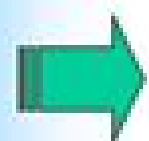


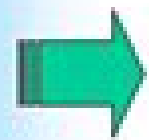
# *The membership problem in matrix semigroups*

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Given a finite set of matrices  $G = \{M_1, M_2, \dots, M_k\}$  and a matrix  $M$ . Determine whether there exists a sequence of matrices  $M_{i_1}, M_{i_2}, \dots, M_{i_l}$  from  $G$  such that  $M_{i_1} \times M_{i_2} \times \dots \times M_{i_l} = M$



In other words, Let  $S$  be a given finitely generated semigroup of  $n \times n$  matrices from  $Z^{n \times n}$  ( $Q^{n \times n}$ ). Determine whether a matrix  $M$  belongs to  $S$ .



*The motrality (membership for the zero matrix) is undecidable for 3x3 matrices. [M.Paterson]*

# Semigroups Of Matrices

**John Rhodes, Benjamin Steinberg**



## **Semigroups Of Matrices:**

**Semigroups Of Matrices** Jan Okninski, 1998-07-31 This book is concerned with the structure of linear semigroups that is subsemigroups of the multiplicative semigroup  $M_n(K)$  of  $n \times n$  matrices over a field  $K$  or more generally skew linear semigroups if  $K$  is allowed to be a division ring and its applications to certain problems on associative algebras semigroups and linear representations It is motivated by several recent developments in the area of linear semigroups and their applications It summarizes the state of knowledge in this area presenting the results for the first time in a unified form The book's point of departure is a structure theorem which allows the use of powerful techniques of linear groups Certain aspects of a combinatorial nature connections with the theory of linear representations and applications to various problems on associative algebras are also discussed

*Semigroups of Matrices* Jan Okninski, 1998 This book is concerned with the structure of linear semigroups that is subsemigroups of the multiplicative semigroup  $M_n(K)$  of  $n \times n$  matrices over a field  $K$  or more generally skew linear semigroups if  $K$  is allowed to be a division ring and its applications to certain problems on associative algebras semigroups and linear representations It is motivated by several recent developments in the area of linear semigroups and their applications It summarizes the state of knowledge in this area presenting the results for the first time in a unified form The book's point of departure is a structure theorem which allows the use of powerful techniques of linear groups Certain aspects of a combinatorial nature connections with the theory of linear representations and applications to various problems on associative algebras are also discussed

Probability Measures on Semigroups Göran Högnäs, Arunava Mukherjee, 2010-11-02 This second edition presents up to date material on the theory of weak convergence of convolution products of probability measures in semigroups the theory of random walks on semigroups and their applications to products of random matrices In addition this unique work examines the essentials of abstract semigroup theory and its application to concrete semigroups of matrices This substantially revised text includes exercises at various levels at the end of each section and includes the best available proofs on the most important theorems used in a book making it suitable for a one semester course on semigroups In addition it could also be used as a main text or supplementary material for courses focusing on probability on algebraic structures or weak convergence This book is ideally suited to graduate students in mathematics and students in other fields such as engineering and the sciences with an interest in probability Students in statistics using advanced probability will also find this book useful

**Semigroups of Matrices** Lawrence John Huber, 1962

**Probability Measures on Semigroups: Convolution Products, Random Walks and Random Matrices** Göran Högnäs, Arunava Mukherjee, 2013-03-09 A Scientific American article on chaos see Crutchfield et al 1986 illustrates a very persuasive example of recurrence A painting of Henri Poincaré or rather a digitized version of it is stretched and cut to produce a mildly distorted image of Poincaré The same procedure is applied to the distorted image and the process is repeated over and over again on the successively more and more blurred images After a dozen repetitions

nothing seems to be left of the original portrait Miraculously structured images appear briefly as we continue to apply the distortion procedure to successive images After 241 iterations the original picture reappears unchanged Apparently the pixels of the Poincare portrait were moving about in accordance with a strictly deterministic rule More importantly the set of all pixels the whole portrait was transformed by the distortion mechanism In this example the transformation seems to have been a reversible one since the original was faithfully recreated It is not very farfetched to introduce a certain amount of randomness and irreversibility in the above example Think of a random miscoloring of some pixels or of inadvertently giving a pixel the color of its neighbor The methods in this book are geared towards being applicable to the asymptotics of such transformation processes The transformations form a semigroup in a natural way we want to investigate the long term behavior of random elements of this semigroup

