are found, represented by unstable periodic orbits of the model. Finally, it is demonstrated that the forcing of large-scale flow due to small-scale motions has a complicated nature and cannot be parametrized by simple stochastic processes.

1989 121 pages
ISBN 90-6196-368-0 Dfl. 24.00

61. CENTRAL LIMIT THEOREMS FOR GENERALIZED MULTILINEAR FORMS
*by P. de Jong*
Consider a probability space $(\Omega,\mathcal{F},P)$ on which independent random variables $X_1,\ldots,X_n$ are defined. Define for a finite subset $I\subset\{1,\ldots,n\}$ the $\sigma$-algebra $\mathcal{F}_I=\sigma\{X_i:i\in I\}$ and let $W_1$ be a $\mathcal{F}_I$-measurable random variable, subject to the condition $E(W_I|\mathcal{F}_J)=0$ a.s. if $I\setminus J\neq\emptyset$. We shall mainly be concerned with $d$-homogeneous sums: $W(n)=\sum_{|I|=d}W_I$, with $\mathrm{var}W(n)=1$, where the summation extends over all $\binom{n}{d}$ subsets $I\subset\{1,\ldots,n\}$ of size $|I|=d$. The main result is the following central limit theorem: Suppose $\max_i\sum_{I\ni i}EW_I^2\to 0$ for $n\to\infty$, and $EW_I^4\leq DE^2W_I^2$, with $D$ not depending on $n$. Then the condition $EW(n)^4\to 3$ for $n\to\infty$ is necessary and sufficient for asymptotic normality. Generally known results for $d=1$ or $d=2$ are extended for general $d$. It is shown how some results in multilinear algebra play a role in the theory of the limit distributions of multilinear forms.

1989 84 pages
ISBN 90-6196-369-9 Dfl. 19.10

62. A Specification System for Statistical Software
*by V.J. de Jong*
Statistical software no longer needs to be programmed in a higher level programming language. Instead efficient statistical software can be developed and maintained in a specification system. Such a system is multilingual; it combines software written by statisticians, computer scientists and data experts. Each of these experts can implement their part of the software in a language close to their problem domain. The emphasis in this book lies on the specification language for statisticians (a symbolic matrix language). Both the design and a prototype of a specification system for statistical software are discussed in detail.

1989 250 pages
ISBN 90-6196-370-2 Dfl. 42.90

63. Identifiability, Recursive Identification and Spaces of Linear Dynamical Systems. Part I
*by B. Hanzon*
A model, as a relation between observable variables, can have several different representations. In the case of linear dynamical systems such representations can be the state space form, an arma-representation, a Hankel matrix, a transfer function, etc. In many instances it will be profitable to change from one representation to another. This basic theme is worked out in two problem areas: the finite identifiability problem, and recursive identification for multivariable time-invariant linear systems.

1989 124 pages
ISBN 90-6196-371-0 Dfl. 24.00

64. Identifiability, Recursive Identification and Spaces of Linear Dynamical Systems. Part II
*by B. Hanzon*
See CWI Tract 63.

1989 190 pages
ISBN 90-6196-372-9 Dfl. 34.10



# CWI Syllabi

1. Vacantiecursus 1984: Hewet-Plus Wiskunde
This syllabus (in Dutch), for high-school teachers of mathematics, contains fourteen articles on operations research, matrix algebra, statistics and probability theory, geometry in three-dimensional space, mathematical modelling, and computer science.

1984 233 pages
ISBN 90-6196-276-5 Dfl. 40.40

2. Proceedings Seminar 1981-1982 Mathematical Structures in Field Theories
*edited by E.M. de Jager and H.G.J. Pijls*
Reflecting the growing mutual interest between mathematicians and physicists, a national seminar 'Mathematical Structures in Field Theories' started in 1981 at the University of Amsterdam. This syllabus contains the lectures in the academic year 1981-1982. The programme of this first year seminar was mainly directed to differential geometry and gauge field theory. In order to give participants a better understanding of theories in which they are not fully conversant, some of the lectures are of an introductory character.

