Course guide
270208 - AP2 - Algorithmics and Programming II

Last modified: 30/01/2024

Unit in charge: Barcelona School of Informatics
Teaching unit: 723 - CS - Department of Computer Science.

Degree: BACHELOR'S DEGREE IN DATA SCIENCE AND ENGINEERING (Syllabus 2017). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 7.5 **Languages:** Catalan, Spanish, English

LECTURER

Coordinating lecturer: JORDI CORTADELLA FORTUNY

Others: Segon quadrimestre:
JORDI CORTADELLA FORTUNY - 11, 12, 13
PABLO FERNANDEZ DURAN - 13
JORDI PETIT SILVESTRE - 11, 12

PRIOR SKILLS

Those acquired at the course AP1-GCED.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE2. To be able to program solutions to engineering problems: Design efficient algorithmic solutions to a given computational problem, implement them in the form of a robust, structured and maintainable program, and check the validity of the solution.

Generical:
CG1. To design computer systems that integrate data of provenances and very diverse forms, create with them mathematical models, reason on these models and act accordingly, learning from experience.
CG2. Choose and apply the most appropriate methods and techniques to a problem defined by data that represents a challenge for its volume, speed, variety or heterogeneity, including computer, mathematical, statistical and signal processing methods.
CG5. To be able to draw on fundamental knowledge and sound work methodologies acquired during the studies to adapt to the new technological scenarios of the future.

Transversal:
CT4. Teamwork. Be able to work as a member of an interdisciplinary team, either as a member or conducting management tasks, with the aim of contributing to develop projects with pragmatism and a sense of responsibility, taking commitments taking into account available resources.
CT5. Solvent use of information resources. Manage the acquisition, structuring, analysis and visualization of data and information in the field of specialty and critically evaluate the results of such management.
CT6. Autonomous Learning. Detect deficiencies in one's own knowledge and overcome them through critical reflection and the choice of the best action to extend this knowledge.
CT7. Third language. Know a third language, preferably English, with an adequate oral and written level and in line with the needs of graduates.

Basic:
CB5. That the students have developed those learning skills necessary to undertake later studies with a high degree of autonomy

TEACHING METHODOLOGY

The syllabus is presented in a very practical way, through the presentation of many examples.

The theory classes introduce all the necessary concepts and techniques, which are put into practice in the classes of problems and laboratory through a collection of problems and exercises in an automatic judge.

Every week, there are two hours of theory classes, one hour of problems and two hours of laboratory.

The course uses C++ and Python as programming languages.

LEARNING OBJECTIVES OF THE SUBJECT

1.Being able to design, analyze, implement algorithms that solve problems using algorithmic and programming techniques.

STUDY LOAD

Type	Hours	Percentage
Hours small group	30,0	16.00
Hours large group	45,0	24.00
Self study	112,5	60.00

Total learning time: 187.5 h

CONTENTS

Abstract Data Types.

Description:
Specification and implementation. Abstraction, functional and data decomposition, information hiding and encapsulation. Object-oriented languages: classes and objects, private and public methods, constructors and destructors. Genericity. Examples: point, rectangle, rational numbers.

Algorithm analysis.

Description:
Cost in time and space. Worst, best and average case. Asymptotic notation. Analysis of the cost of iterative and recursive algorithms. Examples: insertion and selection sort, maximum subsequence sum, convex hull.

Divide and conquer.

Description:
Principles: partition into subproblems, recombination of solutions. Master theorem. Examples: binary search, merge sort, quick sort, quick select, finding the two closest points in a plane. Fast Fourier Transform (FFT).

Memory management.

Description:
Representation of data in memory. Pointers and references. Dynamic memory management (vector class). Memory layout of a program (code, stack, heap).

Basic containers.

Description:
Operations, usage and implementations of stacks, queues, priority queues and lists.

Graphs.

Description:
Representations: adjacency matrices, adjacency lists and implicit representations. Depth-first search (DFS). Breadth-first search (BFS). Topological sort. Algorithms for shortest paths (Dijsktra, Bellman-Ford). Algorithms for minimum spanning trees (Prim and Kruskal). Algorithms for the maximum flow problem (Ford-Fulkerson).

Sets and dictionaries.

Description:
Trees and their representation. Binary trees and traversals (pre-order, post-order, in-order and level-order). Binary search trees and balanced trees: operations and implementation. Hashing.

