340070 - MADI-D2O43 - Mathematics for Design

Coordinating unit: 340 - EPSEVG - Vilanova i la Geltrú School of Engineering
Teaching unit: 749 - MAT - Department of Mathematics
Academic year: 2017
Degree: BACHELOR’S DEGREE IN INDUSTRIAL DESIGN AND PRODUCT DEVELOPMENT ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)
BACHELOR’S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
ECTS credits: 6
Teaching languages: Catalan

Teaching staff
Coordinator: Jordi Guàrdia
Others: Josep González, Josefina Antonijuan, Joana Prat

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 and Dupin indicatrix of a surface

* 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>Total learning time: 150h</th>
<th>Hours large group:</th>
<th>45h</th>
<th>30.00%</th>
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<tbody>
<tr>
<td></td>
<td>Hours medium group:</td>
<td>0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Hours small group:</td>
<td>15h</td>
<td>10.00%</td>
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<td></td>
<td>Guided activities:</td>
<td>0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Self study:</td>
<td>90h</td>
<td>60.00%</td>
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</tbody>
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## Content

<table>
<thead>
<tr>
<th>1. Review of basic geometry</th>
<th>Learning time: 8h</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 2h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 2h</td>
</tr>
<tr>
<td></td>
<td>Self study: 4h</td>
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</tbody>
</table>

**Description:**
1. Plane geometry: parallelism, perpendicularity, distance
2. Space geometry: lines, planes, parallelism, perpendicularity, distance

**Related activities:**
Activities 1, 2, 3, 4 & 6

<table>
<thead>
<tr>
<th>2. Differential Geometry of curves</th>
<th>Learning time: 36h</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 10h</td>
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<tr>
<td></td>
<td>Laboratory classes: 2h</td>
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<tr>
<td></td>
<td>Self study: 24h</td>
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</table>

**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, 5
### 3. Differential Geometry of Surfaces

**Description:**
- 1. Regular parameterizations
- 2. Cuádricas
- 3. Surfaces of revolution
- 4. Ruled surfaces
- 5. Tangent plane
- 6. Gaussian, normal and mean curvature
- 7. Dupin's indicatrix
- 8. Offset surfaces
- 9. Tubular surfaces

**Related activities:**
Activities 1, 5

**Learning time:** 24h
- Theory classes: 6h
- Laboratory classes: 2h
- Self study: 16h

### 4. Affine maps

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

**Related activities:**
Activities 2, 3, 4, 5

**Learning time:** 20h
- Theory classes: 6h
- Laboratory classes: 2h
- Self study: 12h
### 5. Bézier curves

**Learning time:** 32h  
Theory classes: 10h  
Laboratory classes: 2h  
Self study : 20h

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

**Related activities:**  
Activities 3, 4, 5

### 6. Bezier Surfaces

**Learning time:** 20h  
Theory classes: 6h  
Laboratory classes: 2h  
Self study : 12h

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

**Related activities:**  
Activities 3, 4, 5
### Planning of activities

| 1: EXAM OF ITEMS 1, 2 AND 3 (FIRST MIDTERM EXAM) | Hours: 2h  
Theory classes: 2h |
<table>
<thead>
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Exam: Problems, theoretical questions and labs of topics 1, 2 and 3</td>
</tr>
</tbody>
</table>

| 2: PROJECT 1: Mosaics | Hours: 4h  
Laboratory classes: 2h  
Self study: 2h |
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Design of a mosaic with Geogebra</td>
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</table>

| 3: PROJECT 2: Animation | Hours: 12h  
Laboratory classes: 2h  
Self study: 10h |
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Design of an animation with Geogebra</td>
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</table>

| 4: PROJECT 3: Composition 3D | Hours: 8h  
Laboratory classes: 2h  
Self study: 6h |
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Design of a composition 3D with Geogebra</td>
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| 5: FINAL EXAM | Hours: 2h  
Theory classes: 2h |
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Exam: Problems and theoretical questions of topics 1, 2, 3 4, 5 and 6</td>
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Qualification system

\[
\text{max}(0.4 \times \text{NA1} + 0.1 \times \text{NA2} + 0.3 \times \text{NA3} + 0.2 \times \text{NA4},\ 0.05 \times \text{NA2} + 0.15 \times \text{NA3} + 0.1 \times \text{NA4} + 0.7 \times \text{NA5})
\]

- NA1: First midterm exam (activity 1)
- NA2, NA3, NA4: Projects (activities 2, 3, 4)
- NA5: Final exam (activity 5)

Final exam is re-evaluable

Regulations for carrying out activities

Activities 1 and 5 are standard exams. Activities 2, 3 and 4 are done in pairs, and must be presented in the dates fixed at the beginning of the course.

Bibliography

Basic:


Complementary:


Others resources:

- Geogebra (https://www.geogebra.org/)
- Geogebra page of the course (https://www.geogebra.org/m/da8xm4jG)