1984 217 pages
ISBN 90-6196-278-1 Dfl. 38.00

3. Testing Statistical Hypotheses — Worked Solutions
*by W.C.M. Kallenberg et al.*
This syllabus contains complete worked solutions to all the 228 exercises in E.L. Lehmann's book 'Testing Statistical Hypotheses', Wiley and Sons, New York, which was first published in 1959 and has since become a classic in the statistical literature. It should be especially useful to those using the book in statistics courses and for private study.

1984 310 pages
ISBN 90-6196-280-3 Dfl. 52.90

4. Colloquium Topics in Applied Numerical Analysis — Vol. 1
*edited by J.G. Verwer*
The colloquium 'Topics in Applied Numerical Analysis' was held at CWI during the academic year 1983-1984. Its aim was to draw attention to the widespread use of numerical mathematics in real life scientific problems, as well as to foster co-operation between mathematicians working in an academic environment and representatives from industries and institutes where the numerical solution of real life problems is studied. The proceedings, consisting of two volumes,

contain in complete form all 24 papers presented by the speakers in the colloquium. Most of the papers deal with practical problems, mainly arising in the engineering sciences.

1984 253 pages
ISBN 90-6196-281-1 Dfl. 44.20

5. COLLOQUIUM TOPICS IN APPLIED NUMERICAL ANALYSIS — Vol. 2
*edited by J.G. Verwer*
See CWI Syllabus 4.

1984 229 pages
ISBN 90-6196-282-X Dfl. 40.40

6. PROCEEDINGS SEMINAR 1982-1983 MATHEMATICAL STRUCTURES IN FIELD THEORIES
*by P.J.M. Bongaarts, J.N. Buur, E.A. de Kerf, R. Martini, H.G.J. Pijls and J.W. de Roever*
The lectures in this syllabus cover the basics of quantum field theory and Yang-Mills gauge theories, suitable to mathematicians who desire to know more about physics and physical intuition underlying this field, and suitable to theoretical physicists who need to know more about the mathematical techniques involved. Topics covered: Feynman path integral and perturbation quantum field theory, topological solutions and Derricks theorem, fields and Lagrangians, the Ward Ansatz for Y.-M. potentials, massless field equations, shear cohomology, Penrose transform.

1985 250 pages
ISBN 90-6196-290-0 Dfl. 42.90

7. VACANTIECURSUS 1985: VARIATIEREKENING
The calculus of variations is the central theme of this syllabus (in Dutch). Chapter one deals with the creation of the calculus of variations while chapter two treats some aspects of this subject. Chapter three discusses minimax methods and chapter four consistent approximations in mathematical physics. Calculus of variations and numerical analysis is described in chapter five (finite-element method). Duality in optimization is discussed in chapter six. Finally, chapter seven deals with variational inequalities with applications to the so-called 'obstacle' and 'membrane problem'.

1985 245 pages
ISBN 90-6196-291-9 Dfl. 42.90



8. PROCEEDINGS SEMINAR 1983-1985 MATHEMATICAL STRUCTURES IN FIELD THEORIES — Vol. 1: Geometric Quantization
*by G.M. Tuynman*
This syllabus gives explanations and (heuristic) motivations for the fundamental concepts of geometric quantization: the prequantization line bundle, polarizations and the metalinear correction. After each step several examples are given and for each new feature, the influence on the example is studied.

1985 158 pages
ISBN 90-6196-293-5 Dfl. 29.20

9. PARALLEL COMPUTERS AND COMPUTATIONS
*edited by J. van Leeuwen and J.K. Lenstra*
In the Autumn of 1983 eight experts of different backgrounds delivered lectures at the University of Utrecht on various aspects of 'parallel computers and computations'. The lectures covered concrete supercomputer architectures and their programming, the new challenges for systems programming, the design of numeric and combinatorial parallel algorithms, and the complexity of parallel computations. This syllabus contains the full versions of the papers that were presented.

