Guia Docent

11/12

Facultat de Matemàtiques i Estadística

Master of Science in Advanced Mathematics and Mathematical Engineering

Curs R. A. Fisher

1890-1962
Program

As reflected in its name, this master has a dual academic and professional orientation. On the academic side, it provides the skills and techniques needed in scientific research in general and, more specifically, in mathematical research. On the professional side, the goal is to provide the students with an advanced background to work in interdisciplinary teams, in cooperation with engineers, physicists, biologists, economists, etc. The master benefits both from the leading role of Spanish mathematical research at the European level and the technological environment of a technical university such as UPC–Barcelona Tech.

Structure

The master duration is 60 ECTS (European Credit transfer System) credits, and is intended to be completed in one academic year. This comprises 45 ECTS in courses and a master thesis (15 ECTS). Master courses are offered in five broad fields: Algebra and Geometry; Discrete Mathematics and Algorithms; Modelling in Engineering and Biomedical Sciences; Differential Equations; Scientific Computing. In addition, up to half of the course credits (i.e. 22.5 ECTS) may be taken from other master courses. This offers an excellent opportunity of specialisation in a given field according to one’s preferences. The official teaching language of this master is English.

Specific requirements

This master is addressed to students with good abstract reasoning, interest in problem solving, strong work habits and a liking for mathematics. A scientific background is required, with basic mathematical foundations. For these reasons, a bachelor in mathematics, statistics, physics, engineering, economics or science is recommended. This list is non-exclusive, and all applications will be reviewed on an individual basis.
Career prospects

Some of the career prospects of master graduates are academic research (by pursuing a PhD in mathematics, sciences or engineering, for instance), mathematical modelling, finance, statistics, applied research (biomedical research centers, computer vision, etc.)

Additional information

34963 - ACPDE - Advanced Course in Partial Differential Equations

Coordinating unit: 200 - FME - Faculty of Mathematics and Statistics
Teaching unit: 725 - MA I - Department of Applied Mathematics I
Academic year: 2011
Degree: MASTER IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010).
(Teaching unit Optative)
ECTS credits: 7,5
Teaching languages: English

Teaching staff

Coordinator: XAVIER CABRE VILAGUT
Others:
BLANCA AYUSO DE DIOS - A
XAVIER CABRE VILAGUT - A

Prior skills

Basic knowledge of Partial Differential Equations.
Basic knowledge of Mathematical Analysis (undergraduate level).

Requirements

Undergraduate courses in Partial Differential Equations and in Mathematical Analysis.

Degree competences to which the subject contributes

Specific:
1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
2. MODELLING. Formulate, analyse and validate mathematical models of practical problems by using the appropriate mathematical tools.
3. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
4. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.

Generic:
5. 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.
6. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.
7. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
8. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
9. 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.
# 34963 - ACPDE - Advanced Course in Partial Differential Equations

## Teaching methodology

Classes will combine theoretical aspects and proofs with resolution of concrete problems and exercises. Further reading from the bibliography will be given often.

## Learning objectives of the subject

Understand the classical methods to solve the Laplace, heat, and wave equations. Understand the role of Sobolev norms and compact embeddings to solve PDEs and find spectral decompositions. Learn the main methods available to solve nonlinear PDEs, through simple cases.

## Study load

<table>
<thead>
<tr>
<th>Total learning time: 187h 30m</th>
<th>Self study: 127h 30m</th>
<th>68.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 60h</td>
<td>32.00%</td>
</tr>
</tbody>
</table>

## Content

### Classical methods for the Poisson and heat equations

**Learning time:** 47h
- Theory classes: 15h
- Self study: 32h

**Description:**
Maximum principles and Green's functions for the Poisson and heat equations.

### Sobolev spaces and variational methods

**Learning time:** 47h
- Theory classes: 15h
- Self study: 32h

**Description:**
Basic properties of Sobolev spaces. Weak or variational formulation of boundary problems for linear elliptic PDEs.

### Evolution equations

**Learning time:** 46h 45m
- Theory classes: 15h
- Self study: 31h 45m

**Description:**
34963 - ACPDE - Advanced Course in Partial Differential Equations

**Introduction to nonlinear PDEs**

<table>
<thead>
<tr>
<th>Description:</th>
<th>Learning time: 46h 45m</th>
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</thead>
</table>
Self study : 31h 45m |

**Qualification system**

30% of the grade: resolution of problems proposed in class. 70% of the grade: Presentation (written and in class) of a further developed topic of the subject.

**Bibliography**

**Basic:**

**Complementary:**
34952 - AG - Algebraic Geometry

Coordinating unit: 200 - FME - Faculty of Mathematics and Statistics
Teaching unit: 725 - MA I - Department of Applied Mathematics I
Academic year: 2011
Degree: MASTER IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Teaching unit Optative)
ECTS credits: 7,5
Teaching languages: English

Coordinator: PEDRO PASCUAL GAINZA
Others: PEDRO PASCUAL GAINZA - A

Requirements

Basic abstract algebra, Topology and Differential Geometry
Commutative Algebra

Degree competences to which the subject contributes

Specific:
1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
2. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
3. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.

General:
4. 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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8. 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.

Teaching methodology

There will be master classes where the different subjects are introduced and discussed with the students, and also some problem sessions.

Learning objectives of the subject

The main objective of the course is to introduce the student to the Algebraic Geometry of affine and projective varieties.
34952 - AG - Algebraic Geometry

over a field. The course will be based on many examples, as in Harris book in the references, stressing the geometric interest of the subject, using the commutative algebra only as a resource. At the end, depending on the audience, there will be some lectures on schemes theory and their role in algebraic geometry.

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<thead>
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<tbody>
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<td>60h</td>
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</table>

## Content

### Chapter 1: Algebraic sets

**Description:**
Algebraic sets. Hilbert’s basis and nullstellensatz theorems. Zariski topology.

**Learning time:** 18h
- Theory classes: 4h
- Self study: 14h

### Chapter 2: Algebraic varieties

**Description:**

**Learning time:** 28h
- Theory classes: 9h
- Self study: 19h

### Chapter 3: Projective varieties

**Description:**

**Learning time:** 28h
- Theory classes: 9h
- Self study: 19h
# 34952 - AG - Algebraic Geometry

<table>
<thead>
<tr>
<th>Chapter 4: Finite maps</th>
<th>Learning time: 28h</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 9h</td>
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<td>Self study: 19h</td>
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**Description:**

<table>
<thead>
<tr>
<th>Chapter 5: Local theory</th>
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<tr>
<td></td>
<td>Theory classes: 9h</td>
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**Description:**

<table>
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<th>Chapter 6: Dimension theory</th>
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<td></td>
<td>Theory classes: 9h</td>
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<tr>
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<td>Self study: 19h</td>
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</table>

