Guia Docent

22/23
Facultat de Matemàtiques i Estadística

Master in Advanced Mathematics and Mathematical Engineering

Olga A. Ladyzhenskaya
7/03/1922 – 12/01/2004

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Facultat de Matemàtiques i Estadística

Curs 2022-2023

1922-2004

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
UPC

Facultat de Matemàtiques i Estadística

MÀSTER   MAMME

Sumari

Master's degree in Advanced Mathematics and Mathematical Engineering (MAMME)

The **master's degree in Advanced Mathematics and Mathematical Engineering (MAMME)** (**master's degree website**) is a master's programme in mathematics offered at the School of Mathematics and Statistics (FME).

The courses offered in MAMME allow our students to design their curriculum with two different orientations: a pure mathematics curriculum (oriented to research in fundamental mathematics) or an applied mathematics curriculum (preparing them for applied mathematics research and for interdisciplinary teamwork, in collaboration with engineers, physicists, biologists, economists, etc.).

The curriculum comprises a total of 60 ECTS credits, divided into 45 credits for courses and 15 for the master's thesis. It is intended to be completed in one academic year. In addition, MAMME offers the possibility of enrolling for up to 22.5 ECTS credits in other master's degrees in mathematics or statistics, or in other UPC master's programmes, opening the path for an interdisciplinary curriculum based on selected courses in master's degrees in engineering and applied sciences. See the MAMME focus proposals at http://mamme.masters.upc.edu/en.

GENERAL DETAILS

Duration and start date
One academic year, 60 ECTS credits. Starting September and February

Timetable and delivery
Afternoons. Face-to-face

Fees and grants
Approximate fees for the master's degree, excluding other costs, €1,660 (€4,150 for non-EU residents).
More information about fees and payment options
More information about grants and loans

Language of instruction
English

Information on language use in the classroom and students' language rights.

Location

School of Mathematics and Statistics (FME)

Official degree
Recorded in the Ministry of Education's degree register

ADMISSION

General requirements
Academic requirements for admission to master's degrees

Specific requirements

This master's degree is aimed at students with good abstract reasoning, an interest in problem solving, strong work habits and a liking for mathematics.

A scientific background is required, with basic mathematical foundations. For this reason, a bachelor's degree in mathematics, statistics, physics, engineering, economics or science is recommended. This list is non-exhaustive, and all applications will be reviewed on an individual basis.

Admission criteria

The following elements will be taken into consideration during the evaluation process: the academic record, the CV, a statement of purpose and, if deemed necessary, a personal interview and recommendation letters.

Places
33

Pre-enrolment
Pre-enrolment period open.
Expected deadline: 30/11/2022.

How to pre-enrol

Enrolment
How to enrol

Legalisation of foreign documents
All documents issued in non-EU countries must be legalised and bear the corresponding apostille.

DOUBLE-DEGREE AGREEMENTS

Double-degree pathways with universities around the world
- Master's degree in Advanced Mathematics and Mathematical Engineering (FME) + Master of Science in Applied Mathematics (Illinois Institute of Technology). (Only FME students to Illinois, not vice versa.)

PROFESSIONAL OPPORTUNITIES

Professional opportunities

Some of the career prospects of master's degree graduates are academic research (by pursuing a PhD in mathematics, science or engineering, for instance), mathematical modelling in industry, finance, statistics and applied research (biomedical research centres, computer vision, etc.).

Competencies

Generic competencies

Generic competencies are the skills that graduates acquire regardless of the specific course or field of study. The generic competencies established by the UPC are capacity for innovation and entrepreneurship, sustainability and social commitment, knowledge of a foreign language (preferably English), teamwork and proper use of information resources.

Specific competencies

On completing this master's degree, students will be able to:

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.

5. (Teaching). Teach mathematics at university level.

ORGANISATION: ACADEMIC CALENDAR AND REGULATIONS

UPC school
School of Mathematics and Statistics (FME)

Academic coordinator
Juan José Rue Perna

Academic calendar
General academic calendar for bachelor's, master's and doctoral degrees courses

