

# Mathematical Logic

**Theorem 1.2.29:** Let  $p$ ,  $q$ , and  $r$  be statements. Then the following logical equivalences hold.

- (i) **Commutative laws:**  $p \wedge q \equiv q \wedge p$  and  $p \vee q \equiv q \vee p$
- (ii) **Associative laws:**  $(p \wedge q) \wedge r \equiv p \wedge (q \wedge r)$  and  
 $(p \vee q) \vee r \equiv p \vee (q \vee r)$
- (iii) **Distributive laws:**  $p \vee (q \wedge r) \equiv (p \vee q) \wedge (p \vee r)$  and  
 $p \wedge (q \vee r) \equiv (p \wedge q) \vee (p \wedge r)$
- (iv) **Absorption laws:**  $p \wedge (p \vee q) \equiv p$  and  $p \vee (p \wedge q) \equiv p$
- (v) **Idempotent laws:**  $p \wedge p \equiv p$  and  $p \vee p \equiv p$
- (vi) **Double negation law:**  $\sim\sim p \equiv p$
- (vii) **DeMorgan's laws:**  $\sim(p \wedge q) \equiv (\sim p) \vee (\sim q)$  and  
 $\sim(p \vee q) \equiv (\sim p) \wedge (\sim q)$

# Mathematical Logic

**George Tourlakis**



## **Mathematical Logic:**

**Modern Mathematical Logic** Joseph Mileti, 2022-09-22 This textbook gives a complete and modern introduction to mathematical logic. The author uses contemporary notation conventions and perspectives throughout and emphasizes interactions with the rest of mathematics. In addition to covering the basic concepts of mathematical logic and the fundamental material on completeness, compactness, and incompleteness, it devotes significant space to thorough introductions to the pillars of the modern subject: model theory, set theory, and computability. Requiring only a modest background of undergraduate mathematics, the text can be readily adapted for a variety of one or two semester courses at the upper undergraduate or beginning graduate level. Numerous examples reinforce the key ideas and illustrate their applications, and a wealth of classroom-tested exercises serve to consolidate readers' understanding. Comprehensive and engaging, this book offers a fresh approach to this enduringly fascinating and important subject.

**A Concise Introduction to Mathematical Logic** Wolfgang Rautenberg, 2006-09-28 While there are already several well-known textbooks on mathematical logic, this book is unique in treating the material in a concise and streamlined fashion. This allows many important topics to be covered in a one-semester course. Although the book is intended for use as a graduate text, the first three chapters can be understood by undergraduates interested in mathematical logic. The remaining chapters contain material on logic programming for computer scientists, model theory, recursion theory, Gödel's Incompleteness Theorems, and applications of mathematical logic. Philosophical and foundational problems of mathematics are discussed throughout the text.

**Handbook of Mathematical Logic** J. Barwise, 1982-03-01 The handbook is divided into four parts: model theory, set theory, recursion theory, and proof theory. Each of the four parts begins with a short guide to the chapters that follow. Each chapter is written for non-specialists in the field in question. Mathematicians will find that this book provides them with a unique opportunity to apprise themselves of developments in areas other than their own.

**Mathematical Logic** George Tourlakis, 2011-03-01 A comprehensive and user-friendly guide to the use of logic in mathematical reasoning. Mathematical Logic presents a comprehensive introduction to formal methods of logic and their use as a reliable tool for deductive reasoning. With its user-friendly approach, this book successfully equips readers with the key concepts and methods for formulating valid mathematical arguments that can be used to uncover truths across diverse areas of study such as mathematics, computer science, and philosophy. The book develops the logical tools for writing proofs by guiding readers through both the established Hilbert style of proof writing as well as the equational style that is emerging in computer science and engineering applications. Chapters have been organized into the two topical areas of Boolean logic and predicate logic. Techniques situated outside formal logic are applied to illustrate and demonstrate significant facts regarding the power and limitations of logic, such as: Logic can certify truths and only truths; Logic can certify all absolute truths; completeness theorems of Post and Gödel; Logic cannot certify all conditional truths such as those that are specific to the Peano arithmetic.