**Description:**
Dimension of affine varieties and of projective varieties. Dimension of the fibers of a morphism.

<table>
<thead>
<tr>
<th>Chapter 7: Divisors, differentials and intersection theory</th>
<th>Learning time: 28h</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 9h</td>
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<tr>
<td></td>
<td>Self study: 19h</td>
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</tbody>
</table>

**Description:**
Divisors, intersectino theory of divisors. Bézout theorem. Differentials, the canonical divisor.

## Qualification system

The qualification will be based on the exercises done as homework and the exposition of a subject developed by the student.
Bibliography

Basic:


34954 - CC - Codes and Cryptography

Coordinating unit: 200 - FME - Faculty of Mathematics and Statistics
Teaching unit: 726 - MA II - Department of Applied Mathematics II
743 - MA IV - Department of Applied Mathematics IV

Academic year: 2011
Degree: MASTER IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010).
(Teaching unit Optative)
ECTS credits: 7.5  
Teaching languages: English

Teaching staff
Coordinator: M. PAZ MORILLO BOSCH
Others:
SIMEON MICHAEL BALL - A
JAVIER HERRANZ SOTOCA - A
M. PAZ MORILLO BOSCH - A
JORGE LUIS VILLAR SANTOS - A

Prior skills
Basic probability, basic number theory and linear algebra

Requirements
Undergraduate mathematics

Degree competences to which the subject contributes

Specific:
1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
2. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
3. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.

General:
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6. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
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8. 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.
### 34954 - CC - Codes and Cryptography

#### Teaching methodology
The course is divided in two parts: codes and cryptography. Each part consists of 26 h of ordinary classes and 13 of supervised works. In these works some specialized topics will be addressed in deep.

#### Learning objectives of the subject
This course aims to give a solid understanding of the uses of mathematics in Information technologies and modern communications. The course focuses on the reliable and efficient transmission and storage of the information. Both the mathematical foundations and the description of the most important cryptographic protocols and coding systems are given in the course.

#### Study load

<table>
<thead>
<tr>
<th>Total learning time: 187h 30m</th>
<th>Self study:</th>
<th>Learning time:</th>
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<tr>
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<td>60h</td>
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<tr>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
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<td>3h 37m</td>
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<td></td>
<td>Self study:</td>
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<td>7h 18m</td>
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#### Content

<table>
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<th>Introduction to Coding theory</th>
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<td></td>
<td>Self study:</td>
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<td>0h 48m</td>
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</table>

**Description:**
The problem of communication. Information theory, Coding theory and Cryptographic theory

<table>
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<th>Information and Entropy</th>
<th>Learning time:</th>
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<td>Theory classes:</td>
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<tr>
<td></td>
<td>3h 37m</td>
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<td></td>
<td>Self study:</td>
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<tr>
<td></td>
<td>5h 18m</td>
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</tbody>
</table>

**Description:**
Uncertainty or information. Entropy. Mutual information

<table>
<thead>
<tr>
<th>Source codes without memory</th>
<th>Learning time:</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td>Theory classes:</td>
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<td>3h 37m</td>
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<td></td>
<td>Self study:</td>
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<td>7h 18m</td>
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**Description:**
### 34954 - CC - Codes and Cryptography

<table>
<thead>
<tr>
<th>Topic</th>
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</thead>
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<td></td>
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</tr>
<tr>
<td></td>
<td>Self study: 7h 18m</td>
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</table>

#### Channel coding

**Description:**
- Discrete channels without memory. Symmetric channels. Shannon's theorem.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Learning time: 8h 55m</th>
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<tbody>
<tr>
<td></td>
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<td>Self study: 6h 18m</td>
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#### Finite fields

**Description:**

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<td>Self study: 14h 18m</td>
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#### Block codes

**Description:**

### Cyclic codes

**Description:**

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<th>Topic</th>
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<td></td>
<td>Theory classes: 2h 37m</td>
</tr>
<tr>
<td></td>
<td>Self study: 2h 18m</td>
</tr>
</tbody>
</table>
# 34954 - CC - Codes and Cryptography

| Public key cryptography | **Learning time:** 14h 55m  
|                         | Theory classes: 4h 37m  
|                         | Self study: 10h 18m  |


| Standard hard problems | **Learning time:** 14h 55m  
|                       | Theory classes: 4h 37m  
|                       | Self study: 10h 18m  |

**Description:** Factorization, discrete logarithm over finite fields and elliptic curves. Codes and lattices. Pairings over elliptic curves.

| Analysis of the security of cryptographic protocols | **Learning time:** 18h 55m  
|                                                      | Theory classes: 6h 37m  
|                                                      | Self study: 12h 18m  |

**Description:** Security models. Proofs by reduction. Heuristic security, random oracle model.

| Other cryptographic protocols of interest | **Learning time:** 14h 55m  
|                                         | Theory classes: 4h 37m  
|                                         | Self study: 10h 18m  |

**Description:** Identification protocols. Commitments. Zero-knowledge proofs.

| Distributed cryptography | **Learning time:** 18h 55m  
|                         | Theory classes: 6h 37m  
|                         | Self study: 12h 18m  |

**Description:** Secret sharing schemes. Multiparty computation. Application to distributed encryption and digital signatures protocols.
### Qualification system

Classroom problems: 2 points out of 10  
Theory exam: 2.5 points out of 10  
Supervised work (including oral presentation): 2 points out of 10  
Final exam: 3.5 points out of 10

### Regulations for carrying out activities

All the subjects are important. To pass the course it is required to fulfill all the items.

### Bibliography

**Basic:**


**Complementary:**

34955 - COMB - Combinatorics

Coordinating unit: 200 - FME - Faculty of Mathematics and Statistics
Teaching unit: 726 - MA II - Department of Applied Mathematics II
743 - MA IV - Department of Applied Mathematics IV
Academic year: 2011
Degree: MASTER IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010).
(Teaching unit Optative)
ECTS credits: 7.5  
Teaching languages: English

Teaching staff

Coordinator: ORIOL SERRA ALBO
Others:
SIMEON MICHAEL BALL - A
ANNA DE MIER VINUÉ - A
ORIOL SERRA ALBO - A

Prior skills

Basic calculus and linear algebra. Notions of probability.

Degree competences to which the subject contributes

Specific:
1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
2. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
3. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.

Generical:
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Teaching methodology

There will be a lecture each week, followed by a problem session.
34955 - COMB - Combinatorics

Learning objectives of the subject

To use algebraic, probabilistic and analytic methods for studying combinatorial structures. The main topics of study are: partially ordered sets, extremal set theory, finite geometries, matroids, Ramsey theory and enumerative combinatorics.