Academic regulations
Academic regulations for master's degree courses at the UPC

CURRICULUM

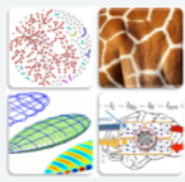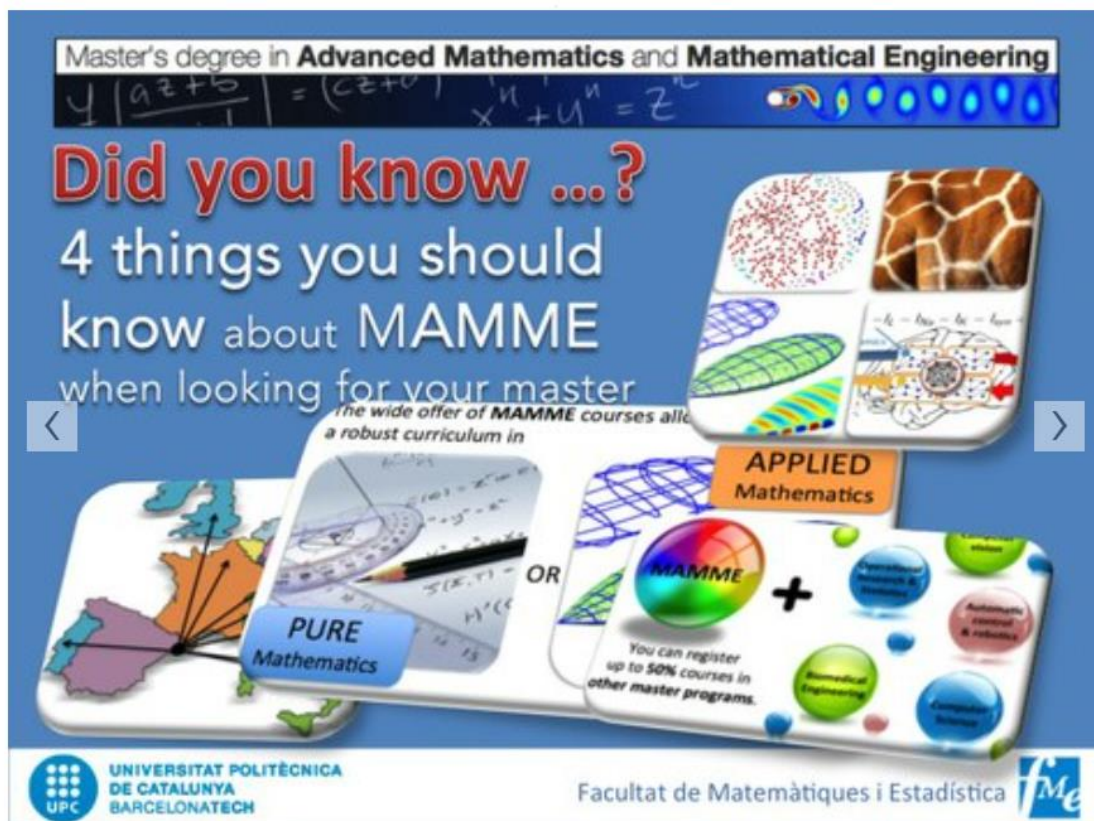| Subjects	ECTS credits	Type
FIRST SEMESTER		
Commutative Algebra	7.5	Optional
Discrete and Algorithmic Geometry	7.5	Optional
Graph Theory	7.5	Optional
Mathematical Modelling with Partial Differential Equations	7.5	Optional
Mathematical Models in Biology	7.5	Optional
Non-Commutative Algebra	7.5	Optional
Number Theory	7.5	Optional
Numerical Methods for Dynamical Systems	7.5	Optional
Numerical Methods for Partial Differential Equations	7.5	Optional
Quantitative and Qualitative Methods in Dynamical Systems	7.5	Optional
SECOND SEMESTER		
Advanced Course in Partial Differential Equations	7.5	Optional
Algebraic Geometry	7.5	Optional
Codes and Cryptography	7.5	Optional
Combinatorics	7.5	Optional
Computational Mechanics	7.5	Optional
Differentiable Manifolds	7.5	Optional
Hamiltonian Systems	7.5	Optional
Machine Learning	7.5	Optional
Seminar on Algebra, Geometry and Discrete Mathematics	3	Optional
Seminar on Analysis, Differential Equations and Modelling	3	Optional

General Information

Wellcome to the web page of the **master in Advanced Mathematics and Mathematical Engineering** (MAMME) offered by **Facultat de Matemàtiques i Estadística** (FME), UPC Barcelona-Tech.

COURSES
45 ECTS

master THESIS
15 ECTS

Study program

Focus proposals

Contact & Locatio

Admissions for academic year 2021/22 are now closed. Here you can find the list of accepted and non-accepted candidates

Admissions for academic year 2022/23 will open during the first quarter 2022

MAMME we are working joint with ENSIMAG-Grenoble to propose a double master degree. Information to be updated soon.

Study Program

The master in Advanced Mathematics and Mathematical Engineering (MAMME) is a 60 ECTS (European Credit transfer System) official master program. It is intended to be completed in one academic year, with 45 ECTS in courses and a master thesis (15 ECTS).

The courses offered in MAMME allow our students to design their curriculum, with two different orientations:

- a **pure mathematics curriculum**, oriented to research in fundamental mathematics, or
- an **applied mathematics curriculum**, preparing them for applied mathematics research and for interdisciplinary team working, in collaboration with engineers, physicists, biologists, economists, etc.

In addition, MAMME offers the possibility of registering **up to 22.5 ECTS in other master programs,** such as the master in Statistics and Operations Research (MESIO UPC-UB), or the master in Advanced Mathematics offered by Universitat de Barcelona (UB), or other UPC master programs, opening the path for an interdisciplinary curriculum based on selected courses in masters in engineering and applied sciences. See the MAMME focus proposals.

A **minimum of 22.5 ECTS in MAMME** courses (3 courses) is mandatory. Registration to non-MAMME courses requires the approval of the director of MAMME and of the director of the other master.

A tutor is assigned to each student, to provide academic guidance for the selection of courses (according to the student background and interests) and for the proposal of the master thesis topic.

MAMME courses are offered in five broad fields: Algebra and Geometry, Discrete Mathematics and Algorithmics, Modelling in Engineering and Biomedical Sciences, Differential Equations, and Scientific Computing.
The following courses (7.5 ECTS each) are offered.

Field: Algebra and Geometry
Commutative Algebra ⊡ (Autumn term Q1)
Algebraic Geometry (Spring term Q2)
Differentiable Manifolds (Spring term Q2)
Number Theory ⊡ (Autumn term Q1)
Non-Commutative Algebra (Autumn term Q1)
Field: Discrete Mathematics and Algorithmics
Codes and Cryptography ⊡ (Spring term Q2)
Combinatorics ⊡ (Spring term Q2)
Discrete and Algorithmic Geometry ⊡ (Autumn term Q1)
Graph Theory ⊡ (Autumn term Q1)

Field: Modelling in Engineering and Biomedical Sciences
Mathematical Modelling with Partial Differential Equations ⊡ (Autumn term Q1)
Computational Mechanics ⊡ (Spring term Q2)
Mathematical Models in Biology ⊡ (Autumn term Q1)
Field: Differential Equations
Quantitative and Qualitative Methods in Dynamical Systems ⊡ (Autumn term Q1)
Hamiltonian Systems ⊡ (Spring term Q2)
Advanced course in Partial Differential Equations ⊡ (Spring term Q2)
Field: Scientific Computing
Numerical Methods for Dynamical Systems ⊡ (Autumn term Q1)
Numerical Methods for Partial Differential Equations ⊡ (Autumn term Q1)
Machine Learning (Spring term Q2)
Interdisciplinary seminars (3 ECTS each seminar)
Seminar on algebra, geometry and discrete mathematics (Spring term Q2)
Seminar on analysis, differential equations and modelling (Spring term Q2)

Mobility and double degrees

MAMME offers several possibilities for mobility.