Therefore logic has some serious limitations as shown through Godel's incompleteness theorem. Numerous examples and problem sets are provided throughout the text further facilitating readers' understanding of the capabilities of logic to discover mathematical truths. In addition, an extensive appendix introduces Tarski semantics and proceeds with detailed proofs of completeness and first incompleteness theorems while also providing a self-contained introduction to the theory of computability. With its thorough scope of coverage and accessible style, *Mathematical Logic* is an ideal book for courses in mathematics, computer science, and philosophy at the upper undergraduate and graduate levels. It is also a valuable reference for researchers and practitioners who wish to learn how to use logic in their everyday work. **A Beginner's Guide to**

**Mathematical Logic** Raymond M. Smullyan, 2014-03-19 Combining stories of great writers and philosophers with quotations and riddles, this original text for first courses in mathematical logic examines problems related to proofs, propositional logic, and first order logic, undecidability, and other topics. 2014 edition. **Mathematical Logic for Computer Science**

Mordechai Ben-Ari, 2012-06-16 *Mathematical Logic for Computer Science* is a mathematics textbook with theorems and proofs, but the choice of topics has been guided by the needs of students of computer science. The method of semantic tableaux provides an elegant way to teach logic that is both theoretically sound and easy to understand. The uniform use of tableaux-based techniques facilitates learning advanced logical systems based on what the student has learned from elementary systems. The logical systems presented are propositional logic, first order logic, resolution, and its application to logic programming, Hoare logic for the verification of sequential programs, and linear temporal logic for the verification of concurrent programs. The third edition has been entirely rewritten and includes new chapters on central topics of modern computer science: SAT solvers and model checking. *Introduction to Mathematical Logic* Elliott Mendelson, 2015-05-21 The

new edition of this classic textbook *Introduction to Mathematical Logic* Sixth Edition explores the principal topics of mathematical logic. It covers propositional logic, first order logic, first order number theory, axiomatic set theory, and the theory of computability. The text also discusses the major results of Godel, Church, Kleene, and Rosser. *Mathematical Logic* Roman Kossak, 2018-10-03 This book, presented in two parts, offers a slow introduction to mathematical logic and several basic concepts of model theory such as first order definability, types, symmetries, and elementary extensions. Its first part, *Logic Sets and Numbers*, shows how mathematical logic is used to develop the number structures of classical mathematics. The exposition does not assume any prerequisites; it is rigorous but as informal as possible. All necessary concepts are introduced exactly as they would be in a course in mathematical logic but are accompanied by more extensive introductory remarks and examples to motivate formal developments. The second part, *Relations Structures Geometry*, introduces several basic concepts of model theory such as first order definability, types, symmetries, and elementary extensions, and shows how they are used to study and classify mathematical structures. Although more advanced, this second part is accessible to the reader who is either already familiar with basic mathematical logic or has carefully read the first part of the book. Classical developments in model

