Degree competences to which the subject contributes

Specific:
1. CE-2. Solve problems in Mathematics, through basic calculation skills, taking in account tools availability and the constraints of time and resources.
2. CE-3. Have the knowledge of specific programming languages and software.
3. CE-4. Have the ability to use computational tools as an aid to mathematical processes.

Generical:
4. CB-1. Demonstrate knowledge and understanding in Mathematics that is founded upon and extends that typically associated with Bachelor’s level, and that provides a basis for originality in developing and applying ideas, often within a research context.
5. CB-2. Know how to apply their mathematical knowledge and understanding, and problem solving abilities in new or unfamiliar environments within broader or multidisciplinary contexts related to Mathematics.
6. CB-3. Have the ability to integrate knowledge and handle complexity, and formulate judgements with incomplete or limited information, but that include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgements.
7. CG-1. Show knowledge and proficiency in the use of mathematical language.
8. CG-2. Construct rigorous proofs of some classical theorems in a variety of fields of Mathematics.
9. CG-3. Have the ability to define new mathematical objects in terms of others already know and ability to use these objects in different contexts.
10. CG-4. Translate into mathematical terms problems stated in non-mathematical language, and take advantage of this translation to solve them.
11. CG-6 Detect deficiencies in their own knowledge and pass them through critical reflection and choice of the best action to extend this knowledge.

Transversal:
11. 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.
200004 - CD - Differential Calculus

**Teaching methodology**

(Section not available)

**Learning objectives of the subject**

(Section not available)

**Study load**

<table>
<thead>
<tr>
<th>Total learning time: 187h 30m</th>
<th>Hours large group:</th>
<th>45h</th>
<th>24.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Hours small group:</td>
<td>30h</td>
<td>16.00%</td>
</tr>
<tr>
<td></td>
<td>Guided activities:</td>
<td>7h 30m</td>
<td>4.00%</td>
</tr>
<tr>
<td></td>
<td>Self study:</td>
<td>105h</td>
<td>56.00%</td>
</tr>
</tbody>
</table>
## Content

### 1. Topology of \( \mathbb{R}^n \). Sequences of vectors.

**Learning time:** 25h  
- Theory classes: 6h  
- Practical classes: 4h  
- Self study: 15h

**Description:**  
- Euclidean, normed and metric spaces. Case study: \( \mathbb{R}^n \).  
- Open and closed sets. Interior, exterior and boundary of a set.  
- Connected sets.

### 2. Limits and continuity of functions.

**Learning time:** 25h  
- Theory classes: 6h  
- Practical classes: 4h  
- Self study: 15h

**Description:**  
- Functions of several variables. Level sets and graphics of real functions.  
- Limit of a function at a point (special emphasis on the case of two variables).  
- Continuity at a point and a set. Properties of continuous functions.  
- Continuity and compactness. Weierstrass theorem.  
- Uniform continuity. Heine-Cantor theorem.  
- Equivalence norms and equivalence metrics. Fixed point theorem.

### 3. Differentiability.

**Learning time:** 34h  
- Theory classes: 8h  
- Practical classes: 6h  
- Self study: 20h

**Description:**  
- Differentiability at a point. Hyperplane tangent to the graph of a real function.  
- Differentiability and operations. Chain rule. Relationship between differentiability, continuity and partial derivatives.  
- Differentiability in an open set. Mean Value Theorem. Functions of class \( C^1 \).  
- Differentiable curves. Tangent vector.
### Qualification system

Final Mark = \[ \text{Max}(\text{Final Exam}, 0.7 \times \text{Final Exam} + 0.3 \times \text{Midterm Exam}) \]

Eventually, the grading of the mid-term exam could be modified by other grades.

An extra exam will take place on July for students that failed during the regular semester.

---

<table>
<thead>
<tr>
<th>4. Theorems of differentiable functions.</th>
<th>Learning time: 41h</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Higher-order partial derivatives.</td>
<td>Theory classes: 10h</td>
</tr>
<tr>
<td>- Schwarz theorem.</td>
<td>Practical classes: 6h</td>
</tr>
<tr>
<td>- Cn-class functions.</td>
<td>Self study: 25h</td>
</tr>
<tr>
<td>- Examples of mathematical physics</td>
<td></td>
</tr>
<tr>
<td>- equations.</td>
<td></td>
</tr>
<tr>
<td>- Change of variables in equations</td>
<td></td>
</tr>
<tr>
<td>- containing partial derivatives.</td>
<td></td>
</tr>
</tbody>
</table>

**Description:**
- The inverse function theorem. Diffeomorphisms.
- The implicit function theorem. Derivatives of implicit functions.
- Rank theorems.

---

<table>
<thead>
<tr>
<th>5. Taylor formula. Local extrema.</th>
<th>Learning time: 33h</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Taylor formula.</td>
<td>Theory classes: 8h</td>
</tr>
<tr>
<td>- Expressions of the rest.</td>
<td>Practical classes: 5h</td>
</tr>
<tr>
<td>- Local extrema.</td>
<td>Self study: 20h</td>
</tr>
<tr>
<td>- Critical points.</td>
<td></td>
</tr>
<tr>
<td>- Classification of critical points:</td>
<td></td>
</tr>
<tr>
<td>- Quadratic forms, Hessian matrix.</td>
<td></td>
</tr>
<tr>
<td>- Criteria of Silvester and of eigenvalues of the Hessian matrix.</td>
<td></td>
</tr>
</tbody>
</table>

**Description:**
- Taylor formula. Expressions of the rest.
- Local extrema. Critical points.
- Classification of critical points: quadratic forms, Hessian matrix.
- Criteria of Silvester and of eigenvalues of the Hessian matrix.

---

<table>
<thead>
<tr>
<th>6. Submanifolds of Rn and constrained extrema.</th>
<th>Learning time: 32h</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Submanifolds of Rn.</td>
<td>Theory classes: 7h</td>
</tr>
<tr>
<td>- Tangent vectors.</td>
<td>Practical classes: 5h</td>
</tr>
<tr>
<td>- Tangent and normal spaces at a point.</td>
<td>Self study: 20h</td>
</tr>
<tr>
<td>- Parameterized and implicit submanifolds.</td>
<td></td>
</tr>
<tr>
<td>- Regular curves and surfaces.</td>
<td></td>
</tr>
<tr>
<td>- Constrained extrema and Lagrange multipliers.</td>
<td></td>
</tr>
<tr>
<td>- Absolute extrema.</td>
<td></td>
</tr>
</tbody>
</table>

---

**Description:**
- Submanifolds of Rn. Tangent vectors. Tangent and normal spaces at a point.
- Parameterized and implicit submanifolds. Regular curves and surfaces.
- Constrained extrema and Lagrange multipliers.
- Absolute extrema.
**Bibliography**

**Basic:**


**Complementary:**


**Others resources:**