Erasmus mobility

MAMME allows mobility under the Erasmus program, usually during the Spring semester (Q2).

Students may do courses at the host institution, provided they have passed a minimum of 22.5 ECTS in MAMME courses.

There are two options for the master thesis:

1. Erasmus+ studies: only for the institutions in http://fme.upc.edu/ca/estudis/mobilitat/socrates-erasmus#erasmus. For Erasmus fellowships, eligible students must register 30 ECTS (usually 15 ECTS in courses + master thesis). You should previously check if the potential receiving institution allows the registration of the master thesis for Erasmus students.
2. Erasmus+ training: only master thesis, no courses. An agreement can be done with any institution, even when it is not appearing in the previous list.

Applications for spring semester: at https://esecretaria.upc.edu/, please check deadlines at http://www.fme.upc.edu/ca/estudis/mobilitat.

MAMME-ENSIMAG master's double degree
MAMME students will be able to do a joint master double degree with ENSiMAG, Grenoble:

https://ensimag.grenoble-inp.fr/

Information to be posted soon.

MAMME-IIT master's double degree

MAMME students may apply to the Illinois Institute of Technology (IIT, USA) master of Science offered by the Department of Applied Mathematics of 32 credit hours (equivalent to 62 ECTS), see https://science.iit.edu/programs/graduate/master-science-applied-mathematics

2 students per year are selected and nominated by FME-UPC.

Study plan:

- 1st Fall semester at FME-UPC: 30 ECTS in MAMME courses (equivalent to 9 credit hours)
- Spring semester at IIT: 9 credit hours
- Summer at IIT: 5 credit hours (thesis)
- Fall semester at IIT: 9 credit hours, including the master's thesis defense.

Complete 2 core sequences of 4 possibilities: computational (Math 577 and 578), Discrete (Math 553 and 554, and Math 554 prior at FME), Stochastics (Math 540, and 543 or 544 or 545, and Math 540 prior at FME)

Note that students are eligible for transfer credit of 9 credit hours (3 courses) in the IIT master's degree, reducing the total cost from 32 to 23 credit hours. For transfer credit the courses Math 554 (which requires 553), Math 540 and Math 500 should be completed and successfully passed at FME during the 1st semester.

Requirements:

- 270 ECTS at FME-UPC (240 at bachelor level + 30 at MAMME)
- TOEFL >= 90 iBT   or   IELTS>=6.5
- GRE general score of 304 (combined Verbal & Quantitative sections)
- 2.5 out of 6 in the Analytical section for the Department of Applied Mathematics
- 2 letters of recommendation from FME-UPC faculty

Tuition and Fees: see http://web.iit.edu/financial-aid/tuition-fees-and-costs

As an example, the cost for August 2015-May 2016 per credit hour is 1.313$. The final cost with the transfer credit IIT scholarship is 22.321$.

IIT application deadline: October

MAMME master's thesis at IIT

Illinois Institute of Technology (IIT, USA) agrees to consider accepting academically qualified students from FME-UPC who have completed 270 ECTS as Visiting Research Scholars, to do research in the field of Applied Mathematics up to 6 months.

Requirements:

- 270 ECTS at FME-UPC (240 at bachelor level + 30 at MAMME)
- proof of English language proficiency, intermediate level
- 2 letters of recommendation from FME-UPC faculty
- Identification of 2 professors at IIT to work with in the area of research

Tuition and fees: 2 research credits per semester, 1 research credit during summer. See costs at http://web.iit.edu/financial-aid/tuition-fees-and-costs

IIT application deadline: November

Focus Proposals

The following is a **NON-EXHAUSTIVE** list of focus proposals that may be considered for the selection of courses in MAMME, including both MAMME courses and courses in other master programs. They are **just examples** for selection of courses, and they will not be mentioned in the master's degree certificate. Students are encouraged to design their own curriculum with total freedom.

In any case, recall that a minimum of 22.5 ECTS in MAMME courses is mandatory. Registration in non-MAMME courses requires the approval of the director of MAMME and of the director of the other master.
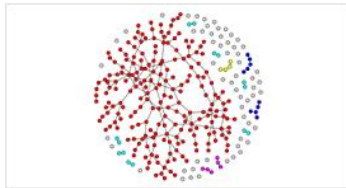
Discrete Mathematics

Partial Differential Equations and Analysis
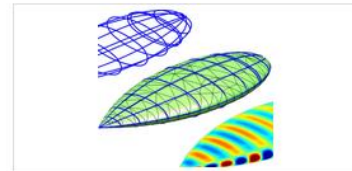
Mathematical and Computational Modelling

Optimization and Operation Research
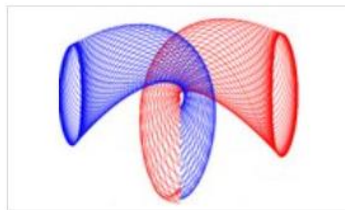
Dynamical Systems and Applications to Celestial Mechanics

Algebra, Geometry and Number Theory
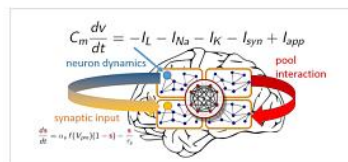
Modelling and analysis in Biomedical Science
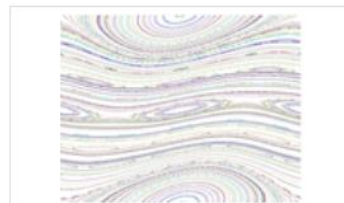
Geometry and its applications

Focus on Discrete Mathematics

Discrete Mathematics has had a strong development from the second half of the XXth century fostered by the development of computers and communication technologies. The main topics include algorithms, coding theory, combinatorics, cryptography, discrete and computational geometry, finite geometry, game theory, graph theory, logic, operation research an random structures. Besides the wealth of problems which have become central in the development of contemporary mathematics, discrete mathematics holds a strong connection with applications in Bioinformatics, Computer Graphics, Information Theory, Networks or Theoretical Computer Science, as well as with other areas of mathematics like Algebra, Analysis, Number Theory or Topology.