theory including the Compactness Theorem and its uses are discussed Other topics include tameness minimality and order minimality of structures The book can be used as an introduction to model theory but unlike standard texts it does not require familiarity with abstract algebra This book will also be of interest to mathematicians who know the technical aspects of the subject but are not familiar with its history and philosophical background Introduction to Mathematical Logic Jerome Malitz,2012-12-06 This book is intended as an undergraduate senior level or beginning graduate level text for mathematical logic There are virtually no prerequisites although a familiarity with notions encountered in a beginning course in abstract algebra such as groups rings and fields will be useful in providing some motivation for the topics in Part III An attempt has been made to develop the beginning of each part slowly and then to gradually quicken the pace and the complexity of the material Each part ends with a brief introduction to selected topics of current interest The text is divided into three parts one dealing with set theory another with computable function theory and the last with model theory Part III relies heavily on the notation concepts and results discussed in Part I and to some extent on Part II Parts I and II are independent of each other and each provides enough material for a one semester course The exercises cover a wide range of difficulty with an emphasis on more routine problems in the earlier sections of each part in order to familiarize the reader with the new notions and methods The more difficult exercises are accompanied by hints In some cases significant theorems are developed step by step with hints in the problems Such theorems are not used later in the sequence **What Is Mathematical Logic?** J. N. Crossley,C.J. Ash,C.J. Brickhill,J.C. Stillwell,2012-08-29 A serious introductory treatment geared toward non logicians this survey traces the development of mathematical logic from ancient to modern times and discusses the work of Planck Einstein Bohr Pauli Heisenberg Dirac and others 1972 edition **Mathematical Logic and Its Applications** Dimiter G. Skordev,2012-12-06 The Summer School and Conference on Mathematical Logic and its Applications September 24 October 4 1986 Druzhba Bulgaria was honourably dedicated to the 80 th anniversary of Kurt Godel 1906 1978 one of the greatest scientists of this and not only of this century The main topics of the Meeting were Logic and the Foundation of Mathematics Logic and Computer Science Logic Philosophy and the Study of Language Kurt Godel s life and deed The scientific program comprised 5 kinds of activities namely a a Godel Session with 3 invited lecturers b a Summer School with 17 invited lecturers c a Conference with 13 contributed talks d Seminar talks one invited and 12 with no preliminary selection e three discussions The present volume reflects an essential part of this program namely 14 of the invited lectures and all of the contributed talks Not presented in the volume remained six of the invited lecturers who did not submit texts Yu Ershov The Language of expressions and its Semantics S Goncharov Mathematical Foundations of Semantic Programming Y Moschovakis Foundations of the Theory of Algorithms N Nagornyj Is Realizability of Propositional Formulae a GBdelean Property N Shanin Some Approaches to Finitization of Mathematical Analysis V Uspensky Algorithms and Randomness joint with A N Mathematical Logic Ian Chiswell,Wilfrid Hodges,2007-05-17 Assuming no previous study

in logic this informal yet rigorous text covers the material of a standard undergraduate first course in mathematical logic using natural deduction and leading up to the completeness theorem for first order logic At each stage of the text the reader is given an intuition based on standard mathematical practice which is subsequently developed with clean formal mathematics Alongside the practical examples readers learn what can and can't be calculated for example the correctness of a derivation proving a given sequent can be tested mechanically but there is no general mechanical test for the existence of a derivation proving the given sequent The undecidability results are proved rigorously in an optional final chapter assuming Matiyasevich's theorem characterising the computably enumerable relations Rigorous proofs of the adequacy and completeness proofs of the relevant logics are provided with careful attention to the languages involved Optional sections discuss the classification of mathematical structures by first order theories the required theory of cardinality is developed from scratch Throughout the book there are notes on historical aspects of the material and connections with linguistics and computer science and the discussion of syntax and semantics is influenced by modern linguistic approaches Two basic themes in recent cognitive science studies of actual human reasoning are also introduced Including extensive exercises and selected solutions this text is ideal for students in Logic Mathematics Philosophy and Computer Science

**Principles of Mathematical Logic** D. Hilbert, W. Ackermann, 2022-05-11 David Hilbert was particularly interested in the foundations of mathematics Among many other things he is famous for his attempt to axiomatize mathematics This now classic text is his treatment of symbolic logic This translation is based on the second German edition and has been modified according to the criticisms of Church and Quine In particular the author's original formulation of Gödel's completeness proof for the predicate calculus has been updated In the first half of the twentieth century an important debate on the foundations of mathematics took place Principles of Mathematical Logic represents one of Hilbert's important contributions to that debate Although symbolic logic has grown considerably in the subsequent decades this book remains a classic

Mathematical Logic Heinz-Dieter Ebbinghaus, Jörg Flum, Wolfgang Thomas, 2021-05-28 This introduction to first order logic clearly works out the role of first order logic in the foundations of mathematics particularly the two basic questions of the range of the axiomatic method and of theorem proving by machines It covers several advanced topics not commonly treated in introductory texts such as Fraïssé's characterization of elementary equivalence Lindström's theorem on the maximality of first order logic and the fundamentals of logic programming

