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## TEXTBOOKS AND MONOGRAPHS IN LOGIC

**ABSTRACT.** Following the chronological order, we present a short overview of some monographs, textbooks or their parts, published in Yugoslavia, Serbia or written by some participants of the Mathematical Institute Logical Seminary of Serbian Academy of Sciences and Arts. We also try to give, as much as possible, a complete reference list of textbooks and monographs in philosophical and mathematical logic published in the area of Former Yugoslavia or written by the authors originating from this area.

### 0. Introduction

During the first half of the twentieth century, crucial and rapid development of logic, through the symbolic (mathematical) logic, and its immediate influence on all sciences, has resulted in the conceptual changes in methodology and philosophy of science. The great mathematical discoveries of the nineteenth century, the possibility of non-Euclidean geometries and impossibility of solving the three classical problems of antiquity, have focused the attention on the axiomatic method, independence, completeness and decidability problems; the problems the solutions of which were possible to understand only by highly formalized tools developed by symbolic logic.

Following the chronological order, we will give a short overview of some monographs, textbooks or their parts, published in Yugoslavia, Serbia or written by some participants of the Mathematical Institute Logical Seminary of Serbian Academy of Sciences and Arts. We also try to give, as much as possible, a complete reference list of textbooks and monographs in logic. In the list of references we include the translations in Serbian of some influential books from foreign languages printed in the area of Former Yugoslavia or written by the authors originating from this area.

Copies of many references mentioned here can be found in the digital library made by a team managed by professor Žarko Mijačlović and supported by the Faculty of Mathematics of the Belgrade University, Mathematical Institute of the Serbian Academy of Science and Art, Serbian Ministry of Science and the National Center for Digitization.

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### 1. The first books in logic in Serbia

Let us note that the first book in logic in Serbian (N. Šimić (1809)) was written by Nikolaž Šimić before the big reform of the Serbian language (middle of the XIX century). We also mention two books printed in Belgrade during the XIX century which were written by Konstantin Branković (K. Branković (1851)) and Alimpije Vasiljević (A. Vasiljević (1871–1873)). It is difficult to find any copy of these books. One of the reasons is that National Library of Serbia, as well as many private libraries, was absolutely destroyed by the nazi bombing of Belgrade during the Second World War.

We note that a book on general logic, written by De Fornel de la Loransi, was translated from French into Serbian in 1911 by A. St. Jotić.

Let us mention a textbook by Svetomir Ristić (S. Ristić (1913)) published at the beginning of the XX century as well. Unfortunately, we have not found any relevant data regarding Svetomir Ristić's books (S. Ristić (1913 and 1938)).

### 2. Period between the First World War and the Second World War

Immediately after the First World War, the Kingdom of Serbs, Croats and Slovenes, later the Kingdom of Yugoslavia, was founded on the territories of the defunct Austro–Hungarian Empire, with the formerly independent Kingdom of Serbia.

Probably the first textbook published in the Kingdom of Yugoslavia was a textbook written by Blagoje D. Marković (B. D. Marković (1926)) intended for high school pupils. This book is devoted to the basic logical notions such as propositions, syllogisms, laws of logical reasoning, scientific methods and proofs.

Almost at the same time, a book (N. O. Loskij (1927)) by Nikolai Onufriyevich Lossky, Russian philosopher, covering foundations of philosophical logic on the level of an undergraduate university level, was translated into Serbian by M. R. Majstorović and appeared in Belgrade.

Branislav Petronijević's textbook (B. Petronijević (1932)) contains his lectures held at the University of Belgrade and at the Higher School (also known as the Great School or Great Academy of Belgrade, established as a predecessor of the University), and some of his original results published earlier in the fields of logic, epistemology and methodology. The first part of the book is devoted to formal logic, and the second one to general methodology of science. This book seems very modern and advanced for that time.

It is interesting that, almost simultaneously with the Petronijević's book, a book by an English economist and logician, William Stanley Jevons, was translated into Serbian and published in Belgrade (see W. S. Jevons (1933)).

Jovan Karamata's textbook on elementary set theory (J. Karamata (1935)) presents notes from the course given at the University of Belgrade and covers countable and uncountable, bounded and unbounded sets.

### 3. Before 1960

This was the period immediately after the Second World War.