The UPC gathers one of the strongest research groups in Spain in the area with a broad international projection providing a sound training. Most of the former students of the master have found job opportunities in industry and in academics by pursuing a PhD in UPC or in prestigious universities in Europe, the USA or Canada.
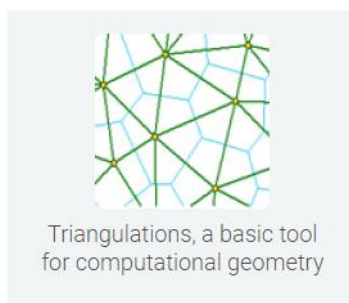

Random graphs, the basic model for random structures

Triangulations, a basic tool for computational geometry

Cryptography, one of the key applications of discrete mathematics
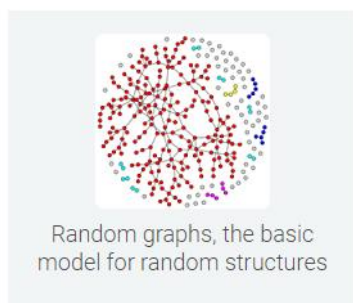
Students interested in focusing on Discrete Mathematics are invited to select 45 ECTS from this list:

Combinatorics	7.5 ECTS	English	MAMME
Graph Theory	7.5 ECTS	English	MAMME
Codes an Cryptography	7.5 ECTS	English	MAMME
Discrete and Algorithmic Geometry	7.5 ECTS	English	MAMME
Optimización Entera y Combinatoria	5 ECTS	Spanish	Máster Univ. en Estadística e Investigación Operativa, UPC-UB
Algorithmic Methods for Mathematical Models	6 ECTS	English	Master in Innovation and Research in Informatics, UPC
Computational Complexity	6 ECTS	English	Master in Innovation and Research in Informatics, UPC
Combinatorial Set Theory	6 ECTS	English	Master in Pure and Applied Logic, UB-UPC

Registration to non-MAMME courses requires the approval of the director of the corresponding master program.

Recall that a minimum of 3 MAMME courses (22.5 ECTS) is mandatory.

Focus on Partial Differential Equations and Analysis

Partial Differential Equations (PDEs) play a central role in physics, chemistry, biology, industry, mathematical finance, and image processing. Their analysis often requires deep mathematical techniques, which makes PDEs to at the heart of both historical and recent developments in analysis, geometry, and probability. Because of this and their applications, PDEs is a very active area of mathematics, the one with the largest number of publications.

Pattern formation with reaction-diffusion systems of PDEs

Free boundaries and PDEs: the Stefan problem for melting ice

Lévy flights and PDEs in finance, biological invasions...

Students interested in focusing on PDEs and Analysis are invited to select 45 ECTS from this list and the suggestions below:

Advanced course in PDEs	7.5 ECTS	English	MAMME
Mathematical Modeling with PDEs	7.5 ECTS	English	MAMME
Numerical Methods for PDEs	7.5 ECTS	English	MAMME
Stochastic Calculus	6 ECTS	English	Master in Advanced Mathematics, UB
Complex Analysis	6 ECTS	English	Master in Advanced Mathematics, UB

A minimum of 3 MAMME courses (22.5 ECTS) is mandatory.

Other appropriate courses (depending on the student interests) with connections to PDEs are:
Quantitative and Qualitative Methods in Dynamical Systems (Q1 MAMME), Hamiltonian Systems (Q2 MAMME), and courses within the Barcelona universities masters offer in Mathematical Finance, Mathematical Biology, Image Processing, Functional Analysis, or Differential Geometry.

Focus on Mathematical and Computational Modelling with PDEs

Mathematical and computational modelling with Partial Differential Equations (PDEs) is nowadays an essential tool for analysing, understanding and predicting phenomena in physics, biology, engineering, economics, social sciences and related fields. The applications cover a wide spectrum ranging from the modelling of the aerodynamical behaviour of an airfoil, to the simulation of the impact of a tsunami in a coastal area, or the study of fracture in epithelial cell sheets.

Hydraulic fracture during epithelial stretching

Flow past a cilindre. Numerical solution of Navier-Stokes eq.

Mesh for 3D Finite Element computations
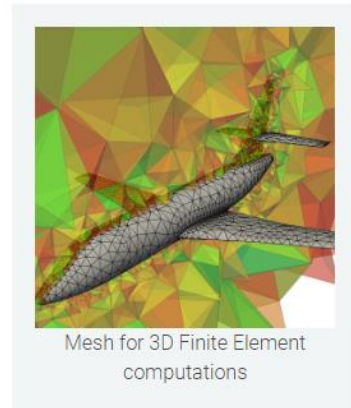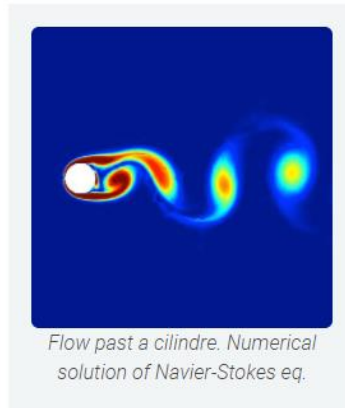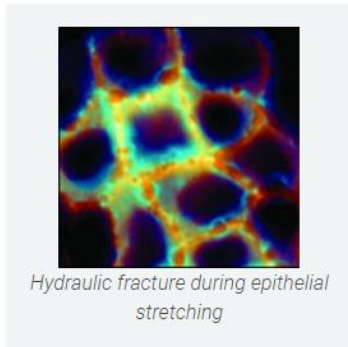
Students interested in focusing on modeling with PDEs are invited to select 45 ECTS from this list:

