Course guide
270405 - CAL - Calculus

Last modified: 02/02/2024

Unit in charge: Barcelona School of Informatics
Teaching unit: 749 - MAT - Department of Mathematics.

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

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: GISSELL ESTRADA RODRÍGUEZ - ANA RIO DOVAL - MONICA SANCHEZ SOLER

Others: Segon quadrimestre:
GISSELL ESTRADA RODRÍGUEZ - 11, 12

PRIOR SKILLS

Students are expected be competent in mathematics to upper secondary level.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE01. To be able to solve the mathematical problems that may arise in the field of artificial intelligence. Apply knowledge from: algebra, differential and integral calculus and numerical methods; statistics and optimization.
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.

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.

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

TEACHING METHODOLOGY

In theory classes the teacher will explain the topics accompanied by examples.

The worksho /laboratory classes are participatory sessions where students will be asked to solve problems. Students will solve problems under the supervision of the teacher; some of these problems will need to be prepared in advance. The teacher will explain some of the problems on the board.

LEARNING OBJECTIVES OF THE SUBJECT

1.Know how to solve linear, quadratic equations and inequalities and/or with absolute values.
2.Know and understand the basic concepts of successions and series
3.Know and understand the basic concepts of elementary functions.
4.Know, understand and be able to use the approximation given by the Taylor Polynomial for functions of a variable.
5.Knowing and understanding the approximate calculation of definite integrals by the methods of trapezoids and Simpson.
6.Know and understand the different distances in R^n.
7.Know and understand the basic concepts of domain, contour lines and continuity of functions of various variables.
8.Know, understand and be able to interpret the concepts of directional derivative, partial derivative, gradient vector and Jacobian matrix. Know and know how to find the optimal direction. Know and be able to use the chain rule.
9.Know how to find and classify the relative extreme of a scalar function of several variables.
10.Know, understand and know how to use the gradient descent method to optimize scalar functions of various variables.

STUDY LOAD

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

Total learning time: 150 h

CONTENTS

Equations and inequalities with real numbers

Description:
Know how to solve linear, quadratic equations and inequalities and/or with absolute values.

Sequences and series of real numbers

Description:
Basic concepts of sequences and series of real numbers. Convergent, divergent and oscillating successions. Convergent, divergent and oscillating series. Calculation of succession limits and series sums.

Elementary functions

Description:
Polynomial functions. Rational functions. Potential functions. Trigonometric functions. Exponential and logarithmic functions. Hyperbolic functions.

Taylor polynomial for functions of a variable

Description:
Taylor polynomials. Lagrange formula of the residue. Error propagation formula.
Taylor polynomial approximation and error bounding.

Powers series and Taylor series

Description:
Basic concepts of power series. Basic concepts of Taylor series.

Approximate integration

Description:
Trapeze rule and Simpson's formula for the approximate calculation of definite integrals. Dimension of the error.

The R^n space

Description:
The space R^n. Norms and distances in R^n.

Introduction to the functions of various variables

Description:
Domain, contour lines and continuity of functions of several variables.

Derivation of functions of several variables

Description:
Directional derivatives and partial derivatives. Gradient vector and Jacobian matrix. Optimal direction. Chain rule.

Relative extremes

Description:
Critical points of a scalar function of several variables. Necessary condition. Sufficient condition. Calculation of relative extremes.

Optimization

Description:
Gradient descent method for optimization of scalar functions of several variables.

ACTIVITIES

Equations and inequalities linear, quadratic and/or with absolute values

Specific objectives:
1

Related competencies :
CG2. To use the fundamental knowledge and solid work methodologies acquired during the studies to adapt to the new technological scenarios of the future.
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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: 5h
Laboratory classes: 2h
Self study: 3h

Sequences and series of real numbers

Specific objectives:
2

Related competencies :
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.
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Full-or-part-time: 17h
Theory classes: 4h
Laboratory classes: 3h
Self study: 10h

Elementary functions

Specific objectives:
3

Related competencies :
CE01. To be able to solve the mathematical problems that may arise in the field of artificial intelligence. Apply knowledge from: algebra, differential and integral calculus and numerical methods; statistics and optimization.
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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.
CB5. That the students have developed those learning skills necessary to undertake later studies with a high degree of autonomy
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: 3h
Laboratory classes: 3h
Self study: 12h

Taylor polynomial

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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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.

