UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH

Course guide
270417 - PAA - Programming and Advanced Algorithmics

Last modified: 03/02/2025

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

Degree:	BACHELOR'S DEGREE IN ARTIFICIAL INTELLIGENCE (Syllabus 2021). (Compulsory subject).

Academic year: 2024   **ECTS Credits:** 6.0   **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer:	JOSÉ LUIS BALCÁZAR NAVARRO - JORDI DELGADO PIN
Others:	Segon quadrimestre: JORDI DELGADO PIN - 11, 12

PRIOR SKILLS

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DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE02. To master the basic concepts of discrete mathematics, logic, algorithmic and computational complexity, and its application to the automatic processing of information through computer systems . To be able to apply all these for solving problems.
CE03. To identify and apply the basic algorithmic procedures of computer technologies to design solutions to problems by analyzing the suitability and complexity of the proposed algorithms.
CE04. To design and use efficiently the most appropriate data types and structures to solve a problem.
CE10. To analyze, design, build and maintain applications in a robust, secure and efficient way, choosing the most appropriate paradigm and programming languages.
CE12. To master the fundamental principles and models of computing and to know how to apply them in order to interpret, select, assess, model, and create new concepts, theories, uses and technological developments related to artificial intelligence.
CE13. To evaluate the computational complexity of a problem, identify algorithmic strategies that can lead to its resolution and recommend, develop and implement the one that guarantees the best performance in accordance with the established requirements.

Generical:
CG2. To use the fundamental knowledge and solid work methodologies acquired during the studies to adapt to the new technological scenarios of the future.
CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
CG8. Perform an ethical exercise of the profession in all its facets, applying ethical criteria in the design of systems, algorithms, experiments, use of data, in accordance with the ethical systems recommended by national and international organizations, with special emphasis on security, robustness , privacy, transparency, traceability, prevention of bias (race, gender, religion, territory, etc.) and respect for human rights.

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.
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.

Basic:

CB1. That students have demonstrated to possess and understand knowledge in an area of ??study that starts from the base of general secondary education, and is usually found at a level that, although supported by advanced textbooks, also includes some aspects that imply Knowledge from the vanguard of their field of study.

CB2. That the students know how to apply their knowledge to their work or vocation in a professional way and possess the skills that are usually demonstrated through the elaboration and defense of arguments and problem solving within their area of ??study.

TEACHING METHODOLOGY

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LEARNING OBJECTIVES OF THE SUBJECT

1.Learning to analyze algorithms and learning about asymptotic notations.
2.-
3.-
4.-

STUDY LOAD

Type	Hours	Percentage
Self study	90,0	60.00
Hours large group	30,0	20.00
Hours small group	30,0	20.00

Total learning time: 150 h

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ACTIVITIES

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Description:
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Specific objectives:
1, 3

Related competencies :
CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
CG2. To use the fundamental knowledge and solid work methodologies acquired during the studies to adapt to the new technological scenarios of the future.
CE02. To master the basic concepts of discrete mathematics, logic, algorithmic and computational complexity, and its application to the automatic processing of information through computer systems . To be able to apply all these for solving problems.
CE04. To design and use efficiently the most appropriate data types and structures to solve a problem.
CE13. To evaluate the computational complexity of a problem, identify algorithmic strategies that can lead to its resolution and recommend, develop and implement the one that guarantees the best performance in accordance with the established requirements.
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CE12. To master the fundamental principles and models of computing and to know how to apply them in order to interpret, select, assess, model, and create new concepts, theories, uses and technological developments related to artificial intelligence.
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.
CB2. That the students know how to apply their knowledge to their work or vocation in a professional way and possess the skills that are usually demonstrated through the elaboration and defense of arguments and problem solving within their area of ??study.

Full-or-part-time: 6h
Theory classes: 2h
Self study: 4h

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Description:
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Specific objectives:
3

Related competencies :
CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
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CB2. That the students know how to apply their knowledge to their work or vocation in a professional way and possess the skills that are usually demonstrated through the elaboration and defense of arguments and problem solving within their area of ??study.

