

## SYLLABUS

### 1. Information regarding the programme

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

### 2. Information regarding the discipline

2.1 Name of the discipline		<b>Computational Logic</b>					
2.2 Course coordinator		<b>Lecturer Ph.D. Lupea Mihaiela</b>					
2.3 Seminar coordinator		<b>Lecturer Ph.D. Lupea Mihaiela</b>					
2.4. Year of study	<b>1</b>	2.5 Semester	<b>1</b>	2.6. Type of evaluation	<b>E</b>	2.7 Type of discipline	<b>compulsory</b>

### 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

<b>Professional competencies</b>	<p>C 4.1 Definition of concepts and principles of computer science and mathematical theories and models</p> <p>C 4.2 Interpretation of mathematical models and computer science (formal)</p> <p>C 4.3 Identifying appropriate models and methods to solve real problems</p> <p>C 4.5 Incorporation of formal models in specific applications in various fields</p> <p>C 6.1 Identify basic concepts and models for computer systems.</p> <p>C 6.2 Identify and explain the basic architecture for the organization of systems.</p>
<b>Transversal competencies</b>	<p>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.</p> <p>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.</p>

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

7.1 General objective of the discipline	<ul style="list-style-type: none"> <li>To introduce the <b>logical foundations of computer science</b>: propositional calculus and predicate calculus, theorem proving methods, Boolean algebras and Boolean functions. The connection with logic programming and logic circuits is presented.</li> <li>To introduce internal <b>representations</b> of integer and real numbers.</li> </ul>
7.2 Specific objective of the discipline	<ul style="list-style-type: none"> <li>Understand how integer and real numbers are represented and manipulated internally by a computer.</li> <li>Understand the functionality of some simple logic circuits from the hard component of a computer.</li> <li>Identify and apply appropriate logical (propositional/predicate) models and proof methods to solve real problems in the domain of human and mathematical reasoning.</li> </ul>

## 8. Content

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

<p><b>Course 3.</b>  <b>Propositional logic – syntax and semantics</b></p> <ol style="list-style-type: none"> <li>1. Syntax: connectives, formulas.</li> <li>2. Semantics: interpretation, model, consistent formula, inconsistent formula, tautology, logical consequence, truth table for a formula.</li> <li>3. Laws (logical equivalences): DeMorgan, absorption, commutativity, associativity, distributivity, idempotency.</li> <li>4. Clauses and normal forms: conjunctive normal form (CNF) and disjunctive normal form (DNF), algorithm for transformation of a formula into DNF and CNF.</li> </ol>	<p>Exposure: description, explanation, examples, discussion of case studies, debate, dialog</p>	
<p><b>Course 4. Propositional logic – formal system</b></p> <ol style="list-style-type: none"> <li>1. Formal (axiomatic) system associated to propositional logic, deduction, theorem.</li> <li>2. Theorem of deduction and its consequences.</li> <li>3. Properties of propositional logic: coherence, noncontradiction, decidability.</li> </ol>	<p>Exposure: description, explanation, examples, discussion of case studies, proofs, dialog</p>	
<p><b>Course 5. Predicate (first-order) logic</b></p> <ol style="list-style-type: none"> <li>1. Syntax: connectives, quantifiers, terms, atoms, formula, clause, literal, closed formula, free formula, the formal (axiomatic) system.</li> <li>2. Semantics of predicate logic: interpretation, model, valid formula, consistent formula, inconsistent formula, logical consequence.</li> <li>3. Properties of predicate logic: noncontradiction, coherence and semi-decidability.</li> </ol>	<p>Exposure: description, explanation, examples, discussion of case studies, dialog</p>	
<p><b>Course 6. Semantic tableaux method – a refutation proof method for propositional/predicate logic.</b></p> <ol style="list-style-type: none"> <li>1. Classes of formulas, decomposition rules, branch (open, closed), construction of a semantic tableau.</li> <li>2. Build the models and anti-models of a propositional/predicate formula from its semantic tableau. .</li> </ol>	<p>Exposure: description, explanation, examples, discussion of case studies, proofs</p>	
<p><b>Course 7. Resolution in propositional logic</b></p> <ol style="list-style-type: none"> <li>1. Resolution as a formal system.</li> <li>2. Strategies of resolution: level saturation strategy, set-of-support strategy, deletion strategy.</li> <li>3. Refinements of resolution: lock resolution, linear resolution.</li> </ol>	<p>Exposure: description, explanation, examples, discussion of case studies</p>	
<p><b>Course 8. Resolution in predicate logic</b></p> <ol style="list-style-type: none"> <li>1. Prenex normal form, Skolem theorem, Skolemization algorithm, clausal normal form.</li> <li>2. Substitutions and unifications.</li> <li>3. Predicate resolution – formal system.</li> <li>4. Refinements of predicate resolution.</li> </ol>	<p>Exposure: description, explanation, examples, discussion of case studies, proofs</p>	
<p><b>Course 9. Modeling the common-sense human reasoning and mathematical reasoning using propositional and predicate logics.</b></p>	<p>Exposure: description, explanation, examples, discussion of case studies</p>	