**The Algebraic Theory of Semigroups, Volume I** Alfred H. Clifford, G. B. Preston, 1961-12-31 The material in this volume was presented in a second year graduate course at Tulane University during the academic year 1958-1959 The book aims at being largely self contained but it is assumed that the reader has some familiarity with sets mappings groups and lattices Only in Chapter 5 will more preliminary knowledge be required and even there the classical definitions and theorems on the matrix representations of algebras and groups are summarized

*Mathematics across the Iron Curtain* Christopher Hollings, 2014-07-16 The theory of semigroups is a relatively young branch of mathematics with most of the major results having appeared after the Second World War This book describes the evolution of algebraic semigroup theory from its earliest origins to the establishment of a full fledged theory Semigroup theory might be termed Cold War mathematics because of the time during which it developed There were thriving schools on both sides of the Iron Curtain although the two sides were not always able to communicate with each other or even gain access to the other's publications A major theme of this book is the comparison of the approaches to the subject of mathematicians in East and West and the study of the extent to which contact between the two sides was possible

Lectures in Semigroups Mario Petrich, 1977 **Monoids And Semigroups With Applications - Proceedings Of The Berkeley Workshop In Monoids** John Rhodes, 1991-03-06 The purpose of the Berkeley Workshop on Monoids was to give expository talks by the most qualified experts in the emerging main areas of monoid and semigroup theory including applications to theoretical computer science This was supplemented with current research papers The topics covered in an accessible way for the mathematical and theoretical computer community were Kernels and expansions in semigroup theory Implicit operations Inverse monoids Varieties of semigroups and universal algebra Linear semigroups and monoids of Lie type Monoids acting on trees Synthesis theorem regular semigroups and applications Type II conjecture Application to theoretical computer science and decision problems

**Semigroups, Algebras and Operator Theory** P. G. Romeo, John. C. Meakin, A. R. Rajan, 2015-07-06 This book discusses recent developments in semigroup theory and its applications in areas such as operator algebras operator approximations and category theory All contributing authors are eminent researchers in

their respective fields from across the world Their papers presented at the 2014 International Conference on Semigroups Algebras and Operator Theory in Cochin India focus on recent developments in semigroup theory and operator algebras They highlight current research activities on the structure theory of semigroups as well as the role of semigroup theoretic approaches to other areas such as rings and algebras The deliberations and discussions at the conference point to future research directions in these areas This book presents 16 unpublished high quality and peer reviewed research papers on areas such as structure theory of semigroups decidability vs undecidability of word problems regular von Neumann algebras operator theory and operator approximations Interested researchers will find several avenues for exploring the connections between semigroup theory and the theory of operator algebras

*Semigroups* E. S. Lĭapin, 1968 *A Short Course on Operator Semigroups* Klaus-Jochen Engel, Rainer Nagel, 2006-06-06 The book offers a direct and up to date introduction to the theory of one parameter semigroups of linear operators on Banach spaces The book is intended for students and researchers who want to become acquainted with the concept of semigroups