The advanced monograph on set theory by Đuro Kurepa (Đ. Kurepa (1951)) was one of the most influential books in contemporary mathematics during the second half of the twentieth century in Yugoslavia.

High school textbook in logic by Mihailo Marković (M. Marković (1957)) is one of the most important and influential books in Yugoslavia, with many editions until today. This book covers the area of philosophical logic on the corresponding level.

For a long time series of Bogdan Šešić's books (B. Šešić (1957), (1958), (1959), (1962)), printed in many repeated editions, were leading textbooks in general and philosophical logic. These present an extensive overview of laws of thinking, theories of propositions, notions and reasoning, general and special methods of epistemology, theories of truths and logical errors. The books were intended for undergraduate students of social sciences mostly at the Faculty of Philosophy of the University of Belgrade.

#### 4. 60-ties

This was the period of rapid economic reforms and economic growth in Yugoslavia.

The first textbook in mathematical logic in the area of Former Yugoslavia was written by Niko Prijatelj (N. Prijatelj (1960)).

Textbook in logic by Gajo Petrović (G. Petrović (1962)) was intended for high school pupils and covers the basic subject of philosophical and symbolic logic.

Vladimir Devidé's pioneering textbook (V. Devidé (1963)) was the first important modern symbolic logic book published in Belgrade. Although covering propositional logic only, the book is very extensive and treats classical propositions in details. The material is divided roughly into the algebra of propositions and the logic of propositions. This textbook deals with semantical tableaux method and many-valued logics as well.

Undoubtedly, Slaviša Prešić's *Elements of Mathematical Logic* (see S. B. Prešić (1968)) was the most influential textbook in mathematical logic during the next decade in Serbia. Divided into two parts, semantical and syntactic one, this book covers the classical propositional and first-order logic, including the elements of Peano arithmetic and Zermelo–Fraenkel set theory, as well as the completeness and incompleteness results.

The monumental work on advanced algebra (Đ. Kurepa (1969)) one of the leading Yugoslav mathematicians of 20th century Đuro Kurepa (see also Ž. Mijajlović et al. (eds) (1996)) comprises many topics related to algebraic logic.

#### 5. 70-ties

This was the continuation of economic growth. Also, this period could be characterized as an attempt of realization of the so-called *New Math* project in Yugoslavia, introducing the new approach into both elementary and high-school classrooms. Syllabi and textbooks in Mathematics for elementary schools were enriched by notion of set and new concept of function. For the first time in the syllabus of the high school Mathematics, elements of 2-element Boolean algebra, i.e., classical propositional logic, followed by elementary set theory, were included. The corresponding textbook for high school was written by S. B. Prešić and B. Alimpić (see S. B. Prešić and B. Alimpić (1971)), opening and providing the place for this subject matter in the future (see P. Miličić et al. (1994) and R. Despotović et al. (1991)).

Proceedings edited by Tatomir Anđelić (T. Anđelić (ed.) (1977)) includes the papers in the field of set theory and foundations of mathematics by the following authors: J. P. Burgess, M. Đurić, A. Jovanović, G. Kreisel, M. Loi, Ž. Mijajlović, K. Namba, R. P. Nederelt, N. A. Shanin and B. S. Stechkin.

A note (S. Prešić et al. (1979)), edited by S. Prešić, from the fifth meeting of *Seminary for constructive mathematics and model theory Zagreb–Belgrade*, held in Zagreb in 1978, with the theme 'The existence problem in mathematics', was published by the Mathematical Institute of Belgrade.

After his successful textbook (V. Devidé (1963)), Devidé published a collection of problems in abstract algebra (V. Devidé (1979)) which includes problems in propositional calculus, elementary set theory, Boolean algebra and Peano arithmetic.

## 6. 80-ties

This was the period of economic stagnation of Yugoslavia.

A textbook intended for high school pupils by Milan Božić and Slobodan Vujić (M. Božić, S. Vujić (1982)) will be mentioned here as a highly formalized and very modern mathematical logic book.

