# SYLLABUS

## 1. Data about the program of study

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| 1.1 Institution | The Technical University of Cluj-Napoca |
| 1.2 Faculty | Faculty of Automation and Computer Science |
| 1.3 Department | Computer Science |
| 1.4 Field of study | Computer Science and Information Technology |
| 1.5 Cycle of study | Bachelor of Science |
| 1.6 Program of study / Qualification | Computer science/ Engineer |
| 1.7 Form of education | Full time |
| 1.8 Subject code | 38. |

## 2. Data about the subject

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|---|---|---|---|---|---|
| 2.1 Subject name | ***Formal Languages and Translators*** | | | | |
| 2.2 Course responsible / lecturer | Assoc. prof. dr. eng. Chifu Emil Ştefan - emil.chifu@cs.utcluj.ro | | | | |
| 2.3 Teachers in charge of seminars / laboratory / project | Assoc. prof. dr. eng. Chifu Emil Ştefan - emil.chifu@cs.utcluj.ro<br>Assist. drd. eng. Rednic Ana - Ana.Rednic@cs.utcluj.ro | | | | |
| 2.4 Year of study | III | 2.5 Semester | 2 | 2.6 Type of assessment (E - exam, C - colloquium, V - verification) | E |
| 2.7 Subject category | *DF – fundamentală, DD – în domeniu, DS – de specialitate, DC – complementară* | | | | DD |
| | *DI – Impusă, DOp – opțională, DFac – facultativă* | | | | DI |

## 3. Estimated total time

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|---|---|---|---|---|---|---|---|---|---|---|
| 3.1 Number of hours per week | 4 | of which: | Course | 2 | Seminars | - | Laboratory | 2 | Project | - |
| 3.2 Number of hours per semester | 56 | of which: | Course | 28 | Seminars | - | Laboratory | 28 | Project | - |
| 3.3 Individual study: | | | | | | | | | | |
| (a) Manual, lecture material and notes, bibliography | | | | | | | | | | 7 |
| (b) Supplementary study in the library, online and in the field | | | | | | | | | | 5 |
| (c) Preparation for seminars/laboratory works, homework, reports, portfolios, essays | | | | | | | | | | 4 |
| (d) Tutoring | | | | | | | | | | |
| (e) Exams and tests | | | | | | | | | | 3 |
| (f) Other activities: | | | | | | | | | | 0 |

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| 3.4 Total hours of individual study (suma (3.3(a)...3.3(f))) | 19 |
| 3.5 Total hours per semester (3.2+3.4) | 75 |
| 3.6 Number of credit points | 3 |

## 4. Pre-requisites (where appropriate)

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| 4.1 Curriculum | Computer Programming, Data Structures and Algorithms |
| 4.2 Competence | Basic knowledge of programming and data structures (preferably in the C language) |

## 5. Requirements (where appropriate)

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| 5.1. For the course | Onsite: Blackboard, Overhead projector, computer |
| 5.2. For the applications | Computers, specific software / Teams account |

## 6. Specific competence

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| 6.1 Professional competences | **C1 –** Operating with basic Mathematical, Engineering and Computer Science concepts (2 credits)<br>• **C1.1 –** Recognizing and describing concepts that are specific to the fields of calculability, complexity, programming paradigms, and modeling |

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| | computational and communication systems<br>• **C1.2 –** Using specific theories and tools (algorithms, schemes, models, protocols, etc.) for explaining the structure and the functioning of hardware, software and communication systems<br>• **C1.3 –** Building models for various components of computing systems<br>• **C1.4 –** Formal evaluation of the functional and non-functional characteristics of computing systems<br>• **C1.5 –** Providing a theoretical background for the characteristics of the designed systems<br>**C3** – Problems solving using specific Computer Science and Computer Engineering tools (2 credits)<br>• **C3.1 –** Identifying classes of problems and solving methods that are specific to computing systems<br>• **C3.2 –** Using interdisciplinary knowledge, solution patterns and tools, making experiments and interpreting their results<br>• **C3.3 –** Applying solution patterns using specific engineering tools and mehods**C3.4 –** Comparatively and experimentaly evaluation of the alternative solutions for performance optimization<br>• **C3.5 –** Developing and implementing informatic solutions for concrete problems |
| 6.2 Cross competences | N/A |

**7. Discipline objective (as results from the *key competences gained*)**

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| 7.1 General objective | - To know the phases, components, and algorithms used by typical language translators.<br>- To provide a formal basis for the development of concepts relating to lexical and syntactic processors in translators. |
| 7.2 Specific objectives | - To know the underlying formal models such as finite state automata and push-down automata, and to understand their connection to language definition through regular expressions and grammars.<br>- To understand the relationships between formal descriptions of the automata in the formal language theory and their practical implementations as lexical and syntactic analyzers in translators.<br>- To know the classes of languages for which a deterministic parser can be implemented.<br>- To describe the syntax of languages to be implemented by using grammars and regular expressions.<br>- To design, develop and test a software project, by utilizing specialized software tools (parser generators), in order to arrive at a translator for an artificial language.<br>- To master and control the phenomena of ambiguity and nondeterminism (conflicts) which occur when using parser generators and lexical analyzer generators.<br>- Introduction to natural language processing methods. |

**8. Contents**

| **8.1 Lectures** | Hours | Teaching methods | Notes |
|---|---|---|---|
| Descriptive tools: strings and rewriting systems, grammars. | 2 | - The main ideas with multimedia techniques | |
| Descriptive tools: derivations and parse trees, exttended BNF notation | 2 | | |
| Regular grammars and finite automata: finite automata. | 2 | | |