Study load

<table>
<thead>
<tr>
<th>Total learning time: 187h 30m</th>
<th>Self study:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>127h 30m</td>
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<tr>
<td></td>
<td>60h</td>
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<td></td>
<td>68.00%</td>
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<td></td>
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</tbody>
</table>

Content

Partially ordered sets

Learning time: 24h 40m

- Theory classes: 4h
- Practical classes: 4h
- Self study: 16h 40m

Description:
Sperner's theorem. LYM inequalities. Bollobás's theorem. Dilworth's theorem

Extremal set theory

Learning time: 24h 40m

- Theory classes: 4h
- Practical classes: 4h
- Self study: 16h 40m

Description:
Theorems of Baranyai, Erdos-de Bruijn and Erdos-Ko-Rado

Linear algebra methods in combinatorics

Learning time: 18h 30m

- Theory classes: 3h
- Practical classes: 3h
- Self study: 12h 30m

Description:
The polynomial method and applications. Fisher's theorem. Equiangular lines, sets with few differences
### Finite geometries

**Description:**

**Learning time:** 18h 30m
- Theory classes: 3h
- Practical classes: 3h
- Self study: 12h 30m

### Matroids

**Description:**
Axioms. Transversal matroids. Greedy algorithms. The Tutte polynomial

**Learning time:** 18h 30m
- Theory classes: 3h
- Practical classes: 3h
- Self study: 12h 30m

### Probabilistic methods in combinatorics

**Description:**
Permanents, transversals, hypergraph coloring. Monotone properties and threshold functions

**Learning time:** 18h 30m
- Theory classes: 3h
- Practical classes: 3h
- Self study: 12h 30m

### Ramsey theory

**Description:**
Theorems of Ramsey and Hales-Jewett. Theorems of Schur, Van der Waerden and Rado.

**Learning time:** 31h 40m
- Theory classes: 5h
- Practical classes: 5h
- Self study: 21h 40m

### Enumerative combinatorics

**Description:**
Symbolic and analytic methods. Symmetries and Pólya theory.

**Learning time:** 32h 30m
- Theory classes: 5h
- Practical classes: 5h
- Self study: 22h 30m
34955 - COMB - Combinatorics

**Qualification system**

Grading will be based on the solution of exercises. Eventually there will a final examination.

**Bibliography**

**Basic:**

34950 - CALG - Commutative Algebra

Coordinating unit: 200 - FME - Faculty of Mathematics and Statistics
Teaching unit: 725 - MA I - Department of Applied Mathematics I
Academic year: 2011
Degree: MASTER IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010).
(Teaching unit Optative)
ECTS credits: 7,5  Teaching languages: English

Teaching staff
Coordinator: FRANCESC D'ASSIS PLANAS VILANOVA
Others: FRANCESC D'ASSIS PLANAS VILANOVA - A

Prior skills
Linear algebra, calculus, topology, analysis.

Requirements
The two first years of a degree in mathematics.

Degree competences to which the subject contributes

Specific:
1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
2. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
3. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.

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Teaching methodology
Teaching Classes, resolution of problems
Basic course in Commutative Algebra.
An introduction to rings, ideal, primary decomposition, noetherian rings, integral extensions, completions and dimension theory.

Learning objectives of the subject

Content

Rings and ideals

Description:
It covers rings, ideals, radicals, extensions, and contractions.

Modules

Description:
General properties of modules. Tensor product.

Rings and modules of fractions

Description:
Introduction to rings and modules of fractions

Primary decomposition

Description:
Classical primary theory. First theorems.

Study load

Total learning time: 187h 30m
Self study: 127h 30m
Theory classes: 60h

Learning time: 12h 45m
Theory classes: 3h
Self study: 9h 45m

Learning time: 12h 45m
Theory classes: 3h
Self study: 9h 45m

Learning time: 18h
Theory classes: 6h
Self study: 12h

Learning time: 18h
Theory classes: 6h
Self study: 12h

Total learning time: 187h 30m
Self study: 127h 30m
Theory classes: 60h

68.00%
32.00%

Study load
### Integral dependence

**Description:**
Definition of integral dependence. Theorems of going-up and going-down.

**Learning time:** 18h
- Theory classes: 6h
- Self study: 12h

### Chain conditions

**Description:**
Chain conditions on sets, modules, rings.

**Learning time:** 18h
- Theory classes: 6h
- Self study: 12h

### Noetherian rings

**Description:**
They play a central role in Commutative Algebra and Algebraic Geometry.

**Learning time:** 18h
- Theory classes: 6h
- Self study: 12h

### Artin rings

**Description:**
A good examples of noetherian rings. In some sense the simplest.

**Learning time:** 18h
- Theory classes: 6h
- Self study: 12h

### Discrete valuation rings

**Description:**
The next case. Noetherian rings of dimension one.

**Learning time:** 18h
- Theory classes: 6h
- Self study: 12h
34950 - CALG - Commutative Algebra

Completions

| Description: |
| To deal with topologies, completions, filtrations and graded rings. |

Learning time: 18h
Theory classes: 6h
Self study: 12h

Dimension theory

| Description: |
| A brief introduction to Hilbert functions and dimension theory. |

Learning time: 18h
Theory classes: 6h
Self study: 12h

Qualification system

Continuous assessment, a final exam (if necessary)

Bibliography

Basic:


34959 - CM - Computational Mechanics

Coordinating unit: 200 - FME - Faculty of Mathematics and Statistics
Teaching unit: 727 - MA III - Department of Applied Mathematics III
Academic year: 2011
Degree: MASTER IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Teaching unit Optative)
ECTS credits: 7,5 Teaching languages: English

Teaching staff
Coordinator: YONGXING SHEN
Others: YONGXING SHEN - A

Prior skills
Basic knowledge of numerical methods
Basic knowledge of partial differential equations

Degree competences to which the subject contributes

Specific:
1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
2. MODELLING. Formulate, analyse and validate mathematical models of practical problems by using the appropriate mathematical tools.
3. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
4. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.

General:
5. 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.
6. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.
7. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
8. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
9. 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.

Teaching methodology

Three elements will be combined: theory classes, where the main concepts will be presented; practical classes in the computer room, with emphasis on the computational aspects; lists of problems. Students will work on these problems individually or in pairs.
The main objective is to provide a general perspective of the broad field of computational mechanics, covering both the modelling and the computational aspects. A broad range of problems is addressed: solids, fluids and fluid-solid interaction; linear and nonlinear models; static and dynamic problems. By the end of the course, the students should:

- Be able to choose the appropriate type of model for a specific simulation
- Be familiar with the mathematical objects (mainly tensors) used in computational mechanics
- Be aware of the different level of complexity of various problems (e.g. linear vs. nonlinear, static vs. dynamic).

### Content

#### CONTINUUM MECHANICS

**Learning time:** 31h 15m

- Theory classes: 8h
- Practical classes: 2h
- Self study: 21h 15m

**Description:**

#### COMPUTATIONAL ELASTICITY

**Learning time:** 31h 15m

- Theory classes: 8h
- Practical classes: 2h
- Self study: 21h 15m

**Description:**

### Study load

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<thead>
<tr>
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</table>
### 34959 - CM - Computational Mechanics

<table>
<thead>
<tr>
<th>Course</th>
<th>Learning time: 31h 15m</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COMPUTATIONAL PLASTICITY</strong></td>
<td></td>
<td>Basic concepts and motivation. One-dimensional plasticity: elastic and plastic strains; elastoplastic constitutive equation; hardening. Multi-dimensional plasticity: stress and strain invariants; yield surface; plastic flow. Numerical time-integration of the constitutive equation: elastic prediction and plastic correction; iterative methods for the plastic correction. Applications.</td>
</tr>
<tr>
<td><strong>COMPUTATIONAL DYNAMICS</strong></td>
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</tr>
</tbody>
</table>

**Theory classes**: 8h  
**Practical classes**: 2h  
**Self study**: 21h 15m
34959 - CM - Computational Mechanics

Qualification system

Exam and assigned problems.

