

Universal Algebras

1 Operations

A **universal algebra** is a set X with some operations $\ast : X^n \rightarrow X$ and relations¹ $\sim \subseteq X^m$.

For example, there may be specific constants ($n = 0$), functions ($n = 1$), and operations ($n = 2$), etc. An n -ary operation is usually written as $x \ast y \ast \dots$ instead of $\ast(x, y, \dots)$, and an m -ary relation as $x \sim y \sim \dots$ instead of $\sim(x, y, \dots)$.

Elements are *indistinguishable* when

$$\ast(\dots, x, \dots) = \ast(\dots, y, \dots), \quad \sim(\dots, x, \dots) \Leftrightarrow \sim(\dots, y, \dots).$$

A **subalgebra** is a subset closed under all the operations

$$x, y, \dots \in Y \Rightarrow x \ast y \ast \dots \in Y$$

(The relations are obviously inherited.)

If A_i are subalgebras, then $\bigcap_i A_i$ is a subalgebra.

$[A]$, the subalgebra generated by A , is the smallest subalgebra containing A ,

$$[A] := \bigcap \{Y \subseteq X : A \subseteq Y, Y \text{ is a subalgebra}\}$$

Hence $A \subseteq Y \Leftrightarrow [A] \subseteq Y$ (for any subalgebra Y).

$A \cap B$ is the largest subalgebra contained in the algebras A and B ; $[A \cup B]$ is the smallest containing them. The collection of subalgebras form a complete lattice.

<p>For any subsets,</p> $A \subseteq [A], \quad \ [A]\ = [A]$ $A \subseteq B \Rightarrow [A] \subseteq [B].$
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The map $A \mapsto [A]$ is thus a ‘closure’ map on the lattice of subsets of X , with the ‘closed sets’ being the subalgebras.

Proof. Let $x, y, \dots \in [A]$, then for any $Y \supseteq A$, $x \ast y \ast \dots \in Y$, so $x \ast y \ast \dots \in [A]$. Hence $A \subseteq B \subseteq [B]$ gives $[A] \subseteq [B]$. Also $[A] \subseteq [A]$, so $\|[A]\| \subseteq [A] \subseteq \|[A]\|$. □

When the number of operations is finite, the generated subalgebra can be constructed recursively as $[A] = \bigcup_{n \in \mathbb{N}} B_n$ where

$$B_0 := A, \quad B_{n+1} := B_n \cup \bigcup_{\ast} \ast(B_n).$$

¹Relations are not usually included in the definition of universal algebras.

Universal Algebra Universal Algebra

Scott C. Dulebohn



Universal Algebra Universal Algebra:

Universal Algebra for Computer Scientists Wolfgang Wechler, 2012-12-06 A new model theoretic approach to universal algebra is offered in this book. Written for computer scientists, it presents a systematic development of the methods and results of universal algebra that are useful in a variety of applications in computer science. The notation is simple and the concepts are clearly presented. The book concerns the algebraic characterization of axiomatic classes of algebras: equational, implicational, and universal Horn classes by closure operators, generalizing the famous Birkhoff Variety Theorem and the algebraic characterization of the related theories. The book also presents a thorough study of term rewriting systems. Besides basic notions, the Knuth-Bendix completion procedure and termination proof methods are considered. A third main topic is that of fixpoint techniques and complete ordered algebras. Algebraic specifications of abstract data types and algebraic semantics of recursive program schemes are treated as applications. The book is self-contained and suitable both as a textbook for graduate courses and as a reference for researchers. *Topics in Universal Algebra* B. Jonsson, 2006-11-15

Universal Algebra P.M. Cohn, 2012-12-06 The present book was conceived as an introduction for the user of universal algebra rather than a handbook for the specialist, but when the first edition appeared in 1965 there were practically no other books entirely devoted to the subject, whether introductory or specialized. Today the specialist in the field is well provided for, but there is still a demand for an introduction to the subject to suit the user, and this seemed to justify a reissue of the book. Naturally, some changes have had to be made; in particular, I have corrected all errors that have been brought to my notice. Besides errors, some obscurities in the text have been removed, and the references brought up to date. I should like to express my thanks to a number of correspondents for their help, in particular C.G. Ambly, W. Felscher, P. Goralcik, P.J. Higgins, H.J. Hoehnke, J.R. Isbell, A.H. Kruse, E.J. Peake, D. Suter, J.S. Wilson. But I owe a special debt to G.M. Bergman, who has provided me with extensive comments, particularly on Chapter VII, and the supplementary chapters. I have also consulted reviews of the first edition as well as the Italian and Russian translations. **Universal Algebra and Coalgebra** Klaus Denecke, Shelly L. Wismath, 2009

