

# SEMIGROUP THEORY

VICKY G

## 1. THE BASIC CONCEPT

**Definition:** A *semigroup* is a pair  $(S, *)$  where  $S$  is a non-empty set and  $*$  is an associative binary operation on  $S$ . [i.e.  $*$  is a function  $S \times S \rightarrow S$  with  $(a, b) \mapsto a*b$  and for all  $a, b, c \in S$  we have  $a * (b * c) = (a * b) * c$ ].

We abbreviate " $(S, *)$ " by " $S$ " and often omit  $*$  in " $a * b$ " and write " $ab$ ". By induction  $a_1 a_2 \dots a_n$  is unambiguous. Thus we write  $a^n$  for

$$\underbrace{aa \dots a}_{n \text{ times}}.$$

**Index Laws:** We have that for all  $n, m \in \mathbb{N} = \{1, 2, \dots\}$  the following index laws hold

$$\begin{aligned} a^n a^m &= a^{n+m} \\ (a^n)^m &= a^{nm}. \end{aligned}$$

**Definition:** A *monoid*  $M$  is a semigroup with an identity, i.e. there exists  $1 \in M$  such that  $1a = a = a1$  for all  $a \in M$ .

Putting  $a^0 = 1$  then the index laws hold for all  $n, m \in \mathbb{N}^0$ .

*Note.* The identity of a monoid is unique.

**Definition:** A *group*  $G$  is a monoid such that for all  $a \in G$  there exists a  $b \in G$  with  $ab = 1 = ba$ .

**EXAMPLE 1.1.** Groups are monoids and monoids are semigroups. Thus we have

$$\text{Groups} \subset \text{Monoids} \subset \text{Semigroups}.$$

The one element trivial group  $\{e\}$  with multiplication table

$$\begin{array}{c|c} & e \\ \hline e & e \end{array}$$

is also called the *trivial semigroup* or *trivial monoid*.

**EXAMPLE 1.2.** A ring is a semigroup under  $\times$ . A ring with identity is a monoid.

# Semigroup Theory

**Xiaolong Qi**



## **Semigroup Theory:**

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Alfred Hoblitzelle Clifford,1996-05-16 This volume contains survey papers by the invited speakers at the Conference on Semigroup Theory and Its Applications which took place at Tulane University in April 1994 The authors represent the leading areas of research in semigroup theory and its applications both to other areas of mathematics and to areas outside mathematics Included are papers by Gordon Preston surveying Clifford s work on Clifford semigroups and by John Rhodes tracing the influence of Clifford s work on current semigroup theory Notable among the areas of application are the paper by Jean Eric Pin on applications of other areas of mathematics to semigroup theory and the paper by the editors on an application of semigroup theory to theoretical computer science and mathematical logic All workers in semigroup theory will find this volume invaluable **Semigroup Theory and Evolution Equations** Philippe Clement,2023-05-31 Proceedings of the Second International Conference on Trends in Semigroup Theory and Evolution Equations held Sept 1989 Delft University of Technology the Netherlands Papers deal with recent developments in semigroup theory e g positive dual integrated and nonlinear evolution equations e **Semigroup Theory with Applications to Systems and Control** Nasir Uddin Ahmed,1991 [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      **Semigroup Theory - Proceedings Of The Monash Conference On Semigroup Theory In Honor Of G B Preston** T E Hall, Peter R Jones, John C Meakin, 1991-05-21 This conference celebrated the 65th birthday of Professor G B Preston of Monash University Containing contributions from almost all his mathematical progeny the proceedings is a tribute to his influence on semigroup and Australian mathematics      *Semigroups of Operators: Theory and Applications* A.V. Balakrishnan, 2012-12-06 These Proceedings comprise the bulk of the papers presented at the International Conference on Semigroups of Operators Theory and Control held 14-18 December 1998 Newport Beach California U S A The intent of the Conference was to highlight recent advances in the theory of Semigroups of Operators which provides the abstract framework for the time domain solutions of time invariant boundary value initial value problems of partial differential equations There is of course a firewall between the abstract theory and the applications and one of the Conference aims was to bring together both in the hope that it may be of value to both communities In these days when all scientific activity is judged by its value on dot com it is not surprising that mathematical analysis that holds no promise of an immediate commercial product line or even a software tool box is not high in research priority We are particularly pleased therefore that the National Science Foundation provided generous financial support without which this Conference would have been impossible to organize Our special thanks to Dr Kishan Baheti Program Manager      **Techniques of Semigroup Theory** Peter M. Higgins, 1992 This book introduces recently developed ideas and techniques in semigroup theory to provide a handy reference guide The trend is from the abstract to the combinatorial with new probabilistic and word problem results of interest to students of computer science and algebra alike      **The Algebraic Theory of Semigroups, Volume II** Alfred H. Clifford, G. B. Preston, 1961      **Fundamentals of Semigroup Theory**, 1995      **Algorithmic Problems in Groups and Semigroups** Jean-Camille Birget, Stuart Margolis, John Meakin, Mark V. Sapir, 2012-12-06 This volume contains papers which are based primarily on talks given at an international conference on Algorithmic Problems in Groups and Semigroups held at the University of Nebraska Lincoln from May 11-May 16 1998 The conference coincided with the Centennial Celebration of the Department of Mathematics and Statistics at the University of Nebraska Lincoln on the occasion of the hundredth anniversary of the granting of the first Ph D by the department Funding was provided by the US National Science Foundation the Department of Mathematics and Statistics and the College of Arts and Sciences at the University of Nebraska Lincoln through the College's focus program in Discrete Experimental and Applied Mathematics The purpose of the conference was to bring together researchers with interests in algorithmic problems in group theory semigroup theory and computer science A particularly useful feature of this conference was that it provided a framework for exchange of ideas between the research communities in semigroup theory and group theory and several of the papers collected here reflect this interaction of ideas The papers collected in this volume represent a cross section of some of the results and ideas that were discussed in the conference They reflect a synthesis of overlapping ideas and techniques

stimulated by problems concerning finite monoids finitely presented monoids finitely presented groups and free groups