Mathematical Modelling with PDEs	7.5 ECTS	English	MAMME
Numerical Methods for PDEs	7.5 ECTS	English	MAMME
Computational Mechanics	7.5 ECTS	English	MAMME
Advanced Course in PDEs	7.5 ECTS	English	MAMME
Advanced Fluid Mechanics**	5 ECTS	English	Master in Numerical Methods in Engineering, UPC
Finite Elements in Fluids**	5 ECTS	English	Master in Numerical Methods in Engineering, UPC
Advanced Discretization Methods**	5 ECTS	English	Master in Numerical Methods in Engineering, UPC
Numerical Modelling*	9 ECTS	English	Master en Enginyeria de Camins, Canals i Ports, UPC

Recall that a minimum of 3 MAMME courses (22.5 ECTS) is mandatory.

(*) "Numerical Modeling" is recommended to students that do not have a solid background in numerical methods and programming. Registration to this course requires the approval of the director of the corresponding master.

(**) These courses are proposed to students willing to get a deeper focus on numerical methods for PDEs and their applications.

Focus on Optimization and Operation Research for Efficient Decision Making

Efficient decision making based on quantitative results is essential for success in business and management. Operations Research (also known as "Management Sciences" or "Analytics") is a discipline that deals with the application of advanced analytical methods to help make better decisions. Project planning, network optimization, facility location, routing, supply chain management, scheduling, among others, are real problems tackled by Operation Research. Industrial sectors that benefit from Operation Research range from airlines (scheduling, tariff policy), to hospitals (scheduling), to electric utilities (production, trading) and logistics (route scheduling).

Travelling salesman problem solution

Traffic simulation system

Students interested in focusing on Optimization and Operation Research should select 45 ECTS from this list:

Continuous Optimization	5 ECTS	Spanish	MESIO UPC-UB
Optimization in Energy Systems and Markets	5 ECTS	Spanish	MESIO UPC-UB
Stochastic Optimization	5 ECTS	English	MESIO UPC-UB
Large Scale Optimization	5 ECTS	English	MESIO UPC-UB
Integer and Combinatorial Optimization*	5 ECTS	Spanish	MESIO UPC-UB
Statistical Data Protection*	5 ECTS	English	MESIO UPC-UB
Graph Theory*	7.5 ECTS	English	MAMME
Combinatorics*	7.5 ECTS	English	MAMME
Mathematical Models in Biology	7.5 ECTS	English	MAMME
Numerical Methods for Dynamical Systems	7.5 ECTS	English	MAMME
Numerical Methods for Partial Differential Equations	7.5 ECTS	English	MAMME

Recall that a minimum of 3 MAMME courses (22.5 ECTS) is mandatory.

(*) These courses are proposed to students willing to get a deeper focus on discrete and combinatorial optimization.

Focus on Dynamical Systems and Applications to Celestial Mechanics

Dynamical Systems provide a powerful mathematical background to explore a great variety of models involving natural and social sciences, physics, chemistry, ecology, conomics, neuroscience, astrodynamics among other fields. As a consequence Dynamical Systems theory has become an important and attractive branch of mathematics to students in many disciplines.

The courses proposed below aim at adquiring a basic and transversal knowledge of both the theory of Dynamical Systems as well as computational tools. Along the courses several applications are considered (see the course on 'Mathematical methods in Biology') but special emphasis is focused on Celestial Mechanics.

Other complementary courses from the Master at the Universitat de Barcelona are also given.

Qualitative and quantitative methods in dynamical systems	7.5 ECTS	English	MAMME
Numerical methods for dynamical systems	7.5 ECTS	English	MAMME
Hamiltonian systems	7.5 ECTS	English	MAMME
Mathematical models in biology	7.5 ECTS	English	MAMME
Advanced course in partial differential equations	7.5 ECTS	English	MAMME
Dynamical systems	6 ECTS	English	Master's degree in advanced and professional mathematics (UB)
Simulation methods	6 ECTS	English	Master's degree in advanced and professional mathematics (UB)

Focus on Algebra, Geometry and Number Theory

Mathematics departments at UPC gather several research groups specialized in Number Theory, Algebraic Geometry, Differential Geometry and commutative and non-commutative Algebra. All of them collaborate closely with other researchers of the Universitat de Barcelona and the Universitat Autònoma de Barcelona, and with research groups of some of the most prestigious universities around the world. Many young researchers began their scientific careers by coursing the Master and/or doing the PhD in one of the UPC groups: Ariadna, Biel, Carlos, Enrique, Francesc, Francesc, Marc, María, Martí, Pere-Daniel, Santi, Víctor, Xevi, among others.
A knowledge of some basics in Algebra, Geometry and Number Theory is also very useful for people aimed to work in applications of Mathematics to Cryptography, Coding Theory, Discrete Mathematics, Control Theory, Mathematical Physics, Algorithmics, Biosciences, etc.