1985 184 pages
ISBN 90-6196-297-8 Dfl. 34.10

10. VACANTIECURSUS 1986: MATRICES
This course (for high school mathematics teachers) covers a number of applications of matrices. Many different types of matrices (real, positive, complex, integer, partitioned,...) exist as well as many classes of matrices with special properties, each requiring its own 'theory'. Here, the emphasis is on applications. This syllabus is written in Dutch.

1986 162 pages
ISBN 90-6196-304-4 Dfl. 30.30

11. DISCRETE WISKUNDE — Tellen, Grafen, Spelen en Codes
*edited by P.W.H. Lemmens*
This syllabus (in Dutch) contains (corrected) reprints of lectures about discrete mathematics and graph theory, presented at Vacation Courses during the period 1963-1980. They cover interesting aspects of the theory and its applications, without aiming at completeness.

1986 162 pages
ISBN 90-6196-307-9 Dfl. 30.30

12. INTRODUCTION TO TAUBERIAN THEORY — From A. Tauber to N. Wiener
*by J. van de Lune*
This syllabus contains a fairly detailed 'continuous mathematical history' of the *early* development of Tauberian

theory. From Tauber's elementary theorems, along Pitt's work, it gradually works its way up to the Fourier analytic approach of Wiener. The final chapters deal with Ikehara's theorem and (after the necessary preparations) the prime number theorem.

1986 102 pages
ISBN 90-6196-309-5 Dfl. 21.50

13. PROCEEDINGS SEMINAR 1983-1985 MATHEMATICAL STRUCTURES IN FIELD THEORIES — VOL. 2
*by M.J. Bergvelt, G.M. Tuynman and A.P.E. ten Kroode*
These proceedings cover part of the lectures given in the seminar 'Mathematical Structures in Field Theories', held at the University of Amsterdam during the academic years 1983-1984 and 1984-1985 (see CWI-Syllabi 2, 6 and 8). After an introduction to classical mechanics and symplectic geometry, Yang-Mills theory is treated as a classical dynamical system; the mathematical framework is in terms of differential geometry and the paper is an application of the work by Gotay, Nester and Hinds to the Yang-Mills system. The last part is devoted to the geometrical description of the Toda lattice. This lattice is described as a Hamiltonian system on a co-adjoint orbit in the dual of a Lie algebra. The symplectic structure is the Kostant-Kirillov symplectic form.

1987 206 pages
ISBN 90-6196-317-6 Dfl. 36.60

14. VACANTIECURSUS 1987: DE PERSONAL COMPUTER EN DE WISKUNDE OP SCHOOL
This course (for high-school teachers of mathematics) contains four possible applications of a personal computer in teaching mathematics. The topics are fractals, number theory, numerical mathematics and general mathematics. This syllabus has been written in Dutch.

1987 107 pages
ISBN 90-6196-323-0 Dfl. 21.50

15. VACANTIECURSUS 1983: COMPLEXE GETALLEN
This syllabus (in Dutch) contains (corrected) reprints of lectures about complex numbers, presented at the Vacation Course in 1983. They cover interesting aspects of complex numbers with applications in a variety of mathematical disciplines.

1987 114 pages
ISBN 90-6196-328-1 Dfl. 22.80



16. PROCEEDINGS SEMINAR 1984-1986 MATHEMATICAL STRUCTURES IN FIELD THEORIES — VOL. 1
*by P.J.M. Bongaarts, E.A. de Kerf and P.H.M. Kersten*
Lectures given in the seminar 'Mathematical Structures in Field Theories', University of Amsterdam, 1984-1986. Contents: 'axiomatics' of free quantum fields, including Wightman functions and the Fock space formalism (P.J.M. Bongaarts); physical aspects of free quantum fields, starting from the 'particle picture', based on the unitary representations of the inhomogeneous Poincaré group (E.A. de Kerf); infinitesimal symmetries using the local jet bundle formulation from differential geometry (P.H.M. Kersten).

