

# Lecture Notes in Economics and Mathematical Systems

Operations Research, Computer Science, Social Science

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J. Loeckx

## Computability and Decidability

An Introduction for Students of Computer Science



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# Computability And Decidability An Introduction For Students Of Computer Science

**Raymond A. Cuninghame-Green**



## **Computability And Decidability An Introduction For Students Of Computer Science:**

**Computability and Decidability** J. Loeckx, 2012-12-06 The present Lecture Notes evolved from a course given at the Technische Hogeschool Eindhoven and later at the Technische Hogeschool Twente They are intended for computer science students more specifically their goal is to introduce the notions of computability and decidability and to prepare for the study of automata theory formal language theory and the theory of computing Except for a general mathematical background no preliminary knowledge is presupposed but some experience in programming may be helpful While classical treatises on computability and decidability are oriented towards the foundation of mathematics or mathematical logic the present notes try to relate the subject to computer science Therefore the expose is based on the use of strings rather than on that of natural numbers the notations are similar to those in use in automata theory in addition according to a common usage in formal language theory most of the proofs of computability are reduced to the semi formal description of a procedure the constructivity of which is apparent to anybody having some programming experience Notwithstanding these facts the subject is treated with mathematical rigor a great number of informal comments are inserted in order to allow a good intuitive understanding I am indebted to all those who drew my attention to some errors and ambiguities in a preliminary version of these Notes I want also to thank Miss L A Krukerink for her diligence in typing the manuscript Computability and Decidability Jacques Loeckx, 1972 *A Mathematical Primer on Computability* Amilcar Sernadas, Cristina Sernadas, Joao Rasga, 2018-11-07 The book provides a self contained introduction to computability theory for advanced undergraduate or early graduate students of mathematics and computer science The technical material is illustrated with plenty of examples problems with fully worked solutions as well as a range of proposed exercises Part I is centered around fundamental computability notions and results starting with the pillar concepts of computational model an abstract high level programming language computable function decidable and listable set proper universal function decision problem and the reduction technique for transferring decidability and listability properties The essential results namely Rice s Theorem Rice Shapiro s Theorem Rice Shapiro McNaughton Myhill s Theorem as well as Rogers Theorem and the Recursion Theorem are presented and illustrated Many to one reducibility and many to one degrees are investigated A short introduction to computation with oracles is also included Computable as well as non computable operators are introduced as well as monotonic and finitary operators The relationship between them is discussed in particular via Myhill Shepherdson s Theorem Kleene s Least Fixed Point Theorem is also presented Finally Part I terminates with a briefing on the Turing computational model Turing reducibility and Turing degrees Part II of the book concentrates on applications of computability in several areas namely in logic undecidability of arithmetic satisfiability in propositional logic decidability in modal logic Euclidean geometry graphs and Kolmogorov complexity Nevertheless no previous knowledge of these subjects is required The essential details for understanding the applications are provided *Computing Methods in Applied Sciences and Engineering R.*

