

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.

For any subsets, $A \subseteq [A], \quad \ [A]\ = [A]$ $A \subseteq B \Rightarrow [A] \subseteq [B].$
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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

Klaus Denecke, Shelly L. Wismath



Universal Algebra Universal Algebra:

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

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

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

Topics in Universal Algebra B. Jonsson, 2006-11-15

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

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 **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 *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

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