SYLLABUS

1. Information regarding the programme

1.1 Higher education institution	**Babeş-Bolyai University, Cluj-Napoca**
1.2 Faculty	**Faculty of Mathematics and Computer Science**
1.3 Department	**Department of Computer Science**
1.4 Field of study	**Computer Science**
1.5 Study cycle	**Bachelor**
1.6 Study programme / Qualification	**Artificial Intelligence**

2. Information regarding the discipline

2.1 Name of the discipline	**Computational Logic**						
2.2 Course coordinator	**Lecturer Ph.D. Lupea Mihaiela**						
2.3 Seminar coordinator	**Lecturer Ph.D. Lupea Mihaiela**						
2.4. Year of study	**1**	2.5 Semester	**1**	2.6. Type of evaluation	**E**	2.7 Type of discipline	**compulsory**
2.8 Code of the discipline	**MLE5055**						

3. Total estimated time (hours/semester of didactic activities)

3.1 Hours per week	4	Of which: 3.2 course	2	3.3 seminar/laboratory	2
3.4 Total hours in the curriculum	56	Of which: 3.5 course	28	3.6 seminar/laboratory	28

Time allotment:	hours
Learning using manual, course support, bibliography, course notes	20
Additional documentation (in libraries, on electronic platforms, field documentation)	10
Preparation for seminars/labs, homework, papers, portfolios and essays	26
Tutorship	8
Evaluations	30
Other activities:	

3.7 Total individual study hours	94
3.8 Total hours per semester	150
3.9 Number of ECTS credits	6

4. Prerequisites (if necessary)

4.1. curriculum	
4.2. competencies	

5. Conditions (if necessary)

5.1. for the course	

5.2. for the seminar /lab activities	

6. Specific competencies acquired

Professional competencies	C 4.1 Definition of concepts and principles of computer science and mathematical theories and models C 4.2 Interpretation of mathematical models and computer science (formal) C 4.3 Identifying appropriate models and methods to solve real problems C 4.5 Incorporation of formal models in specific applications in various fields C 6.1 Identify basic concepts and models for computer systems. C 6.2 Identify and explain the basic architecture for the organization of systems.
Transversal competencies	CT1. Application of organized and efficient working rules, of responsible attitudes concerning scientific teaching, for creative exploitation of their own potential with respect to the principles and rules of professional ethics. CT3. Use of effective methods and techniques of learning, information, research and capacity development to exploit knowledge, to adapt to a dynamic society and to communicate in Romanian language and in a foreign language.

7. Objectives of the discipline (outcome of the acquired competencies)

7.1 General objective of the discipline	• To introduce the **logical foundations of computer science**: propositional calculus and predicate calculus, theorem proving methods, Boolean algebras and Boolean functions. The connection with logic circuits is presented. • To introduce internal **representations** of integer and real numbers.
7.2 Specific objective of the discipline	• Understand how integer and real numbers are represented and manipulated internally by a computer. • Understand the functionality of some simple logic circuits from the hard component of a computer. • Identify and apply appropriate logical (propositional/predicate) models and proof methods to solve real problems in the domain of human and mathematical reasoning.

8. Content

8.1 Course	Teaching methods	Remarks
Course 1. Numeration systems 1. Definitions, representation of numbers in a base **b.** 2. Conversions between bases using the *substitution method* and the *method of successive divisions/multiplications* for integer and rational numbers. 3. Rapid conversions (bases 2,4,8,16).	Exposure: description, explanation, examples, discussion of case studies	
Course 2. Internal representations of numbers 1. Representation of unsigned integers, operations. 2. Representation of signed integers: direct code,	Exposure: description, explanation, examples,	

inverse code, complementary code, operations. 3. Fixed-point and floating-point representations of real numbers.	discussion of case studies	
Course 3. **Propositional logic – syntax and semantics** 1. Syntax: connectives, formulas. 2. Semantics: interpretation, model, consistent formula, inconsistent formula, tautology, logical consequence, truth table for a formula. 3. Laws (logical equivalences): DeMorgan, absorption, commutativity, associativity, distributivity, idempotency. 4. Clauses and normal forms: conjunctive normal form (CNF) and disjunctive normal form (DNF), algorithm for transformation of a formula into DNF and CNF.	Exposure: description, explanation, examples, discussion of case studies, debate, dialog	
Course 4. Propositional logic – formal system 1. Formal (axiomatic) system associated to propositional logic, deduction, theorem. 2. Theorem of deduction and its consequences. 3. Properties of propositional logic: coherence, noncontradiction, decidability.	Exposure: description, explanation, examples, discussion of case studies, proofs, dialog	
Course 5. Predicate (first-order) logic 1. Syntax: connectives, quantifiers, terms, atoms, formula, clause, literal, closed formula, free formula, the formal (axiomatic) system. 2. Semantics of predicate logic: interpretation, model, valid formula, consistent formula, inconsistent formula, logical consequence. 3. Properties of predicate logic: noncontradiction, coherence and semi-decidability.	Exposure: description, explanation, examples, discussion of case studies, dialog	
Course 6. Semantic tableaux method – a refutation proof method for propositional/predicate logic. 1. Classes of formulas, decomposition rules, branch (open, closed), construction of a semantic tableau. 2. Build the models and anti-models of a propositional/predicate formula from its semantic tableau. .	Exposure: description, explanation, examples, discussion of case studies, proofs	
Course 7. Resolution in propositional logic (I) 1. Resolution as a formal system. 2. Strategies of resolution: level saturation strategy, set-of–support strategy, deletion strategy. 3. Refinements of resolution: lock resolution, linear resolution.	Exposure: description, explanation, examples, discussion of case studies	
Course 8. Resolution in predicate logic (II) 1. Prenex normal form, Skolem theorem, Skolemization algorithm, clausal normal form. 2. Substitutions and unifications. 3. Predicate resolution – formal system. 4. Refinements of predicate resolution.	Exposure: description, explanation, examples, discussion of case studies, proofs	

