Course guide
270612 - RA - Randomized Algorithms

Last modified: 29/07/2025

Unit in charge:	Barcelona School of Informatics
Teaching unit:	723 - CS - Department of Computer Science.
Degree:	MASTER'S DEGREE IN INFORMATICS ENGINEERING (Syllabus 2012). (Optional subject). MASTER'S DEGREE IN INNOVATION AND RESEARCH IN INFORMATICS (Syllabus 2012). (Optional subject).

Academic year: 2025 **ECTS Credits:** 6.0 **Languages:** English

LECTURER

Coordinating lecturer:	CONRADO MARTÍNEZ PARRA
Others:	Primer quadrimestre: CONRADO MARTÍNEZ PARRA - 10

PRIOR SKILLS

- Basic knowledge of algorithms and data structures: sorting algorithms, graph algorithms, binary search trees, hash tables, analysis of algorithm, notions of complexity, algorithmic schemes, ...

Knowledge of at least one programming language, preferably C++ or Python.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEE3.1. Capability to identify computational barriers and to analyze the complexity of computational problems in different areas of science and technology as well as to represent high complexity problems in mathematical structures which can be treated effectively with algorithmic schemes.
CEE3.2. Capability to use a wide and varied spectrum of algorithmic resources to solve high difficulty algorithmic problems.

Generical:
CG1. Capability to apply the scientific method to study and analyse of phenomena and systems in any area of Computer Science, and in the conception, design and implementation of innovative and original solutions.
CG3. Capacity for mathematical modeling, calculation and experimental designing in technology and companies engineering centers, particularly in research and innovation in all areas of Computer Science.
CG5. Capability to apply innovative solutions and make progress in the knowledge to exploit the new paradigms of computing, particularly in distributed environments.

Transversal:
CTR6. REASONING: Capacity for critical, logical and mathematical reasoning. Capability to solve problems in their area of study. Capacity for abstraction: the capability to create and use models that reflect real situations. Capability to design and implement simple experiments, and analyze and interpret their results. Capacity for analysis, synthesis and evaluation.

Basic:
CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.

TEACHING METHODOLOGY

There will be two kinds of classes: theoretical sessions and practical sessions. On average, two hours per week is dedicated to theory and two hours per week to exercises. The teacher will allocate the hours in accordance with the subject matter.

The theory classes take the form of lectures in which the teacher sets out new concepts or techniques and examples illustrating them.

The practical classes are used to carry out exercises in which students take an active part. Teachers will propose exercises in advance. Students are required to submit the exercises and then discuss the various solutions/alternatives in class.

LEARNING OBJECTIVES OF THE SUBJECT

1.Become acquainted with the main techniques and problems of randomization
2.Examine conditions under which randomized algorithms can be used. Perform an analysis and extract the fundamental properties, from different domains, to assess the suitability and applicability of randomized methods.

STUDY LOAD

Type	Hours	Percentage
Guided activities	6,0	4.00
Hours large group	30,0	20.00
Self study	96,0	64.00
Hours medium group	18,0	12.00

Total learning time: 150 h

CONTENTS

Introduction

Description:
Motivating examples; random algorithms; probabilistic analysis; Monte Carlo algorithms, Las Vegas algorithms.

Probabilistic tools and techniques

Description:
Events and probabilities; random variables and expectations; moments and deviations; tail inequalities; balls and bins and random graphs; Markov chains and random walks.

Sorting and searching

Description:
Randomized quick sort; randomized quick select; randomized selection by sampling.

Data structures

Description:
Hashing; universal hashing, cuckoo hashing, Bloom filters.

Algebraic techniques

Description:
Fingerprinting; database consistency; pattern matching; primality testing.

Optimization, approximation, sampling and counting

ACTIVITIES

Development of the topics in the syllabus (I)

Description:
Development of syllabus topics and practice exercices.

Specific objectives:
1, 2

Related competencies :
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Full-or-part-time: 45h
Theory classes: 10h
Practical classes: 10h
Self study: 25h

Mid-term exam

Specific objectives:
1, 2

Related competencies :
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Full-or-part-time: 14h
Guided activities: 2h
Self study: 12h

Theorey and exercises of the syllabus (II)

Full-or-part-time: 45h
Theory classes: 10h
Practical classes: 10h
Self study: 25h

Lab assignment

Description:
Design, implementation and documentation of a practical work on one of the topics developed in the subject

Full-or-part-time: 20h
Self study: 20h

Oral presentations (I)

Description:
Oral presentation of an academic paper or some specific topic related to the course

Full-or-part-time: 6h
Guided activities: 2h
Self study: 4h

Oral presentations (II)

Full-or-part-time: 6h
Guided activities: 2h
Self study: 4h

Final exam

Specific objectives:
1, 2

Related competencies :
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Guided activities: 2h
Self study: 12h

GRADING SYSTEM

If E >= 3.5 then
Grade = 0.5 E + 0.3 LW + 0.2 OP
Else
Grade = E

P = Mid-term exam (graded between 0 and 10)
F = Final exam (graded between 0 and 10)
E = max(0.4 P + 0.6 F, F)
LW = Programming assignments (between 0 and 10) in which each student presents one or more programming exercises in which randomized algorithms are implemented
OP = Oral presentation of a specific article or topic related to the course, together with a written summary and the audiovisual material of the presentation (rated between 0 and 10); the articles and / or topics will be chosen by the student from among the proposals made by the teacher

BIBLIOGRAPHY

Basic:

- Mitzenmacher, M.; Upfal, E. Probability and computing: randomization and probabilistic techniques in algorithms and data analysis. 2nd ed. Cambridge University Press, 2017. ISBN 9781107154889.
- Motwani, R.; Raghavan, P. Randomized algorithms. Cambridge University Press, 1995. ISBN 0521474655.

Complementary:

- Ross, Sheldon M. Probability models for computer science. San Diego: Harcourt : Academic Press, cop. 2002. ISBN 9780125980517.
- Medjedovic, Dzejla; Tahirovic, Emin; Dedovic, Ines. Algorithms and Data Structures for Massive Datasets [on line]. Shelter Island, NY: Manning, 2022 [Consultation: 07/01/2025]. Available on: https://web-p-ebscohost-com.recursos.biblioteca.upc.edu/ehost/ebookviewer/ebook?sid=bddc5e1c-9751-4594-94a5-527efabc667d%40redis&vid=0&format=EK. ISBN 9781638356561.
- Leskovec, Jurij; Rajaraman, Anand; Ullman, Jeffrey D. Mining of massive datasets. Third edition. Cambridge: Cambridge University Press, 2020. ISBN 9781108476348.