1988 137 pages
ISBN 90-6196-345-1 Dfl. 26.60

17. MARK KAC SEMINAR ON PROBABILITY AND PHYSICS, SYLLABUS 1985-1987
*edited by F. den Hollander and H. Maassen*
This syllabus is a bundle of reports of lectures delivered at the 'Mark Kac seminar on probability and physics' during the academic years 1985-1987. This seminar is a monthly meeting in Amsterdam, held between probabilists and statistical physicists who discuss topics in their common field of interest. As such this booklet shows a cross-section of the activities in the Netherlands in this area of interaction.

1988 162 pages
ISBN 90-6196-350-8 Dfl. 30.30

18. VACANTIECURSUS 1988: DIFFERENTIEREKENING
This course (for high-school teachers of mathematics) covers the theoretical background as well as the applications of difference equations in economy, biology, numerical mathematics and computer science. Difference equations are continually compared with the corresponding differential equations. The syllabus is written in Dutch.

1988 88 pages
ISBN 90-6196-355-9 Dfl. 19.10

19. PUBLICEREN MET LATEX
*by R. de Bruin, C.G. van der Laan, J.R. Luyten, H.F. Vogt*
This course (in Dutch) about mark-up typesetting via LATEX is aimed at scientists although it can also be taken by secretaries. General aspects and terminology with respect to computerized typesetting are treated. The difference between mark-up typesetting and WYSIWYG is dealt with. Next, it is shown how simple structured manuscripts can be obtained via LATEX and how mathematics, tables, fonts and illustrations are handled. Finally, the integration of chapters into a report is treated, in particular the creation of title

page, abstract, table of contents, list of figures, cross referencing, bibliography, index, running heads, etc., as well as a two-column or two-sided result. Exercises and their solutions are included. The book is typeset via LATEX.

1988 196 pages
ISBN 90-6196-357-5 Dfl. 35.40

20. STATAL: STATISTICAL PROCEDURES IN ALGOL 60, PART 1
*edited by R. van der Horst and R.D. Gill*
STATAL is a library of statistical procedures, written in ALGOL-60, for use at the CDC CYBER 70 system of the Stichting Academisch Rekencentrum Amsterdam (SARA). At present (in the year 1988) STATAL works on the CYBER 170-175 (old) or the CYBER 180-990 (new) models under the NOS/BE operating system. STATAL contains a quite complete collection of *procedures* for elementary, generally not simple statistical computations (e.g. computation of distribution functions, inverse distribution functions, random samples from distributions, tables, pictures, statistics). Using the STATAL-procedures it is easy for an ALGOL-programmer to write programs for various statistical problems. So, applications of STATAL will mainly be in non-standard consultation and in research (e.g. simulations).

1988 200 pages
ISBN 90-6196-358-3 Dfl. 35.40

21. STATAL: STATISTICAL PROCEDURES IN ALGOL 60, PART 2
*edited by R. van der Horst and R.D. Gill*
See CWI Syllabus 20.

1988 197 pages
ISBN 90-6196-359-1 Dfl. 35.40

22. STATAL: STATISTICAL PROCEDURES IN ALGOL 60, PART 3
*edited by R. van der Horst and R.D. Gill*
See CWI Syllabus 20.

1988 227 pages
ISBN 90-6196-360-5 Dfl. 40.40

23. PROCEEDINGS VAN HET SYMPOSIUM WISKUNDE EN DE COMPUTER
*edited by J. van Mill and G.Y. Nieuwland*
This syllabus (in Dutch) covers the lectures of a minisymposium on the theme 'Mathematics and the Computer', held during the 25th Mathematical Congress of the Dutch Mathematical Society. Part I presents a comprehensive introduction to the central theme of Mathematics and the Computer. Part II-Part V deal with the special fields of Pure Mathematics, Applied Mathemathics, Stochastics and Education, respectively. The last part gives a short introduction to the central theme on behalf of a plenary discussion during the Congress.