Students interested in focusing on Algebra, Geometry and Number Theory are invited to select 45 ECTS from this list:

Commutative Algebra*	MAMME
Non-Commutative Algebra*	MAMME
Differentiable Manifolds*	MAMME
Number Theory*	MAMME
Algebraic Geometry*	MAMME
Geometry and Topology of Varieties	Master in Advanced Mathematics, UB
Algebraic Curves**	Master in Advanced Mathematics, UB
Computational Algebra	Master in Advanced Mathematics, UB
Geometrical Methods in Number Theory	Master in Advanced Mathematics, UB
Local Algebra	Master in Advanced Mathematics, UB

A minimum of 3 MAMME courses (22.5 ECTS) is mandatory.

(*) Please check at the Study Program web page if this course is offered in the academic year you are interested in.

(**) This course is not recommended to students who have followed the course "Geometría Algebraica" of *Grau en Matemàtiques* at FME.

Focus on Modelling and Analysis in Biomedical Sciences

Research in biomedical sciences increasingly involves mathematical modelling as a support to validate theories, to test computational replicas, to manage biomedical data and to deal with new challenges that are hard to explore either clinically or experimentally. All these goals require scientists with the solid basis provided in standard mathematical undergraduate programs, but also equipped with advanced mathematical and computational tools, as well as a practical spirit, to serve at the interface of biology, medicine, mathematics and computation. Fortunately, while the MAMME program gives the opportunity of acquiring a basic knowledge of mathematical models in biology and advanced mathematical/computational tools, other master's programs at UPC, allow offering a complete training to prepare our students in this stimulating interdisciplinary area. Students interested in joining this area through the MAMME will receive advice from the master's coordination to tailor their curriculum according to different scopes in mathematical modelling of biomedical sciences. We aim at giving a broad training in the mathematical modelling of medically significant biological problems and, additionally, endow their careers with an initial subfocus in some specific problems. The list of courses below represent the wide offer at the UPC to tailor specific profiles (the student has to select 45 ECTS from it), which can be also complemented with problem-oriented master's theses (for example, study of phylogenetic trees, mathematical and computational neuroscience, electro-mechanical models in cardiac physiology, mathematical epidemiology,...), eventually co-advised with partners in biomedical labs. Researchers involved in the area offer their advice to adapt the curriculum to each student's background and interests.
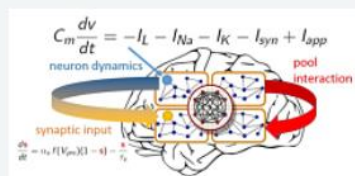
Brain dynamics: modelling and analysis at different levels, with different tools (differential equations, graphs, statistics,...)
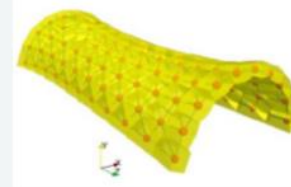
Simulation of curved cellular monolayers with computational mechanics

Mathematical models in biology	7.5 ECTS	English	MAMME
Numerical Methods for dynamical systems	7.5 ECTS	English	MAMME
Mathematical Modeling with PDEs	7.5 ECTS	English	MAMME
Numerical Methods for PDEs	7.5 ECTS	English	MAMME
Computational Mechanics	7.5 ECTS	English	MAMME
Qualitative and quantitative methods in dynamical systems	7.5 ECTS	English	MAMME
Graph theory	7.5 ECTS	English	MAMME
Inferencia estadística avanzada	5 ECTS	Spanish	MESIO UPC-UB
Fundamentos de bioinformática	5 ECTS	Spanish	MESIO UPC-UB
Multivariate data analysis	5 ECTS	Spanish-English	MESIO UPC-UB
Probability and stochastic processes	5 ECTS	English	MESIO UPC-UB
Time series	5 ECTS	Spanish-English	MESIO UPC-UB
Numerical Modeling*	9 ECTS	English	Màster en Enginyeria de Camins, Canals i Ports, UPC
Técnicas básicas en neurociencia**	5 ECTS		Màster official en neurociencia, UB-UPF-UDL-URV
Biología Celular y Molecular de la Neurona**	5 ECTS		Màster official en neurociencia, UB-UPF-UDL-URV
Diseño y análisis de datos en neurociencia cognitive**	2.5 ECTS		Màster official en neurociencia, UB-UPF-UDL-URV
Neurociencia computacional**	2.5 ECTS		Màster official en neurociencia, UB-UPF-UDL-URV

We remind that a minimum of 3 MAMME courses (22.5 ECTS) is mandatory.

(*) "Numerical Modeling" is recommended to students that do not have a solid background in numerical methods and programming. Registration to this course requires the approval of the director of the corresponding master.

(**) These courses are proposed to students willing to get a deeper focus neuroscience. Registration to these courses requires the approval of the director of the corresponding master.

Focus on Geometry and its applications

Geometry is a multifaceted research field which is at the crossroad of other topics such as Mathematical Physics and Applied Mathematics. The different branches of Geometry include Algebraic Geometry and its applications to Phylogenetics and Robotics, Algebraic Topology and its applications to Computational Topology, Differential Geometry and its applications to Mathematical Physics and Control Theory.
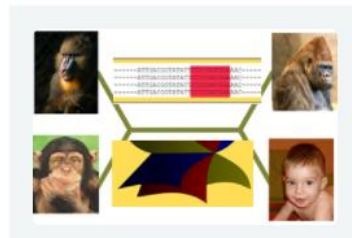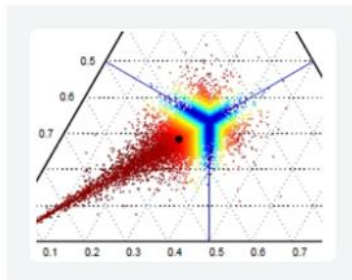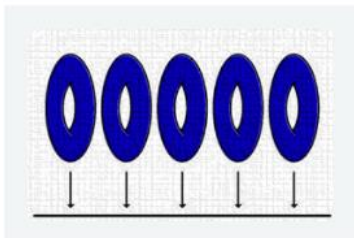
Students interested in focusing on Geometry and its applications are invited to select 45 ECTS from this list:

Commutative Algebra (7,5 ECTS)	MAMME
Non-Commutative Algebra (7,5 ECTS)	MAMME
Differentiable Manifolds (7,5 ECTS)	MAMME
Algebraic Geometry (7,5 ECTS)	MAMME
Geometry and Topology of Varieties (6 ECTS)	Master in Advanced Mathematics, UB
Algebraic Curves (6 ECTS)	Master in Advanced Mathematics, UB
Computational Algebra (6 ECTS)	Master in Advanced Mathematics, UB
Local Algebra (6 ECTS)	Master in Advanced Mathematics, UB

A minimum of 3 MAMME courses (22.5 ECTS) is mandatory.