On the occasion of the 120 anniversary of Hilbert's birth at the Logical Seminary of Mathematical Institute of Serbian Academy of Sciences and Arts, a sequence of lectures was dedicated to this great mathematician. The book published on this occasion (Ž. Mijajlović, Z. Marković, K. Došen (1986)) treats Hilbert's four problems related to mathematical logic: Cantor's continuum problem, consistency of arithmetic, solvability of Diophantine equations and, finally, Robinson's solution of the Hilbert's seventeenth problem.

In order to prepare the reader for fundamentals of the utility theory and the social choice theory, the textbook on contemporary methodology in theoretical economics (B. Boričić et al. (1986)), intended for graduate students of economics, deals in details with the axiomatic method, classical propositional and first-order logic, the logic of preferences, binary relation theory, including an introduction into the Peano arithmetic and the Zermelo–Fraenkel set theory.

Žarko Mijajlović's textbook on model theory (Ž. Mijajlović (1987)) is intended for postgraduate students of mathematical logic. The book covers the Boolean-valued models, completeness, compactness, saturated models and elements of abstract model theory.

## 7. 90-ties

This was the period of economic crisis, destruction of the country and civil war in Former Yugoslavia.

The book written by Stevo Todorčević and Mohamed Bekkali (S. Todorčević, M. Bekkali (1991)) is a selection of advanced topics in set theory and covers applications of forcing and forcing axioms. A particular attention is devoted to the problem of measurability of sets of reals. The book is based on a course that Todorčević gave at the University of Colorado in Boulder.

Svetozar Milić's textbook intended for undergraduate students of mathematics deals with the classical propositional and first-order predicate calculus, as well as an elementary introduction to theory of sets and functions (S. Milić (1991)).

The content of the book by Petar Hotomski and Irena Pevac (P. Hotomski, I. Pevac (1991)) includes papers presented at the Seminar devoted to the mathematical problems of artificial intelligence, held from January to June 1987 in Zrenjanin. The main topics are the automatic theorem proving in the first-order predicate logic and first-order theories, application of *reductio ad absurdum* method, resolution method and heuristic programming.

In this period Aleksandar Kron published his book on elementary set theory (A. Kron (1992)), presenting an introduction to the theory of sets, relations and functions, and a textbook on symbolic logic (A. Kron (1998)) intended for undergraduate students of philosophy dealing with the classical propositional calculus, Boolean algebras, first-order predicate calculus and completeness problem.

Rozália Madarász and Siniša Crvenković published a book on relational algebras (R. Madarász, S. Crvenković (1992)) and covered the main concepts of the subject, including arithmetics of relational algebras, representability, axiomatizability and decidability.

Textbook (P. Hotomski, M. Kujačić (1992)) is intended for undergraduate students of informatics. It contains topics of algebra of logic, algorithms, automata and languages, programming machines and axiomatic method.

Textbook on systems theory by Branislav Boričić (B. Boričić (1993)), intended for undergraduate students of economics, presents the theory of logical systems, through examples of the classical propositional calculus and the logic of preference. The treatment of von Wright's preference logic serves as an introduction to the utility theory, with the Debreu utility function existence theorem, and the social choice theory, with Arrow's general impossibility theorem. One part of this book deals with the basic concepts of computability theory, and one with fuzzy logic.

The method of forcing was invented by Paul Cohen in order to prove the independence of the Continuum Hypothesis from the standard axioms of mathematics, ZFC. The book written by Stevo Todorčević and Ilias Farah (S. Todorčević, I. Farah (1995)) gives an introduction to the method with a particular emphasis on applications of forcing to proving theorems, as opposed to proving consistency results. The book is based on the course given by Todorčević at the Mathematical Institute in Belgrade in Fall 2001.

By using an approachable and popular style, Zvonimir Šikić gives a survey of developing the basic mathematical ideas through the history (Z. Šikić (1995)), paying particular attention to the role of axiomatic method and logic. The book also contains translations of selected papers of R. Carnap, A. Heyting, J. von Neumann and I. Lakatos.

Textbook in mathematical logic by Branislav Boričić (B. Boričić (1995)), written in Greek, intended for both undergraduate and graduate students of mathematics, elaborates the elementary syntactic and semantical properties of the classical and intuitionistic approaches to logic and mathematics, by developing the parallelism between these two approaches from the beginning up to the end of the text. The book includes sequent calculi, natural deduction systems, cut-elimination and normalization theorems. The book is based on the course given by Boričić at the Faculty of Mathematics of the University of Crete during 1994–1996.