Bibliography

Basic:


Complementary:


34966 - VD - Differentiable Manifolds

**Coordinating unit:** 200 - FME - Faculty of Mathematics and Statistics

**Teaching unit:** 743 - MA IV - Department of Applied Mathematics IV

**Academic year:** 2011

**Degree:** MASTER IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010).
(Teaching unit Optative)

**ECTS credits:** 7.5

**Teaching languages:** English

### Teaching staff

**Coordinator:** FRANCESC XAVIER GRACIA SABATE

**Others:** FRANCESC XAVIER GRACIA SABATE - A
          MIGUEL CARLOS MUÑOZ LECANDA - A

### Prior skills

Calculus on manifolds.
Tangent and cotangent bundles. Differential forms and vector fields.
Elementary geometric mechanics.

### Degree competences to which the subject contributes

**Specific:**
1. **RESEARCH.** Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
2. **CALCULUS.** Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
3. **CRITICAL ASSESSMENT.** Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.

**General:**
4. **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.
5. **EFFICIENT ORAL AND WRITTEN COMMUNICATION.** Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.
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8. **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.
34966 - VD - Differentiable Manifolds

**Teaching methodology**

Theory classes will be used to present and develop the contents of the course. Most of the topics will be presented by the instructors, but there can be some sessions devoted to student's presentations. There will be lists of problems, which will not contain solutions. Problems will be designed to help students deepen and mature their command of the concepts and techniques presented in class. Some problems will be solved in the class; some will be left as homework. Some of the problems solved in class will be presented by the students.

**Learning objectives of the subject**

The subject focuses on the fundamental topics used in differential geometry and applications in different areas. By the end of the course, students should:
- Be able to understand all the ideas developed along the course.
- Be able to apply the studied concepts to other areas such as theoretical mechanics, control theory, mathematical physics or geometric dynamical systems.
- Be able to enter a research group on these kinds of topics and their applications.
- Be able to search the bibliography, and to understand the scientific literature on the subject.
- Be aware of the wide range of fields and problems to which differential geometry results can be applied.

**Study load**

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</table>

**Content**

**Vector bundles and de Rham cohomology**

- **Learning time:** 37h 30m
- Theory classes: 10h
- Practical classes: 2h
- Self study: 25h 30m

**Tangent distributions and Fröbenius theorem**

- **Learning time:** 37h 30m
- Theory classes: 10h
- Practical classes: 2h
- Self study: 25h 30m

**Lie groups and algebras**

- **Learning time:** 37h 30m
- Theory classes: 10h
- Practical classes: 2h
- Self study: 25h 30m
In general, it will include an exam as well as class presentations. In the case of a small group, the exam may be replaced by personal work. In particular, presentations of parts of the different subjects or solved problems as well as scientific research are considered as possible alternatives to the exam.

**Qualification system**

**Bibliography**

**Basic:**


34956 - DG - Discrete and Algorithmic Geometry

Coordinating unit: 200 - FME - Faculty of Mathematics and Statistics
Teaching unit: 726 - MA II - Department of Applied Mathematics II
Academic year: 2011
Degree: MASTER IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010).
(Teaching unit Optative)
ECTS credits: 7,5  Teaching languages: English

Teaching staff

Coordinator: VERA SACRISTAN ADINOLFI
Others:
JULIAN PFEIFLE - A
VERA SACRISTAN ADINOLFI - A

Prior skills

- Elementary combinatorics.
- Elementary graph theory.
- Elementary algorithmics.
- Elementary data structures.

Degree competences to which the subject contributes

Specific:
1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
2. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
3. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.

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34956 - DG - Discrete and Algorithmic Geometry

Teaching methodology

Theory classes will be used to present and develop the contents of the course. Most of the topics will be presented by the instructors, but there can be some sessions devoted to students presentations.

There will be lists of problems, which will not contain solutions. Problems will be designed to help students deepen and mature their command of the concepts and techniques presented in class. Some problems will be solved in class, some will be left as homework. In the problem sessions, the goal will be to propose and analyze alternative strategies to solve each problem, and to show how the results presented in class are applied. Most of the problems solved in class will be presented by the students.

Learning objectives of the subject

Discrete, combinatorial and computational geometry are facets of a common body of knowledge that integrates fundamental elements from mathematics -mainly from algebra, topology and classical branches of geometry- with elements and problems from theoretical computer science and its applications.

The area focuses on the combinatorial and structural study of discrete geometric objects, as well as the design of algorithms to construct or analyze them. Among the objects studied, we can mention discrete sets of points, curves and manifolds, polytopes, convex bodies, packings, space decompositions, graphs, and geometric matroids.

By the end of the course, students should:
- Be able to recognize and formally express discrete geometric problems.
- Be able to discretize geometric problems, when possible.
- Be able to apply combinatorial techniques, as well as data structures and algorithms to discrete geometric problems.
- Be able to search the bibliography, and to understand the scientific literature on the subject.
- Be aware of the wide range of fields and problems to which discrete geometry results apply.
- Be aware of the most commonly used software in the field.

Study load

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</table>

Content

Preliminaries

Learning time: 12h 30m
- Theory classes: 4h
- Self study: 8h 30m

Description:
Computational complexity. Data structures. Representation of geometric objects.
### Convexity

**Description:**
Convex hull computation. Linear programming in low dimensions.

**Learning time:** 19h
- Theory classes: 4h
- Practical classes: 2h
- Self study: 13h

### Decompositions and arrangements

**Description:**

**Learning time:** 31h
- Theory classes: 7h
- Practical classes: 3h
- Self study: 21h

### Proximity Structures

**Description:**
Proximity problems. Voronoi diagram, Delaunay triangulation. Shape reconstruction.

**Learning time:** 31h
- Theory classes: 7h
- Practical classes: 3h
- Self study: 21h

### Discrete geometry in arbitrary dimension

**Description:**

**Learning time:** 37h
- Theory classes: 8h
- Practical classes: 4h
- Self study: 25h
# Nonlinear discrete geometry

**Learning time:** 37h  
- Theory classes: 8h  
- Practical classes: 4h  
- Self study : 25h

**Description:**  
Positive semidefinite quadratic forms and sphere packings; Voronoi reductions; Delaunay subdivisions. Splines regarded as toric varieties; splines with linear precision in reconstructing functions.

