Course guide
340070 - MADI - Mathematics for Design

Last modified: 22/06/2026

Unit in charge: Vilanova i la Geltrú School of Engineering
Teaching unit: 749 - MAT - Department of Mathematics.

Degree: BACHELOR'S DEGREE IN INDUSTRIAL DESIGN AND PRODUCT DEVELOPMENT ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Optional subject).

Academic year: 2026 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: M. DE LAS NIEVES YBERN CARBALLO

Others: Primer quadrimestre:
M. DE LAS NIEVES YBERN CARBALLO - D2011

PRIOR SKILLS

Ability to work with vectors and matrices. Knowledge of scalar product and vector product. Knowledge of the concept of derivative and fluency in its calculation.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. G1. Ability to solve arithmetic problems related to engineering. Aptitude to apply knowledge concerning: linear algebra, geometry, differential geometry, differential and integral calculus, numerical methods, stadistics technology.
D28. D28. Knowledge of ANIMACION and basic 3D simulation.
D33. D33. Knowledge of aesthetics.
D48. D48. Ability to know and apply creative process and its organization.

Transversal:
2. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
4. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.
05 TEQ N2. TEAMWORK - Level 2. Contributing to the consolidation of a team by planning targets and working efficiently to favor communication, task assignment and cohesion.
05 TEQ N1. TEAMWORK - Level 1. Working in a team and making positive contributions once the aims and group and individual responsibilities have been defined. Reaching joint decisions on the strategy to be followed.

TEACHING METHODOLOGY

Large group sessions will consist of theoretical explanations, description of examples and problem solving by hand and with electronic devices.

In small group sessions, GeoGebra will be used to work on the theoretical concepts of the subject, prepare individual assessed practical sessions and develop graphical projects.

Before each assessed practical session, students will be provided with a model practical activity or preparatory material so that they can work autonomously on the contents, tools and constructions that will be assessed.

LEARNING OBJECTIVES OF THE SUBJECT

To understand the classical concepts and techniques of geometry that are essential in CAGD (Computer-Aided Geometric Design). In particular:

- To use affine coordinates and affine transformations to design, move and transform figures in the plane and in space.
- To understand and work with conics and quadrics as examples of basic curves and surfaces.
- To understand and work with the basic concepts of differential geometry: curvature, torsion and osculating circle of a curve; tangent plane and normal vector of a surface.

To use Bézier techniques for the design of curves and surfaces. In particular:

- To work with the expression of Bézier curves and surfaces using Bernstein polynomials.
- To use the De Casteljau algorithm.
- To understand the problem of geometric continuity in Bézier curves and surfaces.

STUDY LOAD

Type	Hours	Percentage
Self study	90,0	60.00
Hours small group	15,0	10.00
Hours large group	45,0	30.00

Total learning time: 150 h

CONTENTS

1. Affine transformations

Description:
1. Affine combinations. Barycentric coordinates
2. Affine transformations in the plane
3. Mosaics
4. Affine transformations in space

Specific objectives:
To use barycentric coordinates and affine combinations to represent points and figures.

To construct and apply affine transformations in the plane and in space.

To apply affine transformations to design, move, transform and repeat geometric figures, especially in the construction of mosaics.

Related activities:
Projects 1, 2 and 3, individual assessed practical sessions and final theory exam.

Related competencies :
. G1. Ability to solve arithmetic problems related to engineering. Aptitude to apply knowledge concerning: linear algebra, geometry, differential geometry, differential and integral calculus, numerical methods, stadistics technology.
. D33. Knowledge of aesthetics.
. D48. Ability to know and apply creative process and its organization.
07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
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Full-or-part-time: 16h
Theory classes: 6h
Laboratory classes: 2h
Self study : 8h

2. Differential Geometry of curves

Description:
1 Regular parametrizations
2 Conics
3 Curvature and torsion
4 Osculating circle and evolutes
5 Frenet frame
6 Geometric continuity

Related activities:
Activities 1, 4

Related competencies :
. G1. Ability to solve arithmetic problems related to engineering. Aptitude to apply knowledge concerning: linear algebra, geometry, differential geometry, differential and integral calculus, numerical methods, stadistics technology.
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Full-or-part-time: 24h
Theory classes: 8h
Laboratory classes: 4h
Self study : 12h

3. Bézier curves

Description:
1 Definition and basic properties
2 Casteljau's algorithm
3 Subdivision
4 Geometric continuity

Related activities:
Activities 2, 4

Related competencies :
. G1. Ability to solve arithmetic problems related to engineering. Aptitude to apply knowledge concerning: linear algebra, geometry, differential geometry, differential and integral calculus, numerical methods, stadistics technology.
. D33. Knowledge of aesthetics.
. D48. Ability to know and apply creative process and its organization.
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Full-or-part-time: 20h
Theory classes: 8h
Laboratory classes: 2h
Self study : 10h