*KWIC Index for Numerical Algebra* Alston Scott Householder, 1972 *The q-theory of Finite Semigroups* John Rhodes, Benjamin Steinberg, 2009-04-05 Discoveries in finite semigroups have influenced several mathematical fields including theoretical computer science tropical algebra via matrix theory with coefficients in semirings and other areas of modern algebra This comprehensive encyclopedic text will provide the reader from the graduate student to the researcher practitioner with a detailed understanding of modern finite semigroup theory focusing in particular on advanced topics on the cutting edge of research Key features 1 Develops q theory a new theory that provides a unifying approach to finite semigroup theory via quantization 2 Contains the only contemporary exposition of the complete theory of the complexity of finite semigroups 3 Introduces spectral theory into finite semigroup theory 4 Develops the theory of profinite semigroups from first principles making connections with spectra of Boolean algebras of regular languages 5 Presents over 70 research problems most new and hundreds of exercises Additional features 1 For newcomers an appendix on elementary finite semigroup theory 2 Extensive bibliography and index The q theory of Finite Semigroups presents important techniques and results many for the first time in book form and thereby updates and modernizes the literature of semigroup theory

Theory and Applications of Models of Computation T.V. Gopal, Gerhard Jäger, Silvia Steila, 2017-04-13 This book constitutes the refereed proceedings of the 14th Annual Conference on Theory and Applications of Models of Computation TAMC 2017 held in Bern Switzerland in April 2017 The 45 revised full papers presented together with 4 invited papers were carefully reviewed and selected from 103 submissions The main themes of TAMC 2017 have been computability computer science logic complexity algorithms and models of computation and systems theory

**Matrix Theory and Applications** Charles R. Johnson, 1990 This volume contains the lecture notes prepared for the AMS Short Course on Matrix Theory and Applications held in Phoenix in January 1989 Matrix theory continues to enjoy a renaissance that has accelerated in the past decade in part because of stimulation from a variety of applications and

considerable interplay with other parts of mathematics In addition the great increase in the number and vitality of specialists in the field has dispelled the popular misconception that the subject has been fully researched *Interval Semigroups* W. B. Vasantha Kandasamy, Florentin Smarandache, 2011 In this book for the first time the concept of interval semigroups using intervals of the form  $[0, a]$  is defined Several types of interval semigroups are introduced and their properties are analyzed A special feature of this book is the wide range of examples and problems Refinement Monoids, Equidecomposability Types, and Boolean Inverse Semigroups Friedrich Wehrung, 2017-09-09 Adopting a new universal algebraic approach this book explores and consolidates the link between Tarski's classical theory of equidecomposability types monoids abstract measure theory in the spirit of Hans Dobbertin's work on monoid valued measures on Boolean algebras and the nonstable K theory of rings This is done via the study of a monoid invariant defined on Boolean inverse semigroups called the type monoid The new techniques contrast with the currently available topological approaches Many positive results but also many counterexamples are provided Nonnegative Matrices in the Mathematical Sciences Abraham Berman, Robert J. Plemmons, 2014-05-10 Nonnegative Matrices in the Mathematical Sciences provides information pertinent to the fundamental aspects of the theory of nonnegative matrices This book describes selected applications of the theory to numerical analysis probability economics and operations research Organized into 10 chapters this book begins with an overview of the properties of nonnegative matrices This text then examines the inverse positive matrices Other chapters consider the basic approaches to the study of nonnegative matrices namely geometrical and combinatorial This book discusses as well some useful ideas from the algebraic theory of semigroups and considers a canonical form for nonnegative idempotent matrices and special types of idempotent matrices The final chapter deals with the linear complementary problem LCP This book is a valuable resource for mathematical economists mathematical programmers statisticians mathematicians and computer scientists *Semigroups and Formal Languages* Jorge M. Andre, 2007 This festschrift volume in honour of Donald B McAlister on the occasion of his 65th birthday presents papers from leading researchers in semigroups and formal languages The contributors cover a number of areas of current interest from pseudovarieties and regular languages to ordered groupoids and one relator groups and from semigroup algebras to presentations of monoids and transformation semigroups The papers are accessible to graduate students as well as researchers seeking new directions for future work

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