The book (Ž. Mijajlović, A. Ivić, Z. Mamuzić, S. Todorčević (eds) (1996)) containing selected papers of Đuro Kurepa, edited by four distinguished Serbian mathematicians, consists of 48 selected mathematical papers taken from the list of 189 of Professor Kurepa papers published in the Volume 57 (71), 1995 of the Publications de l'Institut Mathématique dedicated to him. They are divided into six separate sections each representing a subfield of Set Theory, Discrete Mathematics, General Topology, or Number Theory, where most of his mathematical achievements can be found. Each section is preceded by a commentary by one (or two) members of the Editorial Committee which may help the reader in placing Kurepa's work inside a particular area.

Slobodan Vujošević's textbook in mathematical logic (S. Vujošević (1996)) contains the basic contemporary results in model theory, set theory and computability theory.

Monograph on probability quantifiers and operators written by Miodrag Rašković and Radosav Đorđević (M. Rašković, R. Đorđević (1996)) presents several different logics with probability quantifiers with the main focus on the completeness problem. The authors define logical system by means of axioms and rules, introduce the corresponding model, and prove soundness and completeness.

The monograph on cut–elimination in category theory by Kosta Došen (K. Došen (1999)), published in a prestige edition, deals particularly with the role of adjunction, which can be so formulated as to be characterized by composition elimination. These composition–free formulations yield, among other things, both syntactical and simple model–theoretical, geometrical, decision procedures for the commuting of diagrams of arrows. Composition elimination is the form Gentzen's cut elimination takes in categories, and techniques inspired by Gentzen are here shown to work even better in a purely categorical context than in logic. Besides familiar topics, presented in a novel and simple way, this monograph contains new results, but it may serve as an introductory text in categorical proof theory.

Endre Pap's textbook (E. Pap (1999)) on fuzzy measure and applications deals with triangular norms and co–norms, and fuzzy logics and fuzzy sets based on these operations, followed by non–additive measures and corresponding notion of integral.

## 8. After 2000

This is a period of political democratization and economic transition.

The collection of solved problems (I. Spasić, P. Janičić (2000)) follows the corresponding course on Algorithm Theory at the Faculty of Mathematics of the University of Belgrade and covers the formal languages, automata theory, formal grammars and computability, was written by Irena Spasić and Predrag Janičić.

A complete uniform theory of triangular norms and co–norms is presented by Erich Peter Klement, Radko Mesiar and Endre Pap in their monograph (E. P. Klement, R. Mesiar, E. Pap (2000)), being an appropriate basis for fuzzy logics and fuzzy sets.

Collection of problems written by Gradimir Vojvodić and Boris Šobot (G. Vojvodić, B. Šobot (2003)) comprises solved problems in propositional and predicate calculus, set theory, classical algebraic structures, lattice theory, Boolean algebra and number theory.

Zoran Ognjanović's and Nenad Krdžavac's textbook on theoretical computer science (Z. Ognjanović, N. Krdžavac (2004)) covers the basic topics in computability theory, classical and non–classical logics, formal languages theory and complexity theory.

Kosta Došen's and Zoran Petrić's monograph (K. Došen, Z. Petrić (2004)) in categorial proof theory formulates, in terms of category theory, a generalization, close to linear algebra, of the notions of distributive lattice and Boolean algebra. These notions codify a plausible nontrivial notion of identity of proofs in classical propositional logic and are coherent in the sense that there is a faithful structure–preserving functor from freely generated distributive lattice categories and Boolean categories into the category whose arrows are relations between finite ordinals. The key to this kind of categorification of the proof theory of classical propositional logic is distribution of conjunction over disjunction that is not an isomorphism as in cartesian closed categories.

Ramsey theory is concerned in finding patterns in large systems, and is usually thought of as a branch of discrete mathematics. Nevertheless, it is an indispensable tool in theory of Banach spaces. Some of the most important recent advances are presented in the book by Stevo Todorčević and Spiros Argyros (S. Todorčević, S. A. Argyros (2005)).

Predrag Janičić's textbook (P. Janičić (2005)) intended for undergraduate students of computer science is a nice example of a modern book covering all relevant material such as classical propositional and first–order logic, natural deductions, sequent calculi, resolution method, unification algorithm, tableaux method, decidability, computational complexity, incompleteness theorems etc.