ACTIVITIES

Development of content 1

Specific objectives:
1

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CB5. That the students have developed those learning skills necessary to undertake later studies with a high degree of autonomy

Full-or-part-time: 16h
Theory classes: 5h
Laboratory classes: 3h
Self study: 8h

Partial examination (with computer)

Specific objectives:
1

Related competencies :
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Full-or-part-time: 2h
Guided activities: 2h

Final examination (on paper)

Full-or-part-time: 2h
Guided activities: 2h

Final examination (with computer)

Full-or-part-time: 2h
Guided activities: 2h

Project delivery

Full-or-part-time: 9h
Self study: 9h

Development of content 2

Specific objectives:
1

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Full-or-part-time: 20h
Theory classes: 4h
Laboratory classes: 4h
Self study: 12h

Development of content 3

Specific objectives:
1

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Full-or-part-time: 35h
Theory classes: 9h
Laboratory classes: 6h
Self study: 20h

Development of content 4

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1

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Full-or-part-time: 11h
Theory classes: 3h
Laboratory classes: 2h
Self study: 6h

Development of content 5

Specific objectives:
1

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Full-or-part-time: 27h 30m
Theory classes: 7h
Laboratory classes: 5h
Guided activities: 1h
Self study: 14h 30m

Development of content 6

Specific objectives:
1

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CG1. To design computer systems that integrate data of provenances and very diverse forms, create with them mathematical models, reason on these models and act accordingly, learning from experience.
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Full-or-part-time: 35h
Theory classes: 9h
Laboratory classes: 5h
Guided activities: 1h
Self study: 20h

Development of content 7

Full-or-part-time: 28h
Theory classes: 7h
Laboratory classes: 5h
Guided activities: 1h
Self study: 15h

GRADING SYSTEM

The final grade of the course takes into account the following evaluation acts:
* P1: individual programming project to be delivered in mid-course
* P2: programming project (in pairs) to be delivered in at the end of the course
* PL: partial laboratory exam (with computer)
* FL: final laboratory exam (with computer)
* FT: final theory exam (with paper)

The project grade is calculated as: P = (P1 + P2)/2
The exams grade is calculated as: X = max (0.3 PL + 0.4 FT + 0.3 FL, 0.5 FT + 0.5 FL)

The final grade N is calculated as:
* N = max(0.3 P + 0.7 X, 0.15 P + 0.85 X), if X >= 4
* N = 0.15 P + 0.85 X, if X

BIBLIOGRAPHY

Basic:
- Cortadella, Jordi; Petit, Jordi. Algorithmics and Programming II (lecture notes in English). UPC, 2021.
- Weiss, Mark Allen. Data structures and algorithm analysis in C++. 4th ed., int. ed. Boston: Pearson, 2014. ISBN 9780273769385.
- Dasgupta, Sanjoy.; Papadimitriou, Christos; Vazirani, Umesh. Algorithms. Boston: Mc Graw Hill Higher Education, 2008. ISBN 9780073523408.
- Cormen, T.H. [et al.]. Introduction to algorithms. 4th ed. Cambridge: MIT Press, 2022. ISBN 9780262046305.
- Brassard, Gilles.; Bratley, Paul. Fundamentos de algoritmia. Madrid: Prentice Hall, 1997. ISBN 9788489660007.

Complementary:
- Manber, Udi. Introduction to algorithms: a creative approach. Repr. with corr. Reading: Addison-Wesley, 1989. ISBN 9780201120370.
- Sedgewick, Robert. Algorithms in C++. 3rd ed. Boston: Addison-Wesley, 1998-2002. ISBN 9780201350883.
- Roughgarden, Tim. Algorithms illuminated. Part 1: The Basics. San Francisco: Soundlikeyourself Publishing, 2017-2020. ISBN 9780999282908.
- Roughgarden, Tim. Algorithms illuminated. Part 2: Graph Algorithms and Data Structures. San Francisco: Soundlikeyourself Publishing, 2017-2020. ISBN 9780999282922.
- Roughgarden, Tim. Algorithms illuminated. Part 3: Greedy Algorithms and Dynamic Programming. San Francisco: Soundlikeyourself Publishing, 2017-2020. ISBN 9780999282946.

RESOURCES

Hyperlink:
- http://www.cs.upc.edu/~jordicf/Teaching/AP2- https://jutge.org