The purpose of this book is to study the structures needed to model objects in universal algebra, universal coalgebra, and theoretical computer science. Universal algebra is used to describe different kinds of algebraic structures, while coalgebras are used to model state-based machines in computer science. The connection between algebras and coalgebras provides a way to connect static, data-oriented systems with dynamical, behavior-oriented systems. Algebras are used to describe data types, and coalgebras describe abstract systems or machines. The book presents a clear overview of the area from which further study may proceed. *Universal Algebra and Applications in Theoretical Computer Science* Klaus Denecke, Shelly L. Wismath, 2018-10-03 Over the past 20 years, the emergence of clone theory, hyperequational theory, commutator theory, and tame congruence theory has led to a growth of universal algebra both in richness and in applications, especially in computer science. Yet most of the classic books on the subject are long out of print, and to date no other book has

integrated these theories with the long established work that supports them Universal Algebra and Applications in Theoretical Computer Science introduces the basic concepts of universal algebra and surveys some of the newer developments in the field The first half of the book provides a solid grounding in the core material A leisurely pace careful exposition numerous examples and exercises combine to form an introduction to the subject ideal for beginning graduate students or researchers from other areas The second half of the book focuses on applications in theoretical computer science and advanced topics including Malcev conditions tame congruence theory clones and commutators The impact of the advances in universal algebra on computer science is just beginning to be realized and the field will undoubtedly continue to grow and mature Universal Algebra and Applications in Theoretical Computer Science forms an outstanding text and offers a unique opportunity to build the foundation needed for further developments in its theory and in its computer science applications

A Treatise on Universal Algebra Alfred North Whitehead, 1898 **Lectures in Universal Algebra** L. Szabó, A. Szendrei, 2016-01-22 These 34 papers cover topics ranging from various problems on varieties and other classes of algebras including categorical aspects and duality theory to the structure of finite algebras and clones on finite or infinite sets As well as survey articles by invited speakers the papers contain full proofs of new results not published elsewhere The volume ends with a list of problems

Official Summary of Security Transactions and Holdings Reported to the Securities and Exchange Commission Under the Securities Exchange Act of 1934 and the Public Utility Holding Company Act of 1935, 1988 *Operads and Universal Algebra* Chengming Bai, 2012 The book aims to exemplify the recent developments in operad theory in universal algebra and related topics in algebraic topology and theoretical physics

The conference has established a better connection between mathematicians working on operads mainly the French team and mathematicians working in universal algebra primarily the Chinese team and to exchange problems methods and techniques from these two subject areas Contributions to Universal Algebra B. Csákány, J. Schmidt, 2014-05-15

Contributions to Universal Algebra focuses on the study of algebra The compilation first discusses the congruence lattice of pseudo simple algebras elementary properties of limit reduced powers with applications to Boolean powers and congruent lattices of 2 valued algebras The book further looks at duality for algebras weak homomorphisms of stone algebras varieties of modular lattices not generated by their finite dimensional members and remarks on algebraic operations of stone algebras The text describes polynomial normal forms and the embedding of polynomial algebras coverings in the lattice of varieties embedding semigroups in semigroups generated by idempotents and endomorphism semigroups and subgroupoid lattices The book also discusses a report on sublattices of a free lattice and then presents the cycles in finite semi distributive lattices cycles in S lattices and summary of results The text also describes primitive subsets of algebras ideals normal sets and congruences as well as Jacobson's density theorem The book is a good source for readers wanting to study algebra

Universal Algebra B. Csákány, E. Csákány, Ervin Fried, Eligius Tamás Schmidt, 1982 Universal Algebraic Logic Hajnal

Andréka, Zoltán Gyenis, István Németi, Ildikó Sain, 2022-11-01 This book gives a comprehensive introduction to Universal Algebraic Logic The three main themes are i universal logic and the question of what logic is ii duality theories between the world of logics and the world of algebra and iii Tarskian algebraic logic proper including algebras of relations of various ranks cylindric algebras relation algebras polyadic algebras and other kinds of algebras of logic One of the strengths of our approach is that it is directly applicable to a wide range of logics including not only propositional logics but also e.g. classical first order logic and other quantifier logics Following the Tarskian tradition besides the connections between logic and algebra related logical connections with geometry and eventually spacetime geometry leading up to relativity are also part of the perspective of the book Besides Tarskian algebraizations of logics category theoretical perspectives are also touched upon This book apart from being a monograph containing state of the art results in algebraic logic can be used as the basis for a number of different courses intended for both novices and more experienced students of logic mathematics or philosophy For instance the first two chapters can be used in their own right as a crash course in Universal Algebra