4. Differential Geometry of surfaces

Description:
1. Regular parameterizations
2. Quadric surfaces
3. Tangent plane
4. Offset surfaces
5. Surfaces of revolution
6. Rules surfaces
7. Tubular surfaces
4. Ruled surfaces

Related activities:
Activities 3,4

Related competencies :
. G1. Ability to solve arithmetic problems related to engineering. Aptitude to apply knowledge concerning: linear algebra, geometry, differential geometry, differential and integral calculus, numerical methods, stadistics technology.
. D33. Knowledge of aesthetics.
. D48. Ability to know and apply creative process and its organization.
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Full-or-part-time: 16h
Theory classes: 6h
Laboratory classes: 2h
Self study : 8h

5. Bézier Surfaces

Description:
1. Definition and properties
2. Casteljau algorithm
3. Subdivision
4. Geometric continuity
5. Coon's patches

Related activities:
Activities 3, 4

Related competencies :
. G1. Ability to solve arithmetic problems related to engineering. Aptitude to apply knowledge concerning: linear algebra, geometry, differential geometry, differential and integral calculus, numerical methods, stadistics technology.
. D28. Knowledge of ANIMACION and basic 3D simulation.
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07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

Full-or-part-time: 20h
Theory classes: 8h
Laboratory classes: 2h
Self study : 10h

GRADING SYSTEM

The continuous assessment consists of three projects, individual assessed practical sessions and a final theory exam, with the following weights:

Project 1: 12.5%
Project 2: 12.5%
Project 3: 15%
Individual practical sessions: 25%
Final theory exam: 35%

The three projects aim to integrate the geometric and graphical contents of the subject into broader development tasks. The individual practical sessions allow the personal acquisition of the concepts, procedures and constructions worked on in class to be assessed continuously. The final theory exam assesses conceptual understanding and individual problem-solving ability.

The final exam is reassessable.

No minimum mark is required in any of the assessed parts. The final mark for the subject is obtained using the weighted average indicated above.

EXAMINATION RULES.

Projects 1, 2 and 3 will be carried out in pairs and must be submitted within the deadlines published at the beginning of the course.

The assessed practical sessions will be face-to-face and individual. Before each assessed practical session, students will be provided with a model practical activity or preparatory material to work autonomously on the contents, tools and constructions that will be assessed.

The final theory exam will be face-to-face, individual and reassessable.

BIBLIOGRAPHY

Basic:
- Trias Pairó, Joan. Geometria per a la informàtica gràfica i CAD [on line]. Barcelona: Edicions UPC, 1999 [Consultation: 22/03/2022]. Available on: https://upcommons.upc.edu/handle/2099.3/36243. ISBN 8483013541.
- Farin, Gerald E. Curves and surfaces for computer aided geometric design : a practical guide [on line]. 5th ed. San Francisco [etc.]: Morgan Kaufmann, 2002 [Consultation: 20/02/2024]. Available on: https://www-sciencedirect-com.recursos.biblioteca.upc.edu/book/9781558607378/curves-and-surfaces-for-cagd. ISBN 1558607374.
- Cordero Valle, Juan Manuel; Cortés Parejo, José. Curvas y superficies para modelado geométrico. Madrid: RA-MA, 2002. ISBN 8478975314.

Complementary:
- Boehm, Wolfgang; Prautzsch, Hartmut. Geometric concepts for geometric design [on line]. Wellesley, Mass: A.K. Peters, 1994 [Consultation: 20/02/2024]. Available on: https://www-taylorfrancis-com.recursos.biblioteca.upc.edu/books/mono/10.1201/9781315275475/geometric-concepts-geometric-design-hartmut-prautzsch-wolfgang-boehm. ISBN 1568810040.
- Gallier, Jean H. Geometric methods and applications : for computer science and engineering [on line]. New Yok [etc.]: Springer, 2011 [Consultation: 22/03/2022]. Available on: https://link.springer.com/book/10.1007/978-1-4419-9961-0. ISBN 9781441999603.
- Hoschek, Josef; Lasser, Dieter. Fundamentals of computer aided geometric design. Wellesley, Massachusetts: A. K. Peters, 1993. ISBN 1568810075.
- Marsh, Duncan. Applied geometry for computer graphics and CAD [on line]. 2nd ed. London [etc.]: Springer, 2005 [Consultation: 03/05/2022]. Available on: https://link.springer.com/book/10.1007/b138823. ISBN 1852338016.
- Trias Pairó, Joan. Laboratori de geometria computacional [on line]. Barcelona: Edicions UPC, 2005 [Consultation: 25/03/2022]. Available on: https://upcommons.upc.edu/handle/2117/166489. ISBN 8483018268.

RESOURCES

Other resources:
Geogebra (https://www.geogebra.org/) />Geogebra book of the course (https://www.geogebra.org/m/ewh6xch8) />