Universitat de Lleida

DEGREE CURRICULUM

COMPUTATIONAL MODELS AND COMPLEXITY

Coordination: VALLS MARSAL, MA MAGDALENA

Academic year 2023-24

COMPUTATIONAL MODELS AND COMPLEXITY 2023-24

Subject's general information

Subject name	COMPUTATIONAL MODELS AND COMPLEXITY
Code	102065
Semester	2nd Q(SEMESTER) CONTINUED EVALUATION
Typology	<table><tr><th>Degree</th><th>Course</th><th>Character</th><th>Modality</th></tr><tr><td>Bachelor's Degree in Computer Engineering</td><td>3</td><td>COMPULSORY</td><td>Attendance-based</td></tr><tr><td>Bachelor's Degree in Computer Engineering</td><td>3</td><td>OPTIONAL</td><td>Attendance-based</td></tr></table>
Course number of credits (ECTS)	4.5
Type of activity, credits, and groups	<table><tr><th>Activity type</th><td>PRAULA</td><td>TEORIA</td></tr><tr><th>Number of credits</th><td>3</td><td>1.5</td></tr><tr><th>Number of groups</th><td>1</td><td>1</td></tr></table>
Coordination	VALLS MARSAL, MA MAGDALENA
Department	MATHEMATICS
Teaching load distribution between lectures and independent student work	4,5 ECTS correspond to a workload of 45 h of lectures and assesment and 67 h of autonomous study work for each student.
Important information on data processing	Consult this link for more information.
Language	Catalan
Distribution of credits	There is a single group with 4.5 ECTS, where theoretical lectures are combined with more applied ones.

COMPUTATIONAL MODELS AND COMPLEXITY 2023-24

Teaching staff	E-mail addresses	Credits taught by teacher	Office and hour of attention
SIMÓN BALCELLS, SERGI	sergisiba@gmail.com	1,5	
VALLS MARSAL, MA MAGDALENA	magda.vallsmarsal@udl.cat	3	

Subject's extra information

Previous knowledge on the subjects *Algebra*, *Computational Logics* and *Algorithmics and Complexity, Discrete Mathematics and Languages, Automata and Grammars* is recommended.

This subject is scheduled in the spring semester of the 3rd year, in the especialization on *Computation*.

The knowledge and competencies adquired in this subjects will be useful to follow other subjects in the same especialization, and in particular for the subject *Language Processing Algorithms.*

Learning objectives

- Understand the basic Turing machine model, its relationship with the finite automata and possible extensions of this model.
- Design Turing machines as language recognizers or as function calculators.
- Distinguish between recursively enumerable and recursive languages, and know their properties.
- Get some examples of non-recursive languages.
- Understand the concept of reduction between languages and be able to give reduction functions.
- Understand the relationship between recursive / recursively enumerable languages and decidable / undecidable problems.
- Distinguish between complexity of an algorithm and complexity of a problem.
- Recognize the different kinds of complexity of a problem: P, NP-complete, NP

Competences

Specific competences

- GII-C1 - Capacity to have a deep knowledge of the basic principles and models for computation and to know how to apply them in order to interpret, select, value, model, and create new concepts, theories, uses and technological developments related with the informatics.
- GII-C3 - Capacity to evaluate the computational complexity of a problem, to know the algorithmic strategies that can drive to its solving and recommend, develop and implement the one which guarantee the best performance in accordance with the requirements.

Cross-disciplinary competences

- EPS6 - Capacity of analysis and synthesis.

University strategic competences

- CT2 - Mastering a foreign language, especially English.
- CT3 - Training experience in the use of the new technologies and the information and communication technologies.

Subject contents

1. Turing machines

- Basic Turing machine model.
- Extensions on the basic Turing machine model.
- Turing machine as languages recognizor.
- Turing machine as function calculator .
- Algorithms and Turing machines.
- Church-Turing thesis.
- Gödel number of a Turing machine.
- Universal Turing machine.

2. Recursive languages

- Recursive and recursively enumerable languages.
- Operations with recursive languages.
- Operations with recursively enumerable languages.
- The halting problem.

3. Reductions

- Reductions between languages.
- Properties of the reductions.

4. Undecidability

- Decidable and undecidable problems.
- Undecidable problems on Turing Machines: the halting problem and the belonging problem
- PCP, the Post correspondence problem.

