



UNIVERSIDADE LUSÍADA
LISBOA

Course Unit Program
Computation Theory

Academic Year 2026/2027

1. Organic Unit

Faculty of Business and Economic Sciences

2. Course

Computer Engineering

3. Cycle

1st

4. Course Unit

Computation Theory (L9030)

5. Scientific Area

6. Curricular Year

3rd

7. Type of Curricular Unit / Semester

1st Semester



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8. Class type and workload (work time)

Theoretical classes:

Practical classes:

Theoretical-Practical Classes 30,00

Tutorial Guidance: 20,00

9. ECTS Credits

6,00

10. Scientific Area Coordinator

11. Regent

Prof. Doutor RAUL EDUARDO CAPELA TELLO RATO

12. Assistants

13. Teaching Language

Portuguese

14. General Objectives

Provide a solid understanding of the theoretical foundations of computation, the main formal models, and the limits of what can be computed. Develop abstract reasoning and the ability to analyse computational problems. Introduce the foundations of quantum computation and establish an integrated perspective on classical and quantum computational paradigms.

15. Specific Objectives

Understand the formal foundations of computation, including automata, formal languages, computability, decidability, and complexity. Develop the ability to model and analyse computational problems and their limits. Introduce the principles of quantum computation, namely qubits, quantum gates, and circuits, establishing the fundamental relationships and differences between classical and quantum models of computation.

16. Skills to be acquired

Ability to analyse computational models, formal languages, and problems of computability and complexity. Ability to construct and reason about automata, grammars, and Turing machines. Capacity to identify the theoretical limits of computation and to understand and analyse basic quantum computational models, including qubits, quantum gates, and circuits.

17. Teaching Methodology



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Presentation of theoretical content, followed by the analysis and discussion of representative examples. Guidance for the completion of practical assignments to be carried out independently by students, complementing classroom sessions and promoting the consolidation of the topics covered.

18. Course Unit Program

1. Foundations of computation: abstract models, computability, and the limits of computation.
2. Alphabets, symbols, strings, and formal languages; empty string, empty language, Kleene and positive closures; operations on strings and languages.
3. Recursive definitions and regular languages; regular expressions and the languages they define.
4. Finite automata, determinism, states, transitions, and accepting states; transition graphs and the relationship between automata, graphs, and languages.
5. Computational models with input and output; Moore and Mealy machines.
6. Context-free languages and grammars; BNF, parsing, the Chomsky hierarchy, and Chomsky Normal Form.
7. Decidability, Turing machines, the Church-Turing thesis, Turing completeness, and the Halting Problem.
8. Symbols and physical computation: binary representation, symbol detection, signals, and noise; relationship between physical information and computational representation.
9. Foundations of quantum computation: linear algebra, Dirac notation, kets and bras, complex amplitudes, normalization, qubits, superposition, and the Born rule.
10. Qubit registers and the Kronecker product; computational representation and manipulation of quantum states.
11. Quantum gates and matrix operators: Hadamard, NOT/Pauli-X, and other elementary gates; comparison between stochastic and quantum transformations.
12. Unitary matrices, reversibility, and information conservation; CNOT and Toffoli; design of reversible gates and reversible implementation of Boolean functions.

19. Assessment Methods



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The Complementary Regulations on the Assessment of Knowledge and Competences currently in force shall apply. Continuous assessment must include oral interventions distributed throughout the teaching period and a final written assessment, both weighted by a factor of 3. It may also include individual or group assignments, weighted by a factor of 2, as well as other assessment components, in accordance with the terms and weightings established by the applicable regulations.

20. Didactic Resources

The classes will be given, whenever possible, using visual presentations.
Theoretical-practical lectures and exercises.

21. Sustainability Objectives

Contribute to Sustainable Development Goals (SDGs) 4 and 9 by promoting digital literacy and the development of computational thinking. Studying automata, formal languages, and grammars fosters an understanding of the foundations of computation, enabling the application of these concepts, the development of computational models, and the simulation of solutions in a sustainable manner, with precision, rigour, and creativity.

22. Keywords

Theory of Computation
Automata
Formal Languages
Grammars
Computability
Decidability
Turing Mac



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23. Main Bibliography

Author(s): Michael Sipser
Title: Introduction to the Theory of Computation
Edition: 3 Year: 2021
Local: United states
Publisher: CENGAGE LEARNING, INC
ISBN Code: 9781133187790

Author(s): Daniel I. A. Cohen
Title: Introduction to Computer Theory
Edition: 2 Year: 1996
Local: United States
Publisher: Wiley
ISBN Code: 9780471137726

Author(s): Michael A. Nielsen; Isaac L. Chuang
Title: Quantum Computation and Quantum Information
Edition: 10th Anniversary Year: 2016
Local: Cambridge
Publisher: Cambridge University Press
ISBN Code: 9781107002173

24. Complementary Bibliography

Author(s): John E. Hopcroft; Rajeev Motwani; Jeffrey D. Ullman
Title: Introduction to Automata Theory, Languages, and Computation
Edition: 3rd Edition Year: 2013
Local: Boston, MA
Publisher: Pearson/Addison-Wesley
ISBN Code: 9780321455369

Author(s): Jack D. Hidary
Title: Quantum Computing: An Applied Approach
Edition: 2nd Edition Year: 2021
Local: Cham
Publisher: Springer
ISBN Code: 9783030832735



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Ficha técnica MIP / MIP Datasheet	
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