Full-or-part-time: 17h
Theory classes: 3h
Laboratory classes: 2h
Self study: 12h

Powers series and Taylor series

Specific objectives:
2

Related competencies :
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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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Full-or-part-time: 16h
Theory classes: 3h
Laboratory classes: 3h
Self study: 10h

Approximate integration

Specific objectives:
5

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

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

Partial Exam

Specific objectives:
1, 2, 3, 4, 5

Related competencies :
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.
CE01. To be able to solve the mathematical problems that may arise in the field of artificial intelligence. Apply knowledge from: algebra, differential and integral calculus and numerical methods; statistics and optimization.
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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.
CB5. That the students have developed those learning skills necessary to undertake later studies with a high degree of autonomy
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: 4h
Self study: 4h

Functions of several variables

Specific objectives:
6, 7, 8

Related competencies :
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.
CE01. To be able to solve the mathematical problems that may arise in the field of artificial intelligence. Apply knowledge from: algebra, differential and integral calculus and numerical methods; statistics and optimization.
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.
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.
CB5. That the students have developed those learning skills necessary to undertake later studies with a high degree of autonomy
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: 48h
Theory classes: 11h
Laboratory classes: 12h
Self study: 25h

Optimization in several variables

Specific objectives:
9, 10

Related competencies :
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.
CE01. To be able to solve the mathematical problems that may arise in the field of artificial intelligence. Apply knowledge from: algebra, differential and integral calculus and numerical methods; statistics and optimization.
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.
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.
CB5. That the students have developed those learning skills necessary to undertake later studies with a high degree of autonomy
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: 11h
Theory classes: 4h
Laboratory classes: 2h
Self study: 5h

Workshop Exam

Specific objectives:
1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Related competencies :
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.
CE01. To be able to solve the mathematical problems that may arise in the field of artificial intelligence. Apply knowledge from: algebra, differential and integral calculus and numerical methods; statistics and optimization.
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.
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.
CB5. That the students have developed those learning skills necessary to undertake later studies with a high degree of autonomy
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: 1h
Laboratory classes: 1h

Final Exam

Specific objectives:
1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Related competencies :
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.
CE01. To be able to solve the mathematical problems that may arise in the field of artificial intelligence. Apply knowledge from: algebra, differential and integral calculus and numerical methods; statistics and optimization.
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.
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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: 5h
Self study: 5h

GRADING SYSTEM

The grade of the subject is obtained from:

- Workshop mark (T): assesses the work and achievement of objectives with questionnaires in Athena.
- Mark of the mid-semester exam (P): it does a partial examination P to half semester that corresponds, approximately, to the part of Calculation in 1 variable.
- Final exam (F): a final exam is made in which the knowledge of all the syllabus of the subject is evaluated.

The final grade of the course (NF) is calculated according to:

NF = max (0.2 * T + 0.3 * P + 0.5 * F, 0.2 * T + 0.8 * F)

Not taking the final exam means having a NP of CAL-GIA grade.

CROSS-CURRICULAR COMPETENCE.

The mark of the autonomous learning competence will have grades: A (excellence), B (optimal), C (sufficient), D (not passed). This competence will be evaluated from the marks of the subject.

BIBLIOGRAPHY

Basic:
- Bradley, Gerald L; Smith, Karl J. Cálculo. Madrid: Prentice Hall, 1998. ISBN 8483220415.
- Bradley, Gerald L; Smith, Karl J. Cálculo: vol. 2: cálculo de varias variables. Prentice Hall, cop. 1998. ISBN 8489660778 (V. 2).

Complementary:
- Deisenroth, Marc Peter; Faisal, A. Aldo ; Ong, Cheng Soon. Mathematics for Machine Learning. Cambridge: Cambridge University Press, 2020. ISBN 9781108470049.

- Lubary Martínez, José Antonio; Brunat Blay, Josep M. Cálculo para ingeniería informática. Barcelona: Edicions UPC, 2008. ISBN 9788483019597.
- Larson, Ron; Edwards, Bruce H. Cálculo. Décima edición. México: Cengage Learning, [2016]. ISBN 9786075220154.

RESOURCES

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- http://archives.math.utk.edu/visual.calculus/- http://ocw.mit.edu/OcwWeb/Mathematics/index.htm- http://ocw.mit.edu/ans7870/18/18.013a/textbook/MathML/index.xhtml