Glowinski, J. L. Lions, 1976-12-01 IRIA LABORIA Institut de Recherche d Informatique et d Automatique **Decidability of Logical Theories and Their Combination** João Rasga, Cristina Sernadas, 2020-10-20 This textbook provides a self contained introduction to decidability of first order theories and their combination The technical material is presented in a systematic and universal way and illustrated with plenty of examples and a range of proposed exercises After an overview of basic first order logic concepts the authors discuss some model theoretic notions like embeddings diagrams and elementary substructures The text then goes on to explore an applicable way to deduce logical consequences from a given theory and presents sufficient conditions for a theory to be decidable The chapters that follow focus on quantifier elimination decidability of the combination of first order theories and the basics of computability theory The inclusion of a chapter on Gentzen calculus cut elimination and Craig interpolation as well as a chapter on combination of theories and preservation of decidability help to set this volume apart from similar books in the field Decidability of Logical Theories and their Combination is ideal for graduate students of Mathematics and is equally suitable for Computer Science Philosophy and Physics students who are interested in gaining a deeper understanding of the subject The book is also directed to researchers that intend to get acquainted with first order theories and their combination *A Bibliography of Logic Books* Michael Moss, Dana S. Scott, 1975 **Automata and Computability** Dexter C. Kozen, 2012-12-06 The aim of this textbook is to provide undergraduate students with an introduction to the basic theoretical models of computability and to develop some of the model s rich and varied structure Students who have already some experience with elementary discrete mathematics will find this a well paced first course and a number of supplementary chapters introduce more advanced concepts The first part of the book is devoted to finite automata and their properties Pushdown automata provide a broader class of models and enable the analysis of context free languages In the remaining chapters Turing machines are introduced and the book culminates in discussions of effective computability decidability and G del s incompleteness theorems Plenty of exercises are provided ranging from the easy to the challenging As a result this text will make an ideal first course for students of computer science **Multiple Criteria Decision Making Kyoto 1975** M. Zeleny, 1976-04 Guided soul searching for multi criterion decisions Interpersonal comparison of utilities Group decision analysis Externalizing the parameters of quasirational thought Multivariate selection of students in a racist society a systematically unfair approach A multi objective model for planning equal employment opportunities Experiences in multiobjective management processes The theory of the displaced ideal The surrogate worth trade off method with multiple decision makers An interactive multiple objective decision making aid using nonlinear goal programming Applications of multiple objectives to water resources On the approximation of solutions to multiple criteria decision making problems Why multicriteria decision aid may not fit in with the assessment of a unique criterion Multiattribute preference functions of university administrators Multicriteria simplex method a fortran routine **Proceedings of the International Conference on Regional Science, Energy, and Environment, Louvain,**

**May 1975: Environment, regional science, and interregional modeling** Manas Chatterji, Paul van Rompuy, 1976

**Convex Analysis and Its Applications** Alfred Auslender, 1977 Essays and Surveys on Multiple Criteria Decision Making P. Hansen, 1983-02 The Fifth International Conference on Multiple Criteria Decision Making not surprisingly had several objectives First it aimed at being a forum for exchange and intensive discussion of recent ideas on theory and practice of MCDM following the now well established tradition of the previous meetings in the series organized by H Thiriez and S Zionts in Jouy en Josas 1975 S Zionts in Buffalo 1977 G Fandel and T Gal in Hagen Konigswinter 1979 and J Morse in Newark 1980 Second closer contacts were desired between participants in these meetings and other active groups in the field prominent among which is the European Working Group on Multiple Criteria Decision Aid Third participation of senior or junior researchers who had recently developed important new methodologies such as the Analytical Hierarchy Process was actively sought for Fourth a synthesis of the rapidly expanding field of MCDM was to be made through selective surveys by leading researchers in the various areas it comprises Fifth cross fertilization and multidisciplinary research was to be encouraged through presentations on the connections between MCDM and mathematics economics game theory computer science and other subjects Sixth much emphasis was to be given to real world applications of MCDM particularly large scale ones and or pioneering work in new fields The present volume reflects the general agreement observed among participants that these goals were largely attained *Proceedings of the International Conference on Regional Science, Energy, and Environment, Louvain, May 1975* Manas Chatterji, Paul van Rompuy, 1976 **Optimization and Operations Research** W. Oettli, K. Ritter, 1976-02 Reduction and decomposition of modulo optimization problems Optimization of elastic structures by mathematical programming techniques On closed sets having a least element On the convergence of the variable metric method with numerical derivatives and the effect of noise in the function evaluation Parallel path strategy Theory and numerical illustrations On minimization under linear equality constraints On constrained shortest route problems Bang bang solution of a control problem for the heat equation **Evaluating Mathematical Programming Techniques** J. M. Mulvey, 1982-05 2 APL 3 5 Dyadic functions such as  $x \cdot r$   $\max$   $\min$  and  $e \cdot \log$  operate on scalars and 3 4 2 5 1 7 extend to arrays in a systematic manner Two 8 5 9 array arguments of a function must have the same 3 5 1 7 shape ie vectors must have the same number of 8 4 10 elements matrices must have the same number of 3 5 1 7 rows and columns If one argument of a function 5 3 7 is a scalar it is applied to each element of the 1 2 3 2 other argument 4 1 9 2e1 2 4 8 16 0 2 3 4 1 M 1 2 3 4 5 6 Mx2 2 4 6 8 10 12 M M 2 4 6 8 10 12 5 3 0 2 Monadic functions such as  $I \cdot x$  3 5 0 2 signum  $r$  ceiling  $L \cdot e$  small  $x$  3 5 0 2 integer greater or equal to 0 1 1 1 number  $L$  floor  $i \cdot e$  largest 2 1  $r$  3 5 2 integer less than or equal to 2 4 2  $n$  Ullwer and 0 pi times operate 2 1  $L$  3 5 2 on arrays and produce results 3 3 2 with the same shape as the argument 0 1 2 3 ment 3 14 16 6 28 32 9 42 48 3 3 R Q tion QI functions follow the same rules The 1 result is 1 for true 0 for false **Cahiers du Centre d'études de recherche opérationnelle** Université libre de Bruxelles. Centre d'études de recherche opérationnelle, 1972 **Integer**