Full-or-part-time: 12h
Theory classes: 2h
Laboratory classes: 2h
Self study: 8h

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Description:
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Specific objectives:
3

Related competencies :
CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
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CE03. To identify and apply the basic algorithmic procedures of computer technologies to design solutions to problems by analyzing the suitability and complexity of the proposed algorithms.
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Full-or-part-time: 14h
Theory classes: 2h
Laboratory classes: 4h
Self study: 8h

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Description:
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Specific objectives:
4

Related competencies :
CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
CE02. To master the basic concepts of discrete mathematics, logic, algorithmic and computational complexity, and its application to the automatic processing of information through computer systems . To be able to apply all these for solving problems.
CE13. To evaluate the computational complexity of a problem, identify algorithmic strategies that can lead to its resolution and recommend, develop and implement the one that guarantees the best performance in accordance with the established requirements.
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.
CB1. That students have demonstrated to possess and understand knowledge in an area of ??study that starts from the base of general secondary education, and is usually found at a level that, although supported by advanced textbooks, also includes some aspects that imply Knowledge from the vanguard of their field of study.
CB2. That the students know how to apply their knowledge to their work or vocation in a professional way and possess the skills that are usually demonstrated through the elaboration and defense of arguments and problem solving within their area of ??study.

Full-or-part-time: 8h
Theory classes: 2h
Self study: 6h

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Description:
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Specific objectives:
4

Related competencies :
CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
CE02. To master the basic concepts of discrete mathematics, logic, algorithmic and computational complexity, and its application to the automatic processing of information through computer systems . To be able to apply all these for solving problems.
CE13. To evaluate the computational complexity of a problem, identify algorithmic strategies that can lead to its resolution and recommend, develop and implement the one that guarantees the best performance in accordance with the established requirements.
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CB2. That the students know how to apply their knowledge to their work or vocation in a professional way and possess the skills that are usually demonstrated through the elaboration and defense of arguments and problem solving within their area of ??study.

Full-or-part-time: 14h
Theory classes: 2h
Laboratory classes: 4h
Self study: 8h

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Description:

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Specific objectives:

1, 3, 4

Related competencies :

CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.

CG2. To use the fundamental knowledge and solid work methodologies acquired during the studies to adapt to the new technological scenarios of the future.

CE02. To master the basic concepts of discrete mathematics, logic, algorithmic and computational complexity, and its application to the automatic processing of information through computer systems . To be able to apply all these for solving problems.

CE04. To design and use efficiently the most appropriate data types and structures to solve a problem.

CE13. To evaluate the computational complexity of a problem, identify algorithmic strategies that can lead to its resolution and recommend, develop and implement the one that guarantees the best performance in accordance with the established requirements.

CE03. To identify and apply the basic algorithmic procedures of computer technologies to design solutions to problems by analyzing the suitability and complexity of the proposed algorithms.

CE10. To analyze, design, build and maintain applications in a robust, secure and efficient way, choosing the most appropriate paradigm and programming languages.

CE12. To master the fundamental principles and models of computing and to know how to apply them in order to interpret, select, assess, model, and create new concepts, theories, uses and technological developments related to artificial intelligence.

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.

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.

CB1. That students have demonstrated to possess and understand knowledge in an area of ??study that starts from the base of general secondary education, and is usually found at a level that, although supported by advanced textbooks, also includes some aspects that imply Knowledge from the vanguard of their field of study.

CB2. That the students know how to apply their knowledge to their work or vocation in a professional way and possess the skills that are usually demonstrated through the elaboration and defense of arguments and problem solving within their area of ??study.

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

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Description:
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Specific objectives:
4

Related competencies :
CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
CE02. To master the basic concepts of discrete mathematics, logic, algorithmic and computational complexity, and its application to the automatic processing of information through computer systems . To be able to apply all these for solving problems.
CE13. To evaluate the computational complexity of a problem, identify algorithmic strategies that can lead to its resolution and recommend, develop and implement the one that guarantees the best performance in accordance with the established requirements.
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.
CB1. That students have demonstrated to possess and understand knowledge in an area of ??study that starts from the base of general secondary education, and is usually found at a level that, although supported by advanced textbooks, also includes some aspects that imply Knowledge from the vanguard of their field of study.
CB2. That the students know how to apply their knowledge to their work or vocation in a professional way and possess the skills that are usually demonstrated through the elaboration and defense of arguments and problem solving within their area of ??study.