Course 9. Modeling the common-sense human reasoning and mathematical reasoning using propositional and predicate logics.	Exposure: explanation, examples, discussion of case studies	
Course 10. Boolean algebras and Boolean functions 1. Boolean algebras: definitions, properties, principle of duality, examples; 2. Boolean functions: definitions, maxterms, minterms, the canonical disjunctive form and the canonical conjunctive form, transformation. 3. Maximal and central monoms, factorization.	Exposure: description, explanation, examples, discussion of case studies, dialog, debate	
Course 11. Simplification of Boolean functions 1. Veitch-Karnaugh diagrams method for functions of 2-3-4 variables. 2. The dual simplification algorithm for canonical conjunctive form.	Exposure: description, explanation, examples	
Course 12. Simplification of Boolean functions 1. Quine's analytical method. 2. Moisil's algebraic method.	Exposure: description, explanation, examples, discussion of case studies	
Course 13. Logic circuits 1. Definitions, representations for basic gates and derived gates. 2. Logic circuit analysis and synthesis. 3. Example: 7-segments electronic display.	Exposure: description, explanation, examples, discussion of case studies	
Course 14. Combinational logic circuits - examples Comparator, adder, subtractor, encoder, decoder.	Exposure: description, explanation, examples	

Bibliography

1. M. Ben-Ari: Mathematical Logic for Computer Science, Ed. Springer, 2001.
2. F.Boian, Bazele Matematice ale Calculatoarelor, Editura Presa Universitara Clujeana, 2002 – library.
3. M. Cocan, B. Pop: Bazele matematice ale sistemelor de calcul, Editura Albastra, Cluj-Napoca, 2001 – UBB library.
4. M.Fitting: First-order logic and Automated Theorem Proving, Ed.Springer Verlag, 1990.
5. M. Lupea, A. Mihis: Logici clasice şi circuite logice. Teorie şi exemple, ediţia 3, Editura Albastra, Cluj-Napoca, 2011 – UBB library.
6. Lupea Mihaiela-Ana, Mihis Andreea Diana, Classical Logics in Computer Science (e-book), Presa Universitara Clujeana , Cluj-Napoca, 2014, P. 116, ISBN: 978-973-595-758-2.
7. M. Lupea, A. Mihis: A Computational Approach to Classical Logics and Circuits, Editura Presa Universitară Clujeană, Cluj-Napoca, 2016.
8. Mihaela Malita, Mircea Malita, Bazele Inteligentei Artificiale, Vol. I, Logici propozitionale, Ed. Tehnica, Bucuresti, 1987 – UBB library.

9. L.C. Paulson: Logic and Proof, Univ. Cambridge, 2000, on-line course.
10. M. Possega: Deduction Systems, Inst. of Informatics, 2002, on-line course.
11. D.Tatar: Bazele matematice ale calculatoarelor, ediţia 1999 - UBB library.

8.2 Seminar / laboratory	Teaching methods	Remarks
Seminar 1. Exercises 1. Operations (addition, subtraction, division, multiplication) in different numeration bases. Particular bases: 2,4,8,16. 2. Rapid conversions.	Dialogue, case studies, examples	Attendance to seminars is mandatory for at least 75%.
Seminar 2: Exercises 1. Conversions between bases for integer and rational numbers using the methods: substitution, successive divisions/multiplications. 2. Representation of unsigned integers, operations.	Dialogue, case studies, examples	
Seminar 3. Exercises 1. Representation of signed integers: direct code, inverse code, complementary code, operations. 2. Representations of real numbers: fixed-point and floating-point representations.	Dialogue, case studies, examples	
Seminar 4. Exercises: 1. Using the truth table, decide whether a formula is consistent/tautology/inconsistent or not, write all the models of a consistent formula. 2. Transform a formula into their normal equivalent forms (DNF, CNF) and using these forms decide the validity or inconsistency of a formula.	Dialogue, debate, case studies, examples, students presentations	
Seminar 5 **1. One hour – midterm exam: written paper with subjects from courses 1-2 and seminars 1-3.** **2. Exercises** - Apply the theorem of deduction to prove the syllogism rule, separations of premises rule, reunion of premises rule. - Using the axiomatic system prove that a propositional formula is a theorem.	Dialogue, debate, case studies, examples, proofs, students presentations	Attendance to the midterm exam is mandatory.
Seminar 6. Exercises - predicate logic 1. Transform natural language sentences into predicate formulas. 2. Build models and anti-models for a predicate formula. 3. Using the axiomatic system prove that a predicate formula is a theorem.	Dialogue, debate, case studies, examples, students presentations	
Seminar 7. Exercises – semantic tableaux method (I) 1. Build the semantic tableau of a propositional	Dialogue, debate, case studies, examples,	