<p><b>Course 10. Boolean algebras and Boolean functions</b></p> <ol style="list-style-type: none"> <li>1. Boolean algebras: definitions, properties, principle of duality, examples;</li> <li>2. Boolean functions: definitions, maxterms, minterms, the canonical disjunctive form and the canonical conjunctive form, transformation.</li> <li>3. Maximal and central monoms, factorization.</li> </ol>	<p>Exposure: description, explanation, examples, discussion of case studies, dialog, debate</p>	
<p><b>Course 11. Simplification of Boolean functions</b></p> <ol style="list-style-type: none"> <li>1. Veitch-Karnaugh diagrams method for functions of 2-3-4 variables.</li> <li>2. The dual simplification algorithm for canonical conjunctive form.</li> </ol>	<p>Exposure: description, explanation, examples</p>	
<p><b>Course 12. Simplification of Boolean functions</b></p> <ol style="list-style-type: none"> <li>1. Quine's analytical method.</li> <li>2. Moasil's algebraic method.</li> </ol>	<p>Exposure: description, explanation, examples, discussion of case studies</p>	
<p><b>Course 13. Logic circuits</b></p> <ol style="list-style-type: none"> <li>1. Definitions, representations for basic gates and derived gates.</li> <li>2. Logic circuit analysis and synthesis.</li> <li>3. Examples: 7-segments electronic display.</li> </ol>	<p>Exposure: description, explanation, examples, discussion of case studies</p>	
<p><b>Course 14. Combinational logic circuits - examples</b> Comparator, adder, subtractor, encoder, decoder.</p>	<p>Exposure: description, explanation, examples</p>	

## 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 și circuite logice. Teorie și exemple, ediția 3, Editura Albastra, Cluj-Napoca, 2011 – UBB library.
6. M. Lupea, A. Mihis: A Computational Approach to Classical Logics and Circuits, Editura Risoprint, Cluj-Napoca, 2015.
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, ediția 1999 - UBB library.

8.2 Seminar / laboratory	Teaching methods	Remarks
<b>Seminar 1. Exercises</b> <ol style="list-style-type: none"> <li>Operations (addition, subtraction, division, multiplication) in different numeration bases. Particular bases: 2,4,8,16.</li> <li>Rapid conversions.</li> </ol>	Dialogue, case studies, examples	Attendance to seminars is mandatory for at least 75%.
<b>Seminar 2: Exercises</b> <ol style="list-style-type: none"> <li>Conversions between bases for integer and rational numbers using the methods: substitution, successive divisions/multiplications.</li> <li>Representation of unsigned integers, operations.</li> </ol>	Dialogue, case studies, examples	
<b>Seminar 3. Exercises</b> <ol style="list-style-type: none"> <li>Representation of signed integers: direct code, inverse code, complementary code, operations.</li> <li>Representations of real numbers: fixed-point and floating-point representations.</li> </ol>	Dialogue, case studies, examples	
<b>Seminar 4. Exercises:</b> <ol style="list-style-type: none"> <li>Using the truth table, decide whether a formula is consistent/tautology/inconsistent or not, write all the models of a consistent formula.</li> <li>Transform a formula into their normal equivalent forms (DNF, CNF) and using these forms decide the validity or inconsistency of a formula.</li> </ol>	Dialogue, debate, case studies, examples, students presentations	
<b>Seminar 5</b> <ol style="list-style-type: none"> <li><b>One hour – midterm exam: written paper with subjects from courses 1-2 and seminars 1-3.</b></li> <li><b>Exercises</b> <ul style="list-style-type: none"> <li>Apply the theorem of deduction to prove the syllogism rule, separations of premises rule, reunion of premises rule.</li> <li>Using the axiomatic system prove that a propositional formula is a theorem.</li> </ul> </li> </ol>	Dialogue, debate, case studies, examples, proofs, students presentations	Attendance to the midterm exam is mandatory.
<b>Seminar 6. Exercises - predicate logic</b> <ol style="list-style-type: none"> <li>Transform natural language sentences into predicate formulas.</li> <li>Build models and anti-models for a predicate formula.</li> <li>Using the axiomatic system prove that a predicate formula is a theorem.</li> </ol>	Dialogue, debate, case studies, examples, students presentations	
<b>Seminar 7. Exercises – semantic tableaux method (I)</b> <ol style="list-style-type: none"> <li>Build the semantic tableau of a propositional formula, write all its models and anti-models.</li> <li>Solve the decision problems in propositional logic.</li> </ol>	Dialogue, debate, case studies, examples, students presentations	