5. Complexity

- Classes of complexity.
- Reductions between problems in polynomial time.
- SAT, the satisfiability problem.
- Other NP-complete problems.
- P = NP?

Methodology

Lectures combine theoretical concepts with practical ones. The lectures present the basics of the subject, incorporating illustrative examples that facilitate its understanding. In the classes of problems we combine joint resolution on the board, individual resolution and group resolution.

Students prepare an extension work related with some topics on Theoretical Computer Science. The students have to search for appropiate bibliography and they have to analize it. The work is presented and discussed in the classroom, with all the students and teachers.

Development plan

Week	Lesson	Activities	Student workload
1	Introduction. Lesson 1		2 hours. Study and problem solving.
2	Lesson 1		3 hours. Study and problem solving.
3	Lesson 1	Work topic assignment	3 hours. Study and problem solving.
4	Lesson 2		3 hours. Study and problem solving. Work development.
5	Lesson 2		3 hours. Study and problem solving. Work development.
6	Lesson 2		4 hours. Study and problem solving. Work development.
7	Lesson 3		4 hours. Study and problem solving. Work development.
8	Lesson 3		5 hours. Study for exams.
9		Partial 1 Assesment	6 hours. Study for exams.
10	Lesson 4		3 hours. Study and problem solving.
11	Lesson 4		3 hours. Study and problem solving.
12	Lesson 4		4 hours. Study and problem solving. Prepare work presentation.
13	Lesson 5		4 hours. Study and problem solving. Prepare work presentation..
14	Lesson 5	Work presentation	4 hours. Study and problem solving.
15	Lesson 5		5 hours. Study for exams.
16		Tutorization	5 hours. Study for exams.
17		Partial 2 Assesment	6 hours. Study for exams.
18		Tutorization	
19		Final assesment	

Evaluation

Blocks	Acr.	Assessment activities	Weight	Minimum mark	Resit
Block P1	*P1*	*Partial 1. Lessons 1, 2.*	4.5 points	1 point	YES
Block P2	*P2*	*Partial 2. Lessons 3, 4, 5.*	4.5 points	1 point	YES
Block AC	AC	*Complementary activitities : development and presentation of a work on complementary aspects*	1 point	NO	NO
Additional block	*PCL*	*Participation*	1 point	NO	NO
	FinalMark = P1 + P2 + AC+ PCL				

A student with final mark below 5 or who has not reached the minimum marks required, can resit either P1, P2 or both.

Up to 1 additional point can be assigned, according to participation in the classroom and delivered problems.

Students who have passed can also take the subject's additional tests to raise their grade. In this case, the grade that will be taken into account is the one obtained in this additional exam.

Students who have been authorized to follow the alternative assessment (see requirements and procedure in the assessment regulations), will follow the following assessment procedure:

- Student will be assessed for 100% of the grade in a single exam on the date set for the additional exams.
- This exam will consist of two parts P1 and P2 (with an assessment of 5 points each). In order to pass, you will have to obtain an overall mark of more than 5 and a minimum mark for each of the parts of 2.5 points.
- If the student does not pass this unique assessment or does not reach the minimum mark in one of the parts, he will have the right to recover 100% of the mark under the same terms, on a date to be agreed with the teaching staff.

In the assessment tests, the student must present an official document certifying his identity.

Mobile phones, smart watches or other electronic devices that allow external connectivity may not be brought under any circumstances.

Bibliography

Basic bibliography:

Josep M. MIRET; Magda VALLS. Recull de problemes de Models de Computació i Complexitat. Universitat de Lleida, 2012.

Maria José SERNA; Carme ALVAREZ; Rafel CASES; Antoni LOZANO. Els límits de la computació. indecidibilitat i NP-completesa. Edicions UPC, 2001.

Complementary bibliography:

John HOPCROFT; Jeffrey ULLMAN. Introduction to Automata Theory, Languages and Computation. Addison-Wesley, 1979.

Dean KELLEY. Teoría de Autómatas y Lenguajes Formales. Prentice-Hall, 1995.

Jairo ROCHA; Francesc ROSSELLÓ. Autòmats i Llenguatges: verificació, implementació i concurrència. Materials didàctics 107, Universitat de les Illes Balears, 2003.

Michael SIPSER. Introduction to the theory of computation. Cengage Learning, 2013.