formula, write all its models and anti-models. 2. Solve the decision problems in propositional logic.	students presentations	
Seminar 8. Exercises– semantic tableaux method (II) 1. Using the semantic tableaux method solve the decision problems in predicate logic. 2. From a semantic tableau of a predicate formula build the models of that formula.	Dialogue, debate, case studies, examples, students presentations	
Seminar 9. Exercises – propositional resolution (I) 1. Using resolution check the inconsistency of a set of propositional clauses. 2. Check whether a propositional formula is a theorem/ deductible from a set of formulas using resolution or one of its strategies.	Dialogue, debate, case studies, examples, students presentations	
Seminar 10. Exercises – propositional resolution (II) 1. Apply the refinements of resolution and combinations of strategies and refinements to solve the decisions problems in propositional logic. 2. Details regarding the implementation of lock resolution and linear resolution.	Dialogue, debate, case studies, examples, students presentations	
Seminar 11. Exercises – predicate resolution 1. Build the prenex, Skolem and clausal normal forms of a predicate formula. 2. Compute the most general unifier of two or more atoms. 3. Check whether a predicate formula is a theorem,is deductible from a set of formulas using resolution procedure and its refinements.	Dialogue, debate, case studies, examples, students presentations	
Seminar 12. Exercises: 1. Build the canonical forms for a Boolean function. 2. Apply Veitch-Karnaugh diagrams method to simplify functions with 2, 3 and 4 variables.	Dialogue, debate, case studies, examples, students presentations	
Seminar 13. Exercises: 1. Apply Quine's method and Moisil's method to simplify Boolean functions. 2. Implementation of the corresponding logic circuit.	Dialogue, debate, case studies, examples, students presentations	
Seminar 14. Exercises: 1. Implement a simplified combinational circuit for the 7-segments electronic display. 2. Implement the simplified combinational circuits for the conversion between any two Binary Codes (BCD, Excess, Gray).	Dialogue, debate, case studies, examples, students presentations	

Bibliography

1. W.Bibel: Automated theorem proving, View Verlag, 1987.
2. Cl.BENZAKEN: Systeme formels. Introduction a la logique, ed.Masson, 1991.
3. J.P.DELAHAYE: Outils logiques pour l'intelligence artificielle, ed.Eyrolls, 1986.
4. D.Tatar: Inteligenta artificiala: demonstrare automata de teoreme si NLP, Ed. Microinformatica, 2001.
5. (ed) A.Thayse: From standard logic to Logic Programming, Ed. J.Wiley, vol1(1989), vol2,vol3(1990).

9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program

- The course respects the IEEE and ACM Curricula Recommendations for Computer Science studies;
- The course exists in the studying program of all major universities in Romania and abroad;
- The content of the course offers a theoretical base for the applicative direction of building automated proof systems useful in mathematics, software engineering, intelligent agents, robotics, natural language.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4 Course	- know the basic principles of the domain; - apply the course concepts, methods and algorithms in problem solving.	Written paper (regular session) with subjects from courses 3-13.	65%
	- know to perform operations and conversions in different numeration bases; - know to represent integer and real numbers.	Midterm exam - written paper (seminar 5 - one hour) with subjects from courses 1-2 and seminars 1-3.	20%
10.5 Seminar/lab activities	- solve at home and present during the seminars exercises from an existing benchmark of problems	Seminar activity: responses and individual presentations of solved exercises.	15%
	- exercises: modelling reasoning using propositional logic and predicate logic **or** - implementation of algorithms for operations and conversions in different numeration bases	Optional homework (can increase the final grade)	10%
10.6 Minimum performance standards			
➢ At least grade 5 (from a scale of 1 to 10) at written papers and seminar activity.			

Date	Signature of course coordinator	Signature of seminar coordinator
25.04.2023	Lect. Ph.D. Lupea Mihaiela	Lect. Ph.D. Lupea Mihaiela

Date of approval — Signature of the head of department

Prof. Ph.D. Dioşan Laura