Textbook (P. Hotomski, D. Malbaški (2006)) is an extension of (P. Hotomski, M. Kujačić (1992)) by new chapters devoted to formal grammars, algorithmic structures analysis and fuzzy logics.

Incompactness in the least uncountable cardinality,  $\aleph_1$ , is the mainstream topic in the combinatorial set theory. Many applications of set theory to other branches of mathematics rely on this phenomenon. In his book (S. Todorčević (2007)) Stevo Todorčević presents the unified approach for constructing objects of size  $\aleph_1$  exhibiting properties not present at the least infinite cardinal. It should be remarked that the method works in the full generality, and not only for the space of countable ordinals.

The monograph by Došen and Petrić (K. Došen, Z. Petrić (2007)) formulates equationally a precise notion of star-autonomous category without unit objects, which is called proof-net category. The results presented in this book are of interest for general proof theory. They show how generality of proofs provides a criterion for identity of proofs in a fragment of linear logic. They also make a contribution to the study of coherence in symmetric monoidal closed categories.

The textbook (G. Vojvodić (2007)) is based on the course given by and written by Gradimir Vojvodić the University of Novi Sad and covers the propositional and predicate calculus, set theory, classical algebraic structures, lattice theory, Boolean algebra and number theory.

Spectral logic is a mathematical discipline between mathematical logic and abstract harmonic analysis devoted to the application of spectral transforms on finite groups to solving various problems in mathematical logic and switching theory with targeted applications in the design of digital devices. The book written by M. G. Karpovsky, R. S. Stanković, J. T. Astola (M. G. Karpovsky, R. S. Stanković, J. T. Astola (2008)) the first presents necessary theoretical background from both areas and then discusses different applications in several optimization problems in switching theory and logic design. Special attention has been paid to compact representations of binary and multiple-valued logic functions by different functional expressions and related decision diagrams.

An introduction to logic by Svetislav Nikolić (S. Nikolić (2009)), intended for high school pupils, comprises the notions of definition, classification, proposition, deduction, formal proof and formal system.

Mirjana Borisavljević has published a textbook (M. Borisavljević (2009)), intended to undergraduate students of mathematics and philosophy, covering classical propositional logic, its semantics, completeness, decidability and consistency.

A popular book by Miodrag Rašković and Nebojša Ikodinović (M. Rašković, N. Ikodinović (2010)) is intended for a wide range of readers, interested and talented high school pupils, students of mathematics, philosophy and physics, graduate mathematicians, philosophers and physicists, as well as all the others who are interested in the foundations of mathematics.

Zoran Ognjanović edited Proceedings (Z. Ognjanović (ed.) (2009)) containing following papers: Bicartesian coherence revisited (by K. Došen and Z. Petrić), Probability logic (by Z. Ognjanović, M. Rašković and Z. Marković), Reasoning in Basic Description Logics and Description Logics with Modal Operators (by M. Mosurović, T. Stojanović and A. Kaplarević Mališić) and Computational Interpretations of Logics (by S. Ghilezan and S. Likavec).

Žana Kovijanić Vukićević and Slobodan Vujošević are the authors of a textbook (Z. Kovijanić Vukićević, S. Vujošević (2010)) dealing with completeness of classical propositional and first-order predicate calculus.

In his recent book, Stevo Todorčević (S. Todorčević (2010)) presents his own unified approach to Ramsey theory. A number of results proved over the recent decades are shown to fit into a single framework, and it is demonstrated that in a large class of ‘Ramsey spaces’ strong infinite-dimensional partition results follow from a basic pigeonhole principle, followed by a number of applications.

A recent book by Branislav Boričić (B. Boričić (2010)) presents an extension of the Greek edition of (B. Boričić (1995)) by chapters devoted to the superintuitionistic propositional, modal, fuzzy and preference logics, mainly based on some of the author’s papers published earlier.

Let us emphasize that today many university textbooks in general mathematics, intended for undergraduate students of science, engineering, economics etc, contain some chapters in mathematical logic as well (see M. Ivović et al. (1998); B. Boričić et al. (1998); B. Šešelja, A. Tepavčević (2008)).

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