1989 170 pages
ISBN 90-6196-374-5 Dfl. 31.70



24. BEWIJZEN IN DE WISKUNDE
*edited by P.W.H. Lemmens*
This syllabus (in Dutch) on the phenomenon 'proofs in mathematics' is divided into three chapters. Chapter I - by A.F. Monna - concerns the historical development of several aspects of 'a rigorous proof', with many historical examples of mistakes in proofs. The central themes in Chapter II - by D. van Dalen - are the questions 'why is a proof needed' and 'how should one prove', with discussions on formalisms for proving, the role of axioms, mathematicians and their proofs, didactics and proving in practice. Chapter III - by N.G. de Bruijn - gives a layman's explanation of the mathematical language AUTOMATH for proof checking, followed by an elaborate example of a text in AUTOMATH, proving that a certain algebraic system is a commutative group.

1989 87 pages
ISBN 90-6196-373-7 Dfl. 19.10

# Other Publications

1. L.E.J. Brouwer: Over de Grondslagen der Wiskunde
*edited by D. van Dalen*
This book (in Dutch) contains the full text of Brouwer's famous Ph.D. thesis from 1907 about the foundations of mathematics. It is supplemented with hitherto unpublished fragments, correspondence with his thesis adviser Korteweg, and two reviews by Mannoury. The book was published on the occasion of the 100th anniversary of Brouwer's birthday, under auspices of the Dutch Mathematical Society and the Brouwer Archive.

1981 267 pages
ISBN 90-6196-214-5 Dfl. 45.40

2. Draft Proposal for the B Programming Language
*by L.G.L.T. Meertens*
The programming language B (nowadays called ABC), developed at CWI, is designed to be used on personal computers. Its primary aim is ease of use for the programmer. Applications range from developing games, bookkeeping, simple engineering computations and solving puzzles to learning how to program. The definition of B in this publication is semi-formal because it does not capture most of the 'static semantics' in the syntactic description. The book also contains a Quick Reference.

1981 88 pages
ISBN 90-6196-238-2 Dfl. 19.10

3. A Bibliography of Lambda-Calculi, Combinatory Logics and Related Topics
*by A. Rezus*
The items listed in this bibliography fall roughly into three categories: pure theory (syntax and semantics), theory related to foundations of logic and mathematics, and applications (recursion theory, computer science, proof theory, category theory).

1982 86 pages
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4. A Contribution to the Non-Existence of Perfect Codes
*by M.R. Best*
This treatise is a slightly revised edition of the author's Ph.D. thesis (supervisor J.H. van Lint). It contains a proof that unknown $t$-perfect codes do not exist for $t \geqslant 3$, unless $t=6$ or $t=8$.

1983 99 pages
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5. Deterministic Top-Down and Bottom-Up Parsing — Historical Notes and Bibliographies
*by A. Nijholt*
The theory of parsing, as developed in the sixties by Lewis, Stearns, Knuth, Floyd, Wirth and Weber, has led to a vast body of knowledge in the seventies. This book contains bibliographies in three fields: top-down parsing, LR-grammars and parsing, and precedence parsing. There are more than thousand references, dealing primarily with theoretical problems, but also with more application oriented issues such as compiler construction techniques.

1983 118 pages
ISBN 90-6196-245-5 Dfl. 24.00

6. Zij Mogen Uiteraard Daarbij de Zuivere Wiskunde niet Verwaarloozen
*edited by G. Alberts, F. van der Blij and J. Nuis*
This book (in Dutch) highlights the foundation and early activities of the Stichting Mathematisch Centrum (SMC). The events are considered in the broader context of reconstruction after World War II. Although the book was composed on the occasion of the 40th anniversary of the SMC in 1986, its scope extends to the history of mathematics in the Netherlands during its first ten years. General considerations are complemented by interviews with mathematicians involved in the early history of the SMC, e.g. Freudenthal and Van Wijngaarden.

1987 319 pages
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7. Op de Grens van Twee Werelden
*by A.F. Monna*
This book (in Dutch) contains essays concerning the author's experience with mathematics over a period of 60 years. The central theme of these essays is the author's notion of the change from classical to modern mathematics. Reflections on this theme give way to a comparison of the situation in mathematics 60 years ago with contemporary mathematics.

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