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| Regular grammars and finite automata: state diagrams and regular expressions. | 2 | - Teaching materials available in the Teams platform<br>- Details and examples at the blackboard/ graphics tablet, in interaction with the students<br>- Kahoot tests/ Teams Forms tests | |
| Context-free grammars and pushdown automata. | 2 | | |
| Top-down analysis and LL(*k*) grammars: LL(*k*) grammars, the LL(*k*) algorithm | 2 | | |
| Top-down analysis and LL(*k*) grammars: elimination of left recursion, left factoring. | 2 | | |
| LL parsers: strong LL(*k*) grammars, the LL(1) parsing algorithm. | 2 | | |
| LL parsers: the LL(1) parsing algorithm in the interpretive variant, computation of FIRST and FOLLOW sets. | 2 | | |
| Bottom-up analysis and LR(*k*) grammars: situations and closure of a nonterminal, the LR(*k*) algorithm. | 2 | | |
| Bottom-up analysis and LR(*k*) grammars: the LR(*k*) algorithm. | 2 | | |
| LR parsers: the LR(0) parsing algorithm, LR(0) states. | 2 | | |
| Natural language processing: syntactic analysis, semantic interpretation, representation methods. | 2 | | |
| Natural language processing: neural models for language representation. | 2 | | |

Bibliography:


1. W.M. Waite and G. Goos, Compiler Construction, Springer-Verlag, 1984.
2. I.A. Leţia and E.Şt. Chifu, Limbaje formale şi translatoare, Ed. Casa cărţii de ştiinţă, 1998.
3. A.V. Aho, R. Sethi, and J.D. Ullman, Compilers: Principles, Techniques and Tools, Addison-Wesley, 1986.


| **8.2 Applications - Seminars / Laboratory / Project** | Hours | Teaching methods | Notes |
|---|---|---|---|
| Lexical analyzer for C. Regular expressions in Python. | 2 | Brief presentation at the blackboard (the teacher), implementing and testing examples and exercises on the computer (the students) | |
| *The generator of lexical analyzers Lex*: Lex source, Lex regular expressions, Lex actions, ambiguous rules, Lex source definitions. | 2 | | |
| *Lex generator*: left context sensitivity, examples, Lex applications. | 2 | | |
| *The bottom-up parser generator Yacc*: basic specifications, Yacc syntax, actions, lexical analysis, how the parser works. | 2 | | |
| *Lab test: using Lex.* | 2 | | |
| *Yacc generator*: ambiguity and conflicts, precedence and associativity, error handling. | 2 | | |
| *Yacc generator*: support for arbitrary value types, examples. Yacc/ Lex applications: Translator of arithmetic expressions from infix to postfix. | 2 | | |
| Yacc/ Lex applications: Lisp/C interpreter. | 2 | | |
| Lab test (Using Yacc and Lex) | 2 | | |
| Defining the individual assignment (Implementing a translator by using the Yacc and Lex generators/ Using neural models for language representation) | 2 | | |
| Examples of using neural models for representing language/ Deterministic recursive descent parsing of a language operating on binary trees. | 2 | | |
| Examples of using neural models for representing language/ Deterministic recursive descent parsing of a language operating on binary lists and polynomials. | 2 | | |
| Implementing the assignment. | 2 | | |
| Final evaluation of the individual assignment. | 2 | | |

Bibliography:


1. https://www.cs.utexas.edu/users/novak/lexpaper.htm
2. https://www.cs.utexas.edu/users/novak/yaccpaper.htm
3. Online lab manual
4. Hugging Face https://huggingface.co/


*Se vor preciza, după caz: tematica seminariilor, lucrările de laborator, tematica și etapele proiectului.

**9. Bridging course contents with the expectations of the representatives of the community, professional associations and employers in the field**

It is a specialty course in Computer Science, its syllabus being both classical and modern. It teaches the students with the basic principles in the design of interpreters and translators for artificial languages. The syllabus of the course has been discussed with other important universities and companies from Romania, Europe, and USA. This syllabus has been evaluated by Romanian governmental agencies (CNEAA and ARACIS).

**10. Evaluation**

| Activity type | Assessment criteria | Assessment methods | Weight in the final grade |
|---|---|---|---|
| Course | Problem-solving skills<br>Attendance, Activity | Online test: Moodle Quiz/ Written test | 60% |
| Seminar | - | - | - |
| Laboratory | Problem-solving skills<br>Attendance, Activity | Lab test 1 and 2<br>Evaluation of the individual assignment | 20%<br>20% |
| Project | - | - | - |

Minimum standard of performance:
Modeling a typical engineering problem using the domain specific formal apparatus. Final grade calculus: 40% lab + 60% final exam
Conditions for participating in the final exam: lab ≥ 5
Conditions for promotion: Final grade ≥ 5

| **Date of filling in: 26.02.2025** | **Responsible** | **Title First name Last name** | **Signature** |
|---|---|---|---|
| | Course | Assoc.prof.dr.eng. Emil-Ştefan CHIFU | |
| | Applications | Assoc.prof.dr.eng. Emil-Ştefan CHIFU | |
| | | Assist.drd.eng. Ana REDNIC | |

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| Date of approval in the department | Head of department,<br>Prof.dr.eng. Rodica Potolea |
| Date of approval in the Faculty Council | Dean,<br>Prof.dr.eng. Vlad Mureșan |