*Automata Theory* Matthew Simon, 1999 This book covers substantially the central ideas of a one semester course in automata theory It is oriented towards a mathematical perspective that is understandable to non mathematicians Comprehension is greatly aided by many examples especially on the Chomsky Schutzenberger theorem which is not found in most books in this field Special attention is given to semiautomata theory the relationship between semigroups and sequential machines including Green's relations Schutzenberger's maximal subgroup von Neumann inverses wreath products transducers using matrix notation shuffle and Kronecker shuffle products Methods of formal power series the ambiguity index and linear languages are discussed Core material includes finite state automata regular expressions Kleene's theorem Chomsky's hierarchy and transformations of grammars Ambiguous grammars not limited to context free grammars and modal logics are briefly discussed Turing machine variants with many examples pushdown automata and their state transition diagrams and parsers linear bounded automata 2 PDA and Kuroda normal form are also discussed A brief study of Lindenmeyer systems is offered as a comparison to the theory of Chomsky

*Neutrosophic Theory and Its Applications, Vol. I* Florentin Smarandache, 2014-12-01 This volume contains 45 papers written by the author alone or in collaboration with the following co authors Mumtaz Ali Said Broumi Sukanto Bhattacharya Mamoni Dhar Irfan Deli Mincong Deng Alexandru Gal Valeri Kroumov Pabitra Kumar Maji Maikel Leyva Vazquez Feng Liu Pinaki Majumdar Munazza Naz Karina Perez Teruel R dvan Sahin A A Salama Muhammad Shabir Rajshekhar Sunderraman Luige Vladareanu Magdalena Vladila Stefan Vladutescu Haibin Wang Hongnian Yu Yan Qing Zhang

*Wagner's Theory of Generalised Heaps* Christopher D. Hollings, Mark V. Lawson, 2017-09-09 The theories of V V Wagner 1908 1981 on abstractions of systems of binary relations are presented here within their historical and mathematical contexts This book contains the first translation from Russian into English of a selection of Wagner's papers the ideas of which are connected to present day mathematical research Along with a translation of Wagner's main work in this area his 1953 paper Theory of generalised heaps and generalised groups the book also includes translations of three short precursor articles that provide additional context for his major work Researchers and students interested in both algebra in particular heaps semiheaps generalised heaps semigroups and groups and differential geometry will benefit from the techniques offered by these translations owing to the natural connections between generalised heaps and generalised groups and the role played by these concepts in differential geometry This book gives examples from present day mathematics where ideas related to Wagner's have found fruitful applications

*Inverse Semigroups* Mark V. Lawson, 1998 this volume represents an outstanding contribution to the field The resolute graduate student or mature researcher alike can find a wealth of directions for future work Mathematical Reviews

*Lattices, Semigroups, and Universal Algebra* Jorge Almeida, Gabriela Bordalo, Philip Dwinger, 2013-11-11 This volume contains papers which for the most part are based on talks given at an international conference on Lattices Semigroups and Universal

Algebra that was held in Lisbon Portugal during the week of June 20 24 1988 The conference was dedicated to the memory of Professor Antonio Almeida Costa a Portuguese mathematician who greatly contributed to the development of th algebra in Portugal on the 10 anniversary of his death The themes of the conference reflect some of his research interests and those of his students The purpose of the conference was to gather leading experts in Lattices Semigroups and Universal Algebra and to promote a discussion of recent developments and trends in these areas All three fields have grown rapidly during the last few decades with varying degrees of interaction Lattice theory and Universal Algebra have historically evolved alongside with a large overlap between the groups of researchers in the two fields More recently techniques and ideas of these theories have been used extensively in the theory of semigroups Conversely some developments in that area may inspire further developments in Universal Algebra On the other hand techniques of semi group theory have naturally been employed in the study of semilattices Several papers in this volume elaborate on these interactions

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

Control Theory of Infinite-Dimensional Systems  
Joachim Kerner, Hafida Laasri, Delio Mugnolo, 2020-06-25 This book presents novel results by participants of the conference Control theory of infinite dimensional systems that took place in January 2018 at the FernUniversit t in Hagen Topics include well posedness controllability optimal control problems as well as stability of linear and nonlinear systems and are covered by world leading experts in these areas A distinguishing feature of the contributions in this volume is the particular combination of researchers from different fields in mathematics working in an interdisciplinary fashion on joint projects in mathematical system theory More explicitly the fields of partial differential equations semigroup theory mathematical physics graph and network theory as well as numerical analysis are all well represented

## Unveiling the Power of Verbal Beauty: An Mental Sojourn through **Semigroup Theory**

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