<p><b>Seminar 8. Exercises– semantic tableaux method (II)</b></p> <ol style="list-style-type: none"> <li>Using the semantic tableaux method solve the decision problems in predicate logic.</li> <li>From a semantic tableau of a predicate formula build the models of that formula.</li> </ol>	<p>Dialogue, debate, case studies, examples, students presentations</p>	
<p><b>Seminar 9. Exercises – propositional resolution (I)</b></p> <ol style="list-style-type: none"> <li>Using resolution check the inconsistency of a set of propositional clauses.</li> <li>Check whether a propositional formula is a theorem/ deducible from a set of formulas using resolution or one of its strategies.</li> </ol>	<p>Dialogue, debate, case studies, examples, students presentations</p>	
<p><b>Seminar 10. Exercises – propositional resolution (II)</b></p> <ol style="list-style-type: none"> <li>Apply the refinements of resolution and combinations of strategies and refinements to solve the decisions problems in propositional logic.</li> <li>Details regarding the implementation of lock resolution and linear resolution.</li> </ol>	<p>Dialogue, debate, case studies, examples, students presentations</p>	
<p><b>Seminar 11. Exercises – predicate resolution</b></p> <ol style="list-style-type: none"> <li>Build the prenex, Skolem and clausal normal forms of a predicate formula.</li> <li>Compute the most general unifier of two or more atoms.</li> <li>Check whether a predicate formula is a theorem, is deducible from a set of formulas using resolution procedure and its refinements.</li> </ol>	<p>Dialogue, debate, case studies, examples, students presentations</p>	
<p><b>Seminar 12. Exercises:</b></p> <ol style="list-style-type: none"> <li>Build the canonical forms for a Boolean function.</li> <li>Apply Veitch-Karnaugh diagrams method to simplify functions with 2-3-4 variables.</li> </ol>	<p>Dialogue, debate, case studies, examples, students presentations</p>	
<p><b>Seminar 13. Exercises:</b></p> <ol style="list-style-type: none"> <li>Apply Quine’s method and Moisl’s method to simplify Boolean functions.</li> <li>Implementation of the corresponding logic circuit.</li> </ol>	<p>Dialogue, debate, case studies, examples, students presentations</p>	
<p><b>Seminar 14. Exercises:</b></p> <ol style="list-style-type: none"> <li>Implement a simplified combinational circuit for the 7-segments electronic display.</li> <li>Implement the simplified combinational circuits for the conversion between any two Binary Codes (BCD, Excess, Gray).</li> </ol>	<p>Dialogue, debate, case studies, examples, students presentations</p>	
<p><b>Bibliography</b></p> <ol style="list-style-type: none"> <li>W.Bibel: Automated theorem proving, View Verlag, 1987.</li> <li>Cl.BENZAKEN: Systeme formels. Introduction a la logique, ed.Masson, 1991.</li> <li>J.P.DELAHAYE: Outils logiques pour l’intelligence artificielle, ed.Eyrols, 1986.</li> <li>D.Tatar: Inteligenta artificiala: demonstrare automata de teoreme si NLP, Ed. Microinformatica, 2001.</li> <li>(ed) A.Thayse: From standard logic to Logic Programming, Ed. J.Wiley, vol1(1989), vol2,vol3(1990).</li> </ol>		

**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.	60%
	- 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 <b>or</b> - implementation of algorithms for operations and conversions in different numeration bases	Optional homework (can increase the final mark)	10%
10.6 Minimum performance standards			
➤ At least grade 5 (from a scale of 1 to 10) at written papers and seminar activity.			

Date

5.05.2019

Signature of course coordinator

Lecturer Ph.D. Lupea Mihaiela

Signature of seminar coordinator

Lecturer Ph.D. Lupea Mihaiela

Date of approval

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Signature of the head of department

Prof.Ph.D. Andreica Anca