Mathematical Logic René Cori, Daniel Lascar, 2000 Logic forms the basis of mathematics and is hence a fundamental part of any mathematics course It is a major element in theoretical computer science and has undergone a huge revival with the every growing importance of computer science This text is based on a course to undergraduates and provides a clear and accessible introduction to mathematical logic The concept of model provides the underlying theme giving the text a theoretical coherence whilst still covering a wide area of logic The foundations having been laid in Part I this book starts with recursion theory a topic essential for the complete scientist Then

follows Gödel's incompleteness theorems and axiomatic set theory Chapter 8 provides an introduction to model theory There are examples throughout each section and varied selection of exercises at the end Answers to the exercises are given in the appendix

**Mathematical Logic** Joseph R. Shoenfield, 2001-02-09 8 3 The consistency proof 8 4 Applications of the consistency proof 8 5 Second order arithmetic Problems Chapter 9 Set Theory 9 1 Axioms for sets 9 2 Development of set theory 9 3 Ordinals 9 4 Cardinals 9 5 Interpretations of set theory 9 6 Constructible sets 9 7 The axiom of constructibility 9 8 Forcing 9 9 The independence proofs 9 10 Large cardinals Problems Appendix The Word Problem Index

**Mathematical Logic** Daniel Cunningham, 2023-05-22 Mathematical Logic An Introduction is a textbook that uses mathematical tools to investigate mathematics itself In particular the concepts of proof and truth are examined The book presents the fundamental topics in mathematical logic and presents clear and complete proofs throughout the text Such proofs are used to develop the language of propositional logic and the language of first order logic including the notion of a formal deduction The text also covers Tarski's definition of truth and the computability concept It also provides coherent proofs of Gödel's completeness and incompleteness theorems Moreover the text was written with the student in mind and thus it provides an accessible introduction to mathematical logic In particular the text explicitly shows the reader how to prove the basic theorems and presents detailed proofs throughout the book Most undergraduate books on mathematical logic are written for a reader who is well versed in logical notation and mathematical proof This textbook is written to attract a wider audience including students who are not yet experts in the art of mathematical proof

*Mathematical Logic* Willard Van Orman Quine, 1947  
*A Course on Mathematical Logic* Shashi Mohan Srivastava, 2013-01-16 This is a short modern and motivated introduction to mathematical logic for upper undergraduate and beginning graduate students in mathematics and computer science Any mathematician who is interested in getting acquainted with logic and would like to learn Gödel's incompleteness theorems should find this book particularly useful The treatment is thoroughly mathematical and prepares students to branch out in several areas of mathematics related to foundations and computability such as logic axiomatic set theory model theory recursion theory and computability In this new edition many small and large changes have been made throughout the text The main purpose of this new edition is to provide a healthy first introduction to model theory which is a very important branch of logic Topics in the new chapter include ultraproduct of models elimination of quantifiers types applications of types to model theory and applications to algebra number theory and geometry Some proofs such as the proof of the very important completeness theorem have been completely rewritten in a more clear and concise manner The new edition also introduces new topics such as the notion of elementary class of structures elementary diagrams partial elementary maps homogeneous structures definability and many more

An Algebraic Introduction to Mathematical Logic D.W. Barnes, J.M. Mack, 2013-06-29 This book is intended for mathematicians Its origins lie in a course of lectures given by an algebraist to a class which had just completed a substantial course on abstract algebra Consequently our treatment of the subject is

algebraic Although we assume a reasonable level of sophistication in algebra the text requires little more than the basic notions of group ring module etc A more detailed knowledge of algebra is required for some of the exercises We also assume a familiarity with the main ideas of set theory including cardinal numbers and Zorn's Lemma In this book we carry out a mathematical study of the logic used in mathematics We do this by constructing a mathematical model of logic and applying mathematics to analyse the properties of the model We therefore regard all our existing knowledge of mathematics as being applicable to the analysis of the model and in particular we accept set theory as part of the meta language We are not attempting to construct a foundation on which all mathematics is to be based rather any conclusions to be drawn about the foundations of mathematics come only by analogy with the model and are to be regarded in much the same way as the conclusions drawn from any scientific theory



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