Index

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Course guide
34963 - ACPDE - Advanced Course in Partial Differential Equations

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	749 - MAT - Department of Mathematics.
	981 - CRM - Mathematical Research Centre.
Degree:	MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2022   **ECTS Credits:** 7.5   **Languages:** English

LECTURER

Coordinating lecturer:	ALBERT MAS BLESA
Others:	Segon quadrimestre:
	XAVIER CABRE VILAGUT - A
	ALBERT MAS BLESA - A
	IÑIGO URTIAGA ERNETA - A

PRIOR SKILLS

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

REQUIREMENTS

Undergraduate courses in Partial Differential Equations and in Mathematical Analysis.
It is helpful an undergraduate course in Functional 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.

Transversal:
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

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

This course is intended to be an introduction to modern methods for solving elliptic partial differential equations. However, some insights to classical solutions to parabolic and hyperbolic equations will also be given. The objectives of the course are:
- understand the classical methods to solve the transport, wave, heat, Laplace, and Poisson equations,
- understand the role of Sobolev norms and compact embeddings to solve PDE and find spectral decompositions,
- learn the modern methods to solve elliptic PDE.

STUDY LOAD

Type	Hours	Percentage
Hours large group	60,0	32.00
Self study	127,5	68.00

Total learning time: 187.5 h

CONTENTS

Classical methods in PDEs

Description:
[This topic will only be treated in the exercises sessions.] Classical solutions to the transport, wave, heat, Laplace, and Poisson equations. Maximum principles, Green's functions, separation of variables, energy methods, probabilistic interpretation.

Full-or-part-time: 46h
Theory classes: 15h
Self study : 31h

Hilbert space techniques

Description:
Orthogonal projections, Riesz-Fréchet representation theorem, Lax-Milgram theorem.

Full-or-part-time: 25h
Theory classes: 8h
Self study : 17h

Sobolev spaces

Description:
Mollifiers, Fréchet-Kolmogorov theorem, distributions, Sobolev norms, Poincaré inequality, compact embeddings, approximation by smooth functions, traces.

Full-or-part-time: 29h
Theory classes: 9h
Self study : 20h

Weak formulation and the weak maximum principle

Description:
Weak solutions via Hilbert space techniques and interpretation, comparison principles in the weak formulation.

Full-or-part-time: 25h
Theory classes: 8h
Self study : 17h

Eigenvalues

Description:
Spectral decompositions, applications to (time dependent) evolution equations, Rayleigh quotient, description of the first eigenvalue for the Dirichlet problem on a bounded domain.

Full-or-part-time: 17h
Theory classes: 6h
Self study : 11h

Regularity theory

Description:
Boundedness of weak solutions, Sobolev-Gagliardo-Nirenberg inequality, regularity in Sobolev spaces, the translation method, bootstrap technique.

Full-or-part-time: 25h 30m
Theory classes: 8h
Self study : 17h 30m

Nonlinear problems

Description:
Calculus of variations, monotone iteration method, obstacle problems.

Full-or-part-time: 20h
Theory classes: 6h
Self study : 14h

GRADING SYSTEM

The evaluation of the course is based on:
- the resolution of problems proposed in class (40%),
- a midterm exam (20%),
- a final comprehensive exam (40%).
The active participation during the course will be a requirement for the evaluation of the final exam.

BIBLIOGRAPHY

Basic:

- Chipot, M. Elliptic Equations: An Introductory Course [on line]. Basel: Birkhäuser Basel, 2009 [Consultation: 26/06/2020]. Available on: http://dx.doi.org/10.1007/978-3-7643-9982-5. ISBN 9783764399825.
- Evans, Lawrence C. Partial differential equations. Providence, Rhode Island: American Mathematical Society, 1998. ISBN 0821807722.
- Salsa, Sandro. Partial differential equations in action : from modelling to theory [on line]. Milan: Springer, 2008 [Consultation: 19/05/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=3062992. ISBN 9788847007512.
- Brézis, H. Análisis funcional : teoría y aplicaciones. Madrid: Alianza, 1984. ISBN 8420680885.

Complementary:

- Folland, G. B. Introduction to partial differential equations. 2nd ed. Princeton (N.J.): Princeton University Press, 1995. ISBN 0691043612.
- Gilbarg, David; Trudinger, Neil S. Elliptic partial differential equations of second order. 2nd ed., rev. third printing. Berlin: Springer-Verlag, 1998. ISBN 354013025X.
- Necas, Jindrich. Introduction to the theory of nonlinear elliptic equations. Chichester: John Wiley & Sons, 1986. ISBN 0471908940.
- Struwe, Michael. Variational methods : applications to nonlinear partial differential equations and hamiltonian systems [on line]. 2nd rev. and substantially expanded ed. Berlin: Springer, 1996 [Consultation: 19/05/2020]. Available on: http://dx.doi.org/10.1007/978-3-540-74013-1. ISBN 3540520228.

Course guide
34952 - AG - Algebraic Geometry

Last modified: 19/05/2022

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	749 - MAT - Department of Mathematics.