Full-or-part-time: 18h
Theory classes: 2h
Laboratory classes: 4h
Self study: 12h

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Description:
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Specific objectives:
4

Related competencies :
CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
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CB2. That the students know how to apply their knowledge to their work or vocation in a professional way and possess the skills that are usually demonstrated through the elaboration and defense of arguments and problem solving within their area of ??study.

Full-or-part-time: 19h
Theory classes: 5h
Laboratory classes: 4h
Self study: 10h

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Description:

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Specific objectives:

2, 4

Related competencies :

CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.

CG8. Perform an ethical exercise of the profession in all its facets, applying ethical criteria in the design of systems, algorithms, experiments, use of data, in accordance with the ethical systems recommended by national and international organizations, with special emphasis on security, robustness , privacy, transparency, traceability, prevention of bias (race, gender, religion, territory, etc.) and respect for human rights.

CE02. To master the basic concepts of discrete mathematics, logic, algorithmic and computational complexity, and its application to the automatic processing of information through computer systems . To be able to apply all these for solving problems.

CE13. To evaluate the computational complexity of a problem, identify algorithmic strategies that can lead to its resolution and recommend, develop and implement the one that guarantees the best performance in accordance with the established requirements.

CE03. To identify and apply the basic algorithmic procedures of computer technologies to design solutions to problems by analyzing the suitability and complexity of the proposed algorithms.

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CB2. That the students know how to apply their knowledge to their work or vocation in a professional way and possess the skills that are usually demonstrated through the elaboration and defense of arguments and problem solving within their area of ??study.

Full-or-part-time: 23h
Theory classes: 5h
Laboratory classes: 8h
Self study: 10h

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Description:

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Specific objectives:
2, 4

Related competencies :
CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
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CB2. That the students know how to apply their knowledge to their work or vocation in a professional way and possess the skills that are usually demonstrated through the elaboration and defense of arguments and problem solving within their area of ??study.

Full-or-part-time: 22h
Theory classes: 6h
Laboratory classes: 4h
Self study: 12h

GRADING SYSTEM

The assessment of part of the Algorithmic section of the course (beginning of the course) will require the development of a practical work of a modest size that will be presented at the beginning of the Dynamic Programming part and will be evaluated on its completion and delivery (grade P).

In addition, there will be the grade for the partial (E) and the final exam (grade F). The course grade will be obtained using the following criterion:

max(F*0.8, (E*0.3 + F*0.5)) + P*0.2

Reassessment
Only those who have previously taken the final exam and failed it can take the reassessment exam.

BIBLIOGRAPHY

Basic:

- Sipser, M. Introduction to the theory of computation. 3rd ed. Boston: Cengage Learning, 2013. ISBN 9781133187790.
- Cases, R.; Màrquez, L. Llenguatges, gramàtiques i autòmats: curs bàsic. 2a ed. Edicions UPC, 2003. ISBN 8483017288.
- Serna, M. et al.. Els Límits de la computació: indecidibilitat i NP-completesa. 2a ed. Edicions UPC, 2004. ISBN 9788483017845.
- Brassard, G.; Bratley, P,. Fundamentals of algorithmics. Prentice-Hall International, 1996. ISBN 9780130734877.

Complementary:

- Skiena, S.S. The algorithm design manual. Third edition. Cham: Springer, 2020. ISBN 9783030542559.
- Motwani, R., Raghavan, P.. Randomized Algorithms. Cambridge: Cambridge University Press, 1995. ISBN 0521474655.
- Lee, K. D., Hubbard, S.,. Data structures and algorithms with Python. New York: Springer, 2014. ISBN 9783319130712.
- Hopcroft, J.E.; Motwani, R.; Ullman, J.D.. Introduction to automata theory, languages, and computation. Pearson/Addison Wesley, 2007. ISBN 0321462254.

RESOURCES

Hyperlink:

- https://www.cs.upc.edu/~balqui/paa.html