**Programming and Related Areas** Universität Bonn. Institut für Ökonometrie und Operations Research, 1982

**Minimax Algebra** Raymond A. Cuninghame-Green, 1979 A number of different problems of interest to the operational researcher and the mathematical economist for example certain problems of optimization on graphs and networks of machine scheduling of convex analysis and of approximation theory can be formulated in a convenient way using the algebraic structure  $R$  where we may think of  $R$  as the extended real number system with the binary combining operations  $x \vee y$   $x \wedge y$  defined to be  $\max(x, y)$   $\min(x, y)$  respectively The use of this algebraic structure gives these problems the character of problems of linear algebra or linear operator theory This fact has been independently discovered by a number of people working in various fields and in different notations and the starting point for the present Lecture Notes was the writer's persuasion that the time had arrived to present a unified account of the algebra of linear transformations of spaces of  $n$  tuples over  $R$  to demonstrate its relevance to operational research and to give solutions to the standard linear algebraic problems which arise e.g. the solution of linear equations exactly or approximately the eigenvector eigenvalue problem and so on Some of this material contains results of hitherto unpublished research carried out by the writer during the years 1970-1977

**The Publishers' Trade List Annual**, 1973

Some Aspects of the Foundations of General Equilibrium Theory P.J. Kalman, 1978-08 In a wide number of economic problems the equilibrium values of the variables can be regarded as solutions of a parametrized constrained maximization problem This occurs in static as well as dynamic models in the latter case the choice variables are often paths in certain function spaces and thus can be regarded as points in infinite dimensional spaces It is sometimes possible to determine qualitative properties of the solutions with respect to changes in the parameters of the model The study of such properties is often called comparative statics 15 2 and 10 Certain comparative static properties of the maxima have proven to be of particular importance for economic theory since the works of Slutsky Hicks and Samuelson 15 they have been formulated in terms of symmetry and negative semidefiniteness of a matrix called the Slutsky Hicks Samuelson matrix A discussion of this matrix and its applications is given in Section 1 The study of these properties in economic theory however has so far been restricted to static models where the choice variable and the parameters are elements in Euclidean spaces and where there is only one constraint

**GERT Networks and the Time-Oriented Evaluation of Projects** K. Neumann, U. Steinhardt, 1979-10 Towards the end of the fifties methods for planning scheduling and control of projects were developed on the basis that the evolution of a project can be associated with a special weighted directed graph called activity network In this association the individual activities of the project correspond to the arcs the so called project events beginning or termination of activities correspond to the nodes and the durations of the activities correspond to the weights of the respective arcs of the directed graph 1 Contiguous arcs are assigned to activities which succeed one another immediately The event corresponding to a node occurs exactly at the time at which all activities which are associated with the arcs leading into the node are terminated After the occurrence of an event all those activities are begun which correspond to the

arcs emanating from the respective node This implies especially that the evolution of the project has to be uniquely determined before hand that every activity and every event are realized exactly once during the execution of the project and that feedback corresponding to cycles in the associated network is not permitted Many projects for example most R D projects and projects in the area of production planning do not satisfy the foregoing restrictions

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