Degree:	MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2022   **ECTS Credits:** 7.5   **Languages:** English

LECTURER

Coordinating lecturer:	MARIA ALBERICH CARRAMIÑANA
Others:	Segon quadrimestre: MARIA ALBERICH CARRAMIÑANA - A PEDRO PASCUAL GAINZA - A

PRIOR SKILLS

Aquaintance with mathematical computations, both by hand and with a computer, and mathematical reasoning, including proofs.

REQUIREMENTS

Basic abstract Algebra, Topology and Differential Geometry.

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.

Transversal:
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.
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

Roughly 50% of the class time will be devoted to the master classes, in which the lecturer will discuss the course topics. The other half of the class time will be structured as a problem class, in which the students will solve in the blackboard problems from a proposed list, based on the course syllabus, and their solutions will be discussed by the class.

LEARNING OBJECTIVES OF THE SUBJECT

The course consists of two distinct parts: global algebraic geometry and local algebraic geometry focusing on plane-curve singularities. The main objective of the first part of the course is to introduce the student to the Algebraic Geometry of affine and projective varieties, both algebraically over a field (Q, finite fields) and analytically over the real, and specially over the complex numbers.

The second part aims to give an insight into singularity theory of plane curves and a geometric theory of valuations of the ring of convergent series of two variables over the complex numbers.

The course will be based on many examples, stressing the geometric interest of the subject. The topic of the final lectures will depend on the interests of the audience, with a view towards the assigned final projects of the students.

STUDY LOAD

Type	Hours	Percentage
Self study	127,5	68.00
Hours large group	60,0	32.00

Total learning time: 187.5 h

CONTENTS

Chapter 1: Algebraic varieties

Description:
Affine algebraic varieties. Nullstellensatz. Ring of regular functions. Subvarieties. Products of varieties, fibered products. Separation axiom.

Full-or-part-time: 13h
Theory classes: 6h
Self study : 7h

Chapter 2: Projective varieties

Description:
Projective Nullstellensatz and projective varieties. Elimination theory. Examples: grassmannians.

Full-or-part-time: 13h
Theory classes: 6h
Self study : 7h

Chapter 3: Maps and morphisms

Description:
Basic properties. Noether normalization theorem. Zariski's main theorem. Proper maps. Normalization. Resolution of singularities: blow-ups and Hironaka's theorem.

Full-or-part-time: 18h
Theory classes: 8h
Self study : 10h

Chapter 4: Sheaves

Description:

Sheaves on a paracompact topological space, cohomology. Coherent sheaves on an algebraic variety: the canonical and hyperplane section sheaves, Riemann-Roch for curves. The Dolbeault complex over a complex analytic manifold: Hodge theory.

Full-or-part-time: 18h
Theory classes: 8h
Self study : 10h

Chapter 5: Parametrizing branches of plane curves

Description:

Newton-Puiseux algorithm, Weierstrass preparation and division theorems, intersection multiplicity.

Full-or-part-time: 13h
Theory classes: 6h
Self study : 7h

Chapter 6: Infinitely near points

Description:

Proximity, Enriques diagrams, rings in successive neighbourhoods.

Full-or-part-time: 13h
Theory classes: 6h
Self study : 7h

Chapter 7: Topological and analytic classification of plane curves

Description:

Equisingularity, semigroup of values, Milnor and Tjurina numbers and other invariants.

Full-or-part-time: 18h
Theory classes: 8h
Self study : 10h

Chapter 8: Valuations and complete ideals

Description:

Classification of valuations, Zariski decomposition of complete ideals.

Full-or-part-time: 18h
Theory classes: 8h
Self study : 10h

Chapter 9: Final projects

Description:
The final works of the subject on the topics chosen by the students will be presented by the students themselves and commented by the course lecturers.

Full-or-part-time: 24h
Theory classes: 4h
Self study : 20h

GRADING SYSTEM

Students who solve enough problems on the blackboard in the problem class pass the course. If they want to improve their grade from pass towards top score they will be assigned a final project, which will be to study and lecture on an additional topic at the end of the course.
Students who have not participated enough in the problem class, or still want to improve on their grade after problem class and additional lecture, will have to take a final exam of approximately 4 hours.

EXAMINATION RULES.

The problem list for participation in problem class will be published at the start of every course unit. Students will prepare these problems at home.
The topics for optional, grade increasing lectures at the end of the course will be proposed around Easter. Students will prepare these lectures at home.
Students who take the final exam will have to do so without any notes, books or material whatsoever.

BIBLIOGRAPHY

Basic:
- Harris, Joe. Algebraic geometry: a first course. New York: Springer Verlag, cop. 1992. ISBN 0387977163.
- Griffiths, Phillip ; Harris, Joseph. Principles of algebraic geometry. New York: Wiley, cop. 1978. ISBN 0471327921.
- Shafarevich, I.R. Basic algebraic geometry. 2nd. rev. and expanded ed. Berlin: Springer Verlag, 1994. ISBN 3540548122.
- Reid, Miles. Undergraduate algebraic geometry. Cambridge: Cambridge : Cambridge University Press, 1990. ISBN 0521356628.
- Smith, Karen E. An invitation to algebraic geometry. New York: Springer Verlag, 2000. ISBN 038798980.
- Casas Alvero, Eduardo. Singularities of plane curves. Cambridge: Cambridge University Press, 2000. ISBN 0521789591.

Complementary:
- Voisin, Claire. Hodge theory and complex algebraic geometry v1. Cambridge University Press, ISBN 0521802601.
- Beauville, Arnaud. Complex algebraic surfaces. 2nd ed. Cambridge University Press, 1996. ISBN 0521498422.
- Wall, C. T. C. Singular points of plane curves. Cambridge, UK ; New York: Cambridge University Press, cop. 2004. ISBN 0521547741.
- Chenciner, Alain. Courbes algébriques planes [on line]. Berlin: Springer, 2008Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-3-540-33708-