An Invitation to General Algebra and Universal Constructions George M. Bergman, 2015-02-05 Rich in examples and intuitive discussions this book presents General Algebra using the unifying viewpoint of categories and functors Starting with a survey in non category theoretic terms of many familiar and not so familiar constructions in algebra plus two from topology for perspective the reader is guided to an understanding and appreciation of the general concepts and tools unifying these constructions Topics include set theory lattices category theory the formulation of universal constructions in category theoretic terms varieties of algebras and adjunctions A large number of exercises from the routine to the challenging interspersed through the text develop the reader's grasp of the material exhibit applications of the general theory to diverse areas of algebra and in some cases point to outstanding open questions Graduate students and researchers wishing to gain fluency in important mathematical constructions will welcome this carefully motivated book

A Course in Universal Algebra Stanley Burris, H. P. Sankappanavar, 1981-11-16 Universal algebra has enjoyed a particularly explosive growth in the last twenty years and a student entering the subject now will find a bewildering amount of material to digest This text is not intended to be encyclopedic rather a few themes central to universal algebra have been developed sufficiently to bring the reader to the brink of current research The choice of topics most certainly reflects the authors' interests Chapter I contains a brief but substantial introduction to lattices and to the close connection between complete lattices and closure operators In particular everything necessary for the subsequent study of congruence lattices is included Chapter II develops the most general and fundamental notions of universal algebra these include the results that apply to all types of algebras such as the homomorphism and isomorphism theorems Free algebras are discussed in great detail we use them to derive the existence of simple algebras the rules of equational logic and the important Malcev conditions We introduce the notion of classifying a variety by properties of the lattices of congruences on members of the variety Also the center of an algebra is defined and

used to characterize modules up to polynomial equivalence In Chapter III we show how neatly two famous results the refutation of Euler's conjecture on orthogonal Latin squares and Kleene's characterization of languages accepted by finite automata can be presented using universal algebra We predict that such applied universal algebra will become much more prominent

Algebras and Orders Ivo G. Rosenberg, Gert Sabidussi, 2013-03-09 In the summer of 1991 the Department of Mathematics and Statistics of the Université de Montréal was fortunate to host the NATO Advanced Study Institute Algebras and Orders as its 30th Séminaire de mathématiques supérieures SMS a summer school with a long tradition and well established reputation This book contains the contributions of the invited speakers Universal algebra which established itself only in the 1930's grew from traditional algebra e.g. groups modules rings and lattices and logic e.g. propositional calculus model theory and the theory of relations It started by extending results from these fields but by now it is a well established and dynamic discipline in its own right One of the objectives of the ASI was to cover a broad spectrum of topics in this field and to put in evidence the natural links to and interactions with boolean algebra lattice theory topology graphs relations automata theoretical computer science and partial orders The theory of orders is a relatively young and vigorous discipline sharing certain topics as well as many researchers and meetings with universal algebra and lattice theory W Taylor surveyed the abstract clone theory which formalizes the process of composing operations i.e. the formation of term operations of an algebra as a special category with countably many objects and leading naturally to the interpretation and equivalence of varieties

Generalized Universal Algebra in Initial Structure Categories Manfred Bernd Wischnewsky, 1973

Universal Algebra Clifford Bergman, 2011-09-20 Starting with the most basic notions Universal Algebra Fundamentals and Selected Topics introduces all the key elements needed to read and understand current research in this field Based on the author's two semester course the text prepares students for research work by providing a solid grounding in the fundamental constructions and concepts of

Congruence Classes in Universal Algebra Ivan Chajda, G.

Eigenthaler, Helmut Länger, 2003

Universal Algebra Clifford Bergman, 2011 Starting with the most basic notions Universal Algebra Fundamentals and Selected Topics introduces all the key elements needed to read and understand current research in this field Based on the author's two semester course the text prepares students for research work by providing a solid grounding in the fundamental constructions and concepts of universal algebra and by introducing a variety of recent research topics The first part of the book focuses on core components including subalgebras congruences lattices direct and subdirect products isomorphism theorems a clone of operations terms free algebras Birkhoff's theorem and standard Maltsev conditions The second part covers topics that demonstrate the power and breadth of the subject The author discusses the consequences of Jonsson's lemma finitely and nonfinitely based algebras definable principal congruences and the work of Foster and Pixley on primal and quasiprimal algebras He also includes a proof of Murski's theorem on primal algebras and presents McKenzie's characterization of directly representable varieties which clearly shows the power of the universal

algebraic toolbox The last chapter covers the rudiments of tame congruence theory Throughout the text a series of examples illustrates concepts as they are introduced and helps students understand how universal algebra sheds light on topics they have already studied such as Abelian groups and commutative rings Suitable for newcomers to the field the book also includes carefully selected exercises that reinforce the concepts and push students to a deeper understanding of the theorems and techniques A Treatise on Universal Algebra Alfred North Whitehead, 1898

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