## Applications

**Learning time:** 11h  
- Theory classes: 4h  
- Self study : 7h

**Description:**  
GPS, GIS, structural rigidity and tensegrities; computational astrophysics, algorithmic chemistry; other applications.

## Software

**Learning time:** 9h  
- Laboratory classes: 2h  
- Self study : 7h

**Description:**  
STL, CGAL, polymake, ANN, curved spaces, etc.

## Qualification system

In general, it will include an exam as well as class presentations. In the case of a small group, the exam may be replaced by personal work.

Nevertheless, the evaluation method may be adapted to the students' background, skills, and interests: programming problems or scientific research are considered as possible alternatives to the exam or the class presentations.
34956 - DG - Discrete and Algorithmic Geometry

Bibliography

Basic:


Others resources:

Audiovisual material


Not knot [Enregistrament vídeo] / directed by Charlie Gunn and Delle Maxwell ; [written by David Epstein ... [et al.]]. Minnesota : Geometry Center, University of Minnesota, 1991

34957 - GT - Graph Theory

Coordinating unit: 200 - FME - Faculty of Mathematics and Statistics
Teaching unit: 743 - MA IV - Department of Applied Mathematics IV
726 - MA II - Department of Applied Mathematics II

Academic year: 2011
Degree: MASTER IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010).
(Teaching unit Optative)
ECTS credits: 7,5  Teaching languages: English

Teaching staff
Coordinator: ORIOL SERRA ALBO
Others:
MIGUEL ANGEL Fiol Mora - A
ANNA LLADO SANCHEZ - A
MARCOS NOY SERRANO - A
ORIOL SERRA ALBO - A

Prior skills
Elementary Calculus and Linear Algebra; basic notions and abilities in combinatorics and probability.

Degree competences to which the subject contributes

Specific:
1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
2. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
3. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.

General:
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Teaching methodology
Sessions of presentation of material alternate with sessions with student presentations of problems and specific topics. The active participation of students is a requirement for the evaluation of the course.
34957 - GT - Graph Theory

Learning objectives of the subject

Application of spectral techniques to the study of graphs.
Application of the probabilistic method.
Properties of almost all graphs.
Properties of Cayley and vertex symmetric graphs.
Graphs on surfaces.
Minors.

Study load

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</tbody>
</table>

Content

Spectral techniques in Graph Theory

Description:

Symmetries in graphs

Minors and treewidth

Graphs on surfaces

Graph homomorphisms

Random graphs
The evaluation of the course is based on the weekly work on problems proposed in the presentation sessions. There will be a final comprehensive exam based on the problem sessions during the course.

Qualification system

The active participation in the course is a requirement for the evaluation of the final exam.

Bibliography

Basic:


34962 - HS - Hamiltonian Systems

Coordinating unit: 200 - FME - Faculty of Mathematics and Statistics
Teaching unit: 725 - MA I - Department of Applied Mathematics I
Academic year: 2011
Degree: MASTER IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010).
( Teaching unit Optative)
ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: AMADEU DELSHAMS I VALDES
Others: AMADEU DELSHAMS I VALDES - A

Prior skills

Knowledge of calculus, algebra and ordinary differential equations.

Degree competences to which the subject contributes

Specific:
1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
2. MODELLING. Formulate, analyse and validate mathematical models of practical problems by using the appropriate mathematical tools.
3. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
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9. 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.
34962 - HS - Hamiltonian Systems

Teaching methodology

Standard exposition in front of the blackboard, resolution of exercises, completion of a project and/or attendance to the winter school RTNS

Learning objectives of the subject

To comprehend the basic foundations of the theory of Hamiltonian systems, and to understand its applications to the Celestial Mechanics and other fields.

Study load

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</table>

Content

**Hamiltonian formalism**

Learning time: 26h

- Theory classes: 4h
- Practical classes: 4h
- Self study: 18h

Description:

Hamiltonian dynamical systems: symplectic maps, symplectic manifolds. Linear Hamiltonian systems and their application to the study of stability of equilibrium points.

**Hamiltonian and Lagrangian systems**

Learning time: 13h

- Theory classes: 2h
- Practical classes: 2h
- Self study: 9h

Description:

### Integrand and quasi-integrable Hamiltonian systems

**Learning time:** 13h  
- Theory classes: 2h  
- Practical classes: 2h  
- Self study: 9h

**Description:**  

### Invariant objects of dynamical systems

**Learning time:** 13h  
- Theory classes: 2h  
- Practical classes: 2h  
- Self study: 9h

**Description:**  
Continuous and discrete dynamical systems, Poincaré map. Local structure of hyperbolic invariant objects: invariant manifolds. Center manifold. Local bifurcations.

### Perturbation theory in dynamical systems

**Learning time:** 13h  
- Theory classes: 2h  
- Practical classes: 2h  
- Self study: 9h

**Description:**  
Classical perturbation theory. Perturbations of homoclinic orbits in the plane: Melnikov method.

### Homoclinic points and chaotic dynamics

**Learning time:** 13h  
- Theory classes: 2h  
- Practical classes: 2h  
- Self study: 9h

**Description:**  
Homoclinic points and bifurcations. Hyperbolic sets and transverse homoclinic points: systems with chaotic dynamics. Newhouse phenomenon.
# 34962 - HS - Hamiltonian Systems

## Normal forms

**Description:**

**Learning time:** 13h
- Theory classes: 2h
- Practical classes: 2h
- Self study: 9h

## Stability of dynamical systems and Hamiltonian systems

**Description:**

**Learning time:** 13h
- Theory classes: 2h
- Practical classes: 2h
- Self study: 9h

## Discrete dynamical systems

**Description:**

**Learning time:** 13h
- Theory classes: 2h
- Practical classes: 2h
- Self study: 9h

## Recent Trends in Nonlinear Science

**Description:**
Smooth Ergodic Theory: Lyapunov exponents, Oseledets' Theorem, nonuniform hyperbolicity.
Delay equations with applications to engineering: delay equations, stability, bifurcations.
Multi-frequency Oscillations in Dynamical Systems.

**Learning time:** 57h 30m
- Theory classes: 20h
- Self study: 37h 30m
34962 - HS - Hamiltonian Systems

Planning of activities

RECENT TRENDS IN NONLINEAR SCIENCE

Description:

Specific objectives:
To learn from outstanding researchers a view of the state of the art in several research topics, interacting with students of the rest of Spain and of the World.

Qualification system

The students have to do some problems and a research work. Moreover, they will attend the RTNS and produce a document about them.

Bibliography

Basic:


Others resources:

Hyperlink

Grup de sistemes dinàmics

https://recerca.upc.edu/sd

pàgina web del Grup de Sistemes Dinàmics de la UPC on es descriuen diversos projectes i els investigadors que hi treballen així com diverses activitats relacionades
### Degree competences to which the subject contributes

**Specific:**
1. **RESEARCH.** Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
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3. **CALCULUS.** Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
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### Prior skills

- Good knowledge of Calculus techniques, including integral theorems and basic Complex Variable methods.
- Elementary solution of PDEs and ODEs.
- Some experience on simple cases of mathematical modelling, especially in classical physics (gravitation, heat conduction, mechanics or electromagnetism).
Teaching methodology

The course is divided into two parts that will run in parallel. One part is a general overview of problems that can be modelled with PDEs and the other part focuses on a particular topic with industrial applications, namely Phase Transitions.

