Course guides
230456 - MM1 - Mathematical Methods 1

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 749 - MAT - Department of Mathematics.
Degree: BACHELOR'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2011). (Compulsory subject).
Academic year: 2020  ECTS Credits: 6.0  Languages: Catalan, Spanish

LECTURER
Coordinating lecturer: RAFAEL RAMÍREZ ROS
Others: José Tomás Lázaro Ochoa, Jordi Villanueva Castelltort

PRIOR SKILLS
Calculus of one variable (derivatives, integrals, and power series), and linear algebra (linear maps and diagonalization).

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Ability to solve math problems that may arise in engineering. Ability to apply knowledge about linear algebra, geometry, differential geometry, differential and integral calculus, ordinary and partial differential equations, probability and statistics.
2. Ability to select numerical and optimization methods suitable for solving physical and engineering problems. Ability to apply the knowledge of numerical algorithms and optimization.

General:
3. ABILITY TO IDENTIFY, FORMULATE, AND SOLVE PHYSICAL ENGINEERING PROBLEMS. Planning and solving physical engineering problems with initiative, making decisions and with creativity. Developing methods of analysis and problem solving in a systematic and creative way.

Transversal:
4. EFFECTIVE USE OF INFORMATION RESOURCES - Level 1. Identifying information needs. Using collections, premises and services that are available for designing and executing simple searches that are suited to the topic.

TEACHING METHODOLOGY
Five hours per week of class attendance. Realization of an optional work about a free topic.

LEARNING OBJECTIVES OF THE SUBJECT
At the end of the course, the student should be able: 1) To solve several simple ODEs (first-order linear ODEs, separable ODEs, exact ODEs, n-th order linear ODEs with constant coefficients, etc.); 2) To solve linear ODEs by using the Laplace transform; 3) To solve (and to draw the phase portrait of) 2D and 3D systems of linear ODEs with constant coefficients; 4) To draw local and global phase portraits of 2D and 3D systems of nonlinear ODEs; and 5) To model physical, chemical, biological, and geometrical problems with ODEs.
### STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours large group</td>
<td>65.0</td>
<td>43.33</td>
</tr>
<tr>
<td>Self study</td>
<td>85.0</td>
<td>56.67</td>
</tr>
</tbody>
</table>

Total learning time: 150 h

### CONTENTS

#### Solving first-order ODEs

**Description:**
First-order EDOs: separable, linear, Bernoulli, Ricatti, exact, etc. Applications: snow plow, radioactive decay, Newton's law of cooling, Torricelli's law, logistic equation, etc.

**Full-or-part-time:** 29h  
Practical classes: 12h  
Self study: 17h

#### Systems of linear ODEs

**Description:**
Resolution and classification of systems of linear EDOs to constant coefficients. Applications: Problems of connected deposits, connected spring problems, Wilberforce pendulum, etc.

**Full-or-part-time:** 41h  
Theory classes: 18h  
Self study: 23h

#### Laplace Transform

**Description:**
Definition and computation of Laplace transforms. Application to solving linear ODEs. Dirac's delta.

**Full-or-part-time:** 16h  
Practical classes: 7h  
Self study: 9h

#### Systems of nonlinear ODEs

**Description:**
Case 1D: Phase portraits and bifurcation diagrams. Case 2D: Isoclines, separatrices, limit cycles, trap regions, etc. 3D case: Chaos. Stability of equilibrium points by linearization and by Liapunov. Applications: Pursuit trajectories, biological models, conservative systems with one degree of freedom, pendulum problems, tennis racket theorem, etc.

**Full-or-part-time:** 48h  
Theory classes: 21h  
Self study: 27h
**n-th order linear ODEs**

**Description:**
Homogeneous linear EDOs with constant coefficients: The characteristic polynomial. Non-homogeneous linear EDOs with constant coefficients: Indeterminate coefficients and variation of constants. Applications: Oscillations, spring problems, etc.

**Full-or-part-time:** 16h  
Practical classes: 7h  
Self study: 9h

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**GRADING SYSTEM**

A partial exam, a final exam, and an optional work. The final grade is

\[
FG = \min(10, \max(\text{FE}, 0.3*\text{PE} + 0.7*\text{FE}) + 0.1*\text{W}),
\]

where PE is the grade of the partial exam, FE is the grade of the final exam, and W is the grade of the work.

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**EXAMINATION RULES.**

The student can use a sheet of paper (DIN A4 size) written by hand and a list of Laplace transforms. The use of calculators, cellphones or any programable digital device is forbidden.

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**BIBLIOGRAPHY**

**Basic:**

**Complementary:**