Course guides
340070 - MADI-D2O43 - Mathematics for Design

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 MECHANICAL ENGINEERING (Syllabus 2009). (Optional subject).

Academic year: 2021 ECTS Credits: 6.0 Languages: Catalan

LECTURER

Coordinating lecturer: Francesc Aguiló
Others: Miquel Sánchez i Francesc Aguiló

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
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

There are large group classes, that deal with theoretical explanations, descriptions of selected examples and problem solving (by hand, with computer and smartphone). In the computer lab sessions, students work with Geogebra in order to work the theoretical concepts and prepare graphical projects.

LEARNING OBJECTIVES OF THE SUBJECT

* To understand the concepts and techniques of classical geometry that are essential for CAGD:
  - To use affine coordinates and transformations to move and transform the shape of plane and spacial geometric figures
  - To handle with conics and quadric surfaces, as example of basic curves and surfaces
  - To understand the following concepts of differential geometry: curvature, torsion and osculating circle of a curve; tangent plane, normal vector

* To use the techniques of Bézier designing curves and surfaces:
  - To deal with Bernstein polynomials for Bézier curves and surfaces
  - To learn the de Casteljau Algorithm
  - To understand the problem of geometric continuity for Bézier curves and surfaces
STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Hours large group</td>
<td>45,0</td>
<td>30.00</td>
</tr>
<tr>
<td>Hours small group</td>
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<td>10.00</td>
</tr>
<tr>
<td>Self study</td>
<td>90,0</td>
<td>60.00</td>
</tr>
</tbody>
</table>

Total learning time: 150 h

CONTENTS

**1. 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, 6

**Related competencies:**
- D48. Ability to know and apply creative process and its organization.
- D33. Knowledge of aesthetics.
- 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, statistics technology.
- 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.
- 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.
- 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.
- 06 URI. 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.

**Full-or-part-time:** 24h
Theory classes: 8h
Laboratory classes: 4h
Self study: 12h
2. 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 2,6

Related competencies:
. D48. Ability to know and apply creative process and its organization.
. 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, statistics technology.
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.
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.
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
3. Affine maps

Description:
1. Affine combinations. Barycentric coordinates
2. Plane transformations
3. Mosaics
4. Space transformations

Related activities:
Activities 3,6

Related competencies:
. D48. Ability to know and apply creative process and its organization.
. 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, statistics technology.
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.
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.
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: 16h
Theory classes: 6h
Laboratory classes: 2h
Self study: 8h

4. Bézier curves

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

Related activities:
Activities 4, 6

Related competencies:
. D48. Ability to know and apply creative process and its organization.
. 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, statistics technology.
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.
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.
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Full-or-part-time: 20h
Theory classes: 8h
Laboratory classes: 2h
Self study: 10h
5. Bézier Surfaces

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

**Related activities:**
Activities 5,6

**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, statistics technology.

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

**ACTIVITIES**

1. **PROJECT 1: Differential Geometry of curves**

**Description:**
Project of Differential Geometry of curves with Geogebra

**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, statistics technology.

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

2. **Projecte 2: Differential geometry of surfaces**

**Description:**
Design of a surface with elements of differential geometry

**Full-or-part-time:** 8h
Self study: 8h
3. PROJECT 3: Mosaics

Description:
Design of a mosaic with Geogebra

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, statistics technology.
. D48. Ability to know and apply creative process and its organization.
. 06 URI. 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.
. 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.
. 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.

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

4. PROJECT 4: Animation

Description:
Design of an animation with Geogebra

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, statistics technology.
. 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.
. 06 URI. 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.

Full-or-part-time: 12h
Laboratory classes: 2h
Self study: 10h
5. PROJECT 5: Composition 3D

Description:
Design of a composition 3D with Geogebra

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, statistics technology.
. 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.
06 URI. 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.

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

6. FINAL EXAM

Description:
Exam: Problems and theoretical questions of topics 1, 2, 3, 4, 5.

Full-or-part-time: 2h
Theory classes: 2h

GRADING SYSTEM

Ongoing assessment (OA): 0.15*NA1+0.15*NA2+0.15*NA3+0.3*NA4+0.25*NA5
NA1, NA2, NA3, NA4, N5: Projects (activities 1, 2, 3, 4, 5)
NA6: Final exam (activity 6)
Final assessment: max(OA, 0.3*OA+0.7*NA6)

Final exam is re-evaluable

EXAMINATION RULES.

Activities 1, 2, 3, 4 and 5 are done in pairs, and must be delivered in the dates fixed at the beginning of the course. Activity 6 is a standard exam.

BIBLIOGRAPHY

Basic:

Complementary:
RESOURCES

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