Lectures will contain the main contents of the course, but the students will also be asked to make presentations of additional material. Problem solution will also be asked.

Learning objectives of the subject

The course will provide a general overview on the use of partial differential equations (PDE) and boundary value problems to construct mathematical models of real phenomena. The course will be split into two parts, one section will be more theoretical, covering techniques and basic models. The second will be more applied, building on the theory whilst focusing on a specific, practically important, application of PDEs to phase transition (e.g. ice melting, water evaporating, solidification of steel). This class of problems is of particular interest because it falls into the important field of Moving Boundary Problems, where the solution domain is unknown and must be solved for at the same time as the governing PDEs.

By the end of the course the student should have acquired:

* a knowledge of the problems that can be modelled with PDE's.
* intuitive and physical interpretations of the terms that appear on PDE's.
* a more detailed knowledge of the mathematical models of phase transition and moving boundary problems.
* a more detailed knowledge of the mathematical techniques that are used in the solution of phase transitions problems.

Study load

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Content

1 Modelling with PDEs

Learning time: 93h 45m

- Heat conduction and diffusion.
- Potentials in physics and technology.
- Transients in continuous media
- Populations dynamics.
- Equations of distribution of particles.
34958 - MMPDE - Mathematical Modelling with Partial Differential Equations

**2 Phase Transitions**

**Learning time:** 93h 45m  
- Theory classes: 30h  
- Self study: 63h 45m

**Description:**
- Introduction to phase change problems and exact solutions.  
- Mathematical techniques for phase change and moving boundary problems  
- Integral methods.  
- Approximate solutions methods.  
- Practical applications.

**Qualification system**

Attendance to lectures, presentation of additional materials and problem solving will be the basis of a qualification up to a certain level. A higher mark will require an exam.

**Bibliography**

**Basic:**

**Complementary:**
34960 - MMB - Mathematical Models in Biology

Coordinating unit: 200 - FME - Faculty of Mathematics and Statistics
Teaching unit: 725 - MA I - Department of Applied Mathematics I
726 - MA II - Department of Applied Mathematics II

Academic year: 2011
Degree: MASTER IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010).
(Teaching unit Optative)
ECTS credits: 7,5
Teaching languages: English

Teaching staff

Coordinator: JOAQUIM PUIG SADURNI
Others: JESUS FERNANDEZ SANCHEZ - A
        ANTONI GUILLAMON GRABOLOSA - A
        JOAQUIM PUIG SADURNI - A

Prior skills

* Proficiency in undergraduate mathematics: calculus, algebra, probability and statistics.
* Ability to perform basic operations in linear algebra: eigenvalues and eigenvectors, computation of determinants, rank of matrices...
* Ability to analyze and solve linear differential equations and discuss the stability of simple vector fields.
* Interest towards biological applications of mathematics and/or previous working experience.

Requirements

* Basic knowledge of undergraduate mathematics: calculus, ordinary differential equations, linear algebra, probability and statistics.
* First course in ordinary differential equations: linear differential equations, qualitative and stability theory and numerical simulation.
* Basic knowledge of computer programming for scientific purposes.
* Courses and all the bibliography will be in English.

Degree competences to which the subject contributes

Specific:
1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
2. MODELLING. Formulate, analyse and validate mathematical models of practical problems by using the appropriate mathematical tools.
3. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
4. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.

Generic:
5. 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.
6. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning
34960 - MMB - Mathematical Models in Biology

This course is an introduction to the most common mathematical models in biology: in populations dynamics, ecology, physiology, sequence analysis and phylogenetics. At the end of the course the student should be able to:

* Understand and discuss basic models of dynamical systems of biological origin, in terms of the parameters.
* Model simple phenomena, analyze them (numerically and/or analytically) and understand the effect of parameters.
* Understand the diversity of mechanisms and the different levels of modelization of physiological activity.
* Obtain and analyze genomic sequences of real biological species and databases containing them.
* Use computer software for gene prediction, alignment and phylogenetic reconstruction.
* Compare the predictions given by the models with real data.
* Communicate results in interdisciplinary teams.

**Learning objectives of the subject**

This course is an introduction to the most common mathematical models in biology: in populations dynamics, ecology, physiology, sequence analysis and phylogenetics. At the end of the course the student should be able to:

* Understand and discuss basic models of dynamical systems of biological origin, in terms of the parameters.
* Model simple phenomena, analyze them (numerically and/or analytically) and understand the effect of parameters.
* Understand the diversity of mechanisms and the different levels of modelization of physiological activity.
* Obtain and analyze genomic sequences of real biological species and databases containing them.
* Use computer software for gene prediction, alignment and phylogenetic reconstruction.
* Compare the predictions given by the models with real data.
* Communicate results in interdisciplinary teams.

**Teaching methodology**

The course will consist of lectures, problem sessions and practical computer sessions. Lectures will consist of expositions about the contents of this subject following a biological problem.

Both practical sessions and problem sessions will be in a PC room and will help the student to develop part of the subject with extensions to the lectures, practical problems with real or simulated data and algorithms to perform these operations. The SAGE computing environment will be used, with interfaces to Python, R and C if necessary.

**Learning objectives of the subject**

This course is an introduction to the most common mathematical models in biology: in populations dynamics, ecology, physiology, sequence analysis and phylogenetics. At the end of the course the student should be able to:

* Understand and discuss basic models of dynamical systems of biological origin, in terms of the parameters.
* Model simple phenomena, analyze them (numerically and/or analytically) and understand the effect of parameters.
* Understand the diversity of mechanisms and the different levels of modelization of physiological activity.
* Obtain and analyze genomic sequences of real biological species and databases containing them.
* Use computer software for gene prediction, alignment and phylogenetic reconstruction.
* Compare the predictions given by the models with real data.
* Communicate results in interdisciplinary teams.

**Study load**

<table>
<thead>
<tr>
<th>Total learning time: 187h 30m</th>
<th>Self study: 127h 30m</th>
<th>Theory classes: 60h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>68.00%</td>
<td>32.00%</td>
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</tbody>
</table>

**Content**
# 34960 - MMB - Mathematical Models in Biology

## Models of Population Dynamics

<table>
<thead>
<tr>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Differential equations models. Stability and Bifurcations. Applications to population dynamics.</td>
</tr>
<tr>
<td>2. One-dimensional discrete models. Chaos in biological systems.</td>
</tr>
<tr>
<td>3. Introduction to stochastic models. Branching processes</td>
</tr>
<tr>
<td>4. Simulation with SAGE</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Learning time:</th>
</tr>
</thead>
<tbody>
<tr>
<td>56h 20m</td>
</tr>
<tr>
<td>Theory classes: 9h</td>
</tr>
<tr>
<td>Practical classes: 9h</td>
</tr>
<tr>
<td>Self study : 38h 20m</td>
</tr>
</tbody>
</table>

## Mathematical models in Genomics

<table>
<thead>
<tr>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Brief introduction to genomics (genome, gen structure, genetic code...). Genome databases online.</td>
</tr>
<tr>
<td>4. Multiple sequence alignment: dynamical programming, tropical arithmetics and Pair-HMMs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Learning time:</th>
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</thead>
<tbody>
<tr>
<td>62h 30m</td>
</tr>
<tr>
<td>Theory classes: 12h</td>
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<tr>
<td>Practical classes: 8h</td>
</tr>
<tr>
<td>Self study : 42h 30m</td>
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</table>

## Mathematical Models in Physiology

<table>
<thead>
<tr>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Enzymatic reactions and Michaelis-Menten theory.</td>
</tr>
<tr>
<td>3. Pancreatic Beta cells and bursting models.</td>
</tr>
<tr>
<td>4. Models in systems physiology: hormone physiology, respiration, cardiac activity.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Learning time:</th>
</tr>
</thead>
<tbody>
<tr>
<td>56h 20m</td>
</tr>
<tr>
<td>Theory classes: 11h</td>
</tr>
<tr>
<td>Practical classes: 7h</td>
</tr>
<tr>
<td>Self study : 38h 20m</td>
</tr>
</tbody>
</table>
The course has three parts and each of these parts will give a part of the qualification, based on practical problems to be delivered. Besides, students will be asked to write a report on a specialized subject (from a list of suggested topics) and deliver it 2 days before presenting it in front of the students and teachers. The contents and the clarity of explanations and exposition.

The final qualification will be given by the formula $0.6 \times NP + 0.4 \times NT$ where:

- $NP = NP1 + NP2 + NP3$ practice qualification: this is the qualification of 3 practical qualifications.
- $NT =$ report qualification.

### Qualification system

#### Biological networks

<table>
<thead>
<tr>
<th>Biological networks</th>
<th>Learning time: 12h 20m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 3h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 1h</td>
</tr>
<tr>
<td></td>
<td>Self study : 8h 20m</td>
</tr>
</tbody>
</table>

#### Description:

3. Firing rate models and mean field techniques in cell networks.
Bibliography

Basic:


Complementary:


34953 - NT - Number Theory

Coordinating unit: 200 - FME - Faculty of Mathematics and Statistics
Teaching unit: 726 - MA II - Department of Applied Mathematics II
743 - MA IV - Department of Applied Mathematics IV

Academic year: 2011
Degree: MASTER IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010).
(Teaching unit Optative)
ECTS credits: 7,5
Teaching languages: English

Teaching staff
Coordinator: JORDI GUARDIA RUBIES
Others: JOSEP GONZALEZ ROVIRA - A
        JORDI GUARDIA RUBIES - A

Prior skills
Basic knowledge of algebraic structures: groups, rings and fields.

Requirements
Basic material covered in any standard course on group theory and Galois theory. Although it is not strictly necessary, any background on algebraic curves, elliptic curves and basic number theory. But the course will be completely self-contained.

Degree competences to which the subject contributes

Specific:
1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
2. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
3. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.

General:
4. 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.
5. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.
6. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
7. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
8. 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.
34953 - NT - Number Theory

Teaching methodology

Most of the lectures will take place on the blackboard, explaining carefully the contents of the course and providing as much explicit examples, exercises and applications as possible. The students will be encouraged to consult suitable references and to discuss between them and with the professor in order to achieve a good understanding of the material.

Learning objectives of the subject

1) Algebraic number theory.
2) Arithmetic of elliptic curves

The material covered in this course interplays with topics of commutative algebra (Dedekind rings, discrete valuation rings and prime ideals), non-commutative algebra (group rings, quaternion algebras, associative algebras) and algebraic geometry (spectrum of a ring, algebraic curves, Riemann surfaces).

Study load

<table>
<thead>
<tr>
<th>Total learning time: 187h 30m</th>
<th>Self study: 127h 30m</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>68.00%</td>
<td>32.00%</td>
</tr>
</tbody>
</table>

Content

Algebraic Number Theory

Learning time: 93h 45m
- Theory classes: 30h
- Self study: 63h 45m

Elliptic Curves

Learning time: 93h 45m
- Theory classes: 30h
- Self study: 63h 45m

Qualification system

There will be no exams. The qualification will be based on:
1) Active participation of the student during the course,
2) Resolution of exercises suggested in class and,
3) Elaboration of a document in which the student develops in more detail and depth some of the material of the course.

Regulations for carrying out activities

Solved exercises and works must be delivered on the last day of the course.
Bibliography

**Basic:**


34964 - NMDS - Numerical Methods for Dynamical Systems

Coordinating unit: 200 - FME - Faculty of Mathematics and Statistics
Teaching unit: 725 - MA I - Department of Applied Mathematics I
Academic year: 2011
Degree: MASTER IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010).
(Teaching unit Optative)
ECTS credits: 7,5  Teaching languages: English

Teaching staff
Coordinator: MERCEDES OLLE TORNER
Others: MERCEDES OLLE TORNER - A

Prior skills
Good knowledge of a programming language.

Requirements
Knowledge of theory of systems of differential equations, algebra, calculus and numerical analysis.

Degree competences to which the subject contributes

Specific:
2. MODELLING. Formulate, analyse and validate mathematical models of practical problems by using the appropriate mathematical tools.
1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
3. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
4. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.

General:
5. 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.
6. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.
7. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
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9. 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.
Teaching methodology

Theoretical sessions (presence of the students is necessary) and weekly practical tutorized assignments.

Learning objectives of the subject

- To reach an advanced formation in using numerical methods applied to dynamical systems
- Carry out numerical simulations of particular examples
- To relate different aspects of the dynamics in order to have a global picture of the behavior of a given problem
- To learn different tools to analyse and deal with a problem
- Ability in programming algorithms designed to solve particular problems in dynamical systems

Study load

<table>
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<td>Theory classes: 60h</td>
<td></td>
<td>32.00%</td>
</tr>
</tbody>
</table>

Content

Numerical (preliminary) tools for practical purposes: integrators for ODE and graphical interfaces. Examples.

Learning time: 4h
- Theory classes: 2h
- Practical classes: 2h


Learning time: 6h
- Theory classes: 3h
- Practical classes: 3h


Learning time: 10h
- Theory classes: 5h
- Practical classes: 5h

Computation and stability of periodic orbits. Implementation, continuation of families, bifurcations. Multiple shooting.

Learning time: 10h
- Theory classes: 5h
- Practical classes: 5h
Computation of tori: representation, computation and continuation. Implementation and examples.  
Learning time: 15h
Theory classes: 7h 30m
Practical classes: 7h 30m

Analysis of bifurcations. Some examples.  
Learning time: 15h
Theory classes: 7h 30m
Practical classes: 7h 30m

Qualification system
100% of the qualification will be obtained from the practical assignments done.

Regulations for carrying out activities
No rules, in principle.

Bibliography

Basic:

Particular articles related to the topics of the course and some notes from suitable web pages.
34965 - NMPDE - Numerical Methods for Partial Differential Equations

Coordinating unit: 200 - FME - Faculty of Mathematics and Statistics
Teaching unit: 727 - MA III - Department of Applied Mathematics III
725 - MA I - Department of Applied Mathematics I

Academic year: 2011
Degree: MASTER IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010).
(Teaching unit Optative)
ECTS credits: 7.5

Teaching languages: English

Teaching staff
Coordinator: MARCO DISCACCIATI
Others: MARCO DISCACCIATI - A

Prior skills
Basics on numerical methods, differential equations and calculus.

Degree competences to which the subject contributes

Specific:
1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
2. MODELLING. Formulate, analyse and validate mathematical models of practical problems by using the appropriate mathematical tools.
3. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
4. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.

General:
5. 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.
6. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.
7. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
8. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
9. 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.

Teaching methodology
Lectures, practical work at computer room, exercises and home works.
Some exercises and home works will involve use of finite element or finite difference basic programs and some coding.
This module presents the fundamentals of classical numerical techniques for linear partial differential equations (PDEs), with application to a wide variety of problems in science, engineering, and other fields.

Learning outcomes are:

*A knowledge and understanding of
- the fundamentals of classical numerical techniques for linear PDEs,
- the derivation of weak forms and their solution,
- why finite elements approximate and converge to the solution of a PDE,
- the basic structure of a finite element code,
- different methods for prescribing boundary conditions,
- how to solve transient problems,
- stability properties for explicit and implicit time integrators
- basics on stabilization techniques for convection dominated problems
* Ability to
- identify the key issues when solving a boundary value problem,
- employ appropriate order polynomials together with appropriate integration rules,
- solve simple boundary value problems by hand,
- analyze the convergence and stability of a numerical scheme,
- use a simple FE or FD computer code to set up and produce results for computational simulation,
- formulate and implement simple key aspects of a FE code,
- check the reliability and accuracy of a computed solution.

### Content

**Overview of partial differential equations**

**Learning time:** 6h
- Theory classes: 2h
- Self study: 4h

**Description:**
Mathematical and physical classification of PDEs. Problems in engineering and applied sciences modeled by PDEs.
### Finite element method for elliptic equations

**Learning time:** 35h  
Theory classes: 5h  
Practical classes: 6h  
Self study: 24h

**Description:**  

### Analysis of the FEM: existence and uniqueness of solution and convergence

**Learning time:** 15h  
Theory classes: 3h  
Practical classes: 2h  
Self study: 10h

**Description:**  

### Implementation of boundary conditions

**Learning time:** 25h  
Theory classes: 4h  
Practical classes: 4h  
Self study: 17h

**Description:**  
Techniques for the implementation of Dirichlet boundary conditions: system transformation, Lagrange multipliers, Nitsche's method, etc.

### Parabolic equation

**Learning time:** 50h 30m  
Theory classes: 6h  
Practical classes: 10h  
Self study: 34h 30m

**Description:**  
# Introduction to stabilization techniques for convection dominated problems

**Description:**
Analysis of the 1D convection-diffusion equation and Peclèt number.
Classical stabilization techniques

**Learning time:** 28h  
- Theory classes: 5h  
- Practical classes: 4h  
- Self study: 19h

---

# Introduction to accuracy assessment and adaptivity

**Description:**
Introduction to error estimation and error bounds. Remeshing and adaptivity strategies

**Learning time:** 28h  
- Theory classes: 5h  
- Practical classes: 4h  
- Self study: 19h

---

## Qualification system

Continuous assessment assignments and end of semester open-book examination.

## Bibliography

### Basic:


### Complementary:

34961 - QQMDS - Quantitative and Qualitative Methods in Dynamical Systems

Coordinating unit: 200 - FME - Faculty of Mathematics and Statistics
Teaching unit: 725 - MA I - Department of Applied Mathematics I
Academic year: 2011
Degree: MASTER IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Teaching unit Optative)
ECTS credits: 7.5

Teaching languages: English

Coordinator: M. TERESA MARTINEZ-SEARA ALONSO
Others: AMADEU DELSHAMS I VALDES - A
M. TERESA MARTINEZ-SEARA ALONSO - A

Opening hours
Timetable: A convenir

Prior skills
Basic knowledge of calculus, algebra and differential equations. Some basic ideas of local dynamical systems.

Degree competences to which the subject contributes

Specific:
1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
2. MODELLING. Formulate, analyse and validate mathematical models of practical problems by using the appropriate mathematical tools.
3. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
4. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.

Generical:
5. 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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9. 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.
Teaching methodology

We don't distinguish theoretical and practical classes. Some results about modern theory in Dynamical systems are presented in class. The main idea is to give basic knowledge and useful tools in the study of a dynamical system from both quantitative and qualitative points of view. We will stress the relation between different kinds of systems and we will mainly focus in the use of perturivatives techniques to study a dynamical system globally.

Learning objectives of the subject

Study load

| Total learning time: 187h 30m | Self study: 127h 30m | 68.00% |
| Theory classes: 60h | 32.00% |

Content

-**Invariant objects in Dynamical Systems**

  **Learning time:** 20h
  Theory classes: 5h
  Practical classes: 5h
  Other activities: 10h

  **Description:**

-**Perturbation theory in Dynamical Systems**

  **Learning time:** 20h
  Theory classes: 5h
  Practical classes: 5h
  Other activities: 10h

  **Description:**
  Classic perturbation theory. Perturbed homoclinic orbits in the plane. Melnikov method.
### Discrete Dynamical Systems

**Learning time:** 20h  
Theory classes: 5h  
Practical classes: 5h  
Other activities: 10h

**Description:**  

---

### Homoclinic points and chaotic Dynamics

**Learning time:** 20h  
Theory classes: 5h  
Practical classes: 5h  
Other activities: 10h

**Description:**  
Homoclinic points and bifurcations. Hyperbolic sets and transversal homoclinic points. Dynamical systems with chaotic dynamics. Newhouse phenomenon.

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### Normal forms

**Learning time:** 20h  
Theory classes: 5h  
Practical classes: 5h  
Other activities: 10h

**Description:**  

---

### Normal forms: its application to stability in Dynamical Systems

**Learning time:** 20h  
Theory classes: 5h  
Practical classes: 5h  
Other activities: 10h

**Description:**  
Qualification system

The students have to do some problems and a research work. On the other hand they will attend the "Jornades d'iniciació als Sistemes dinàmics i les EDP" and produce a document about them.

Regulations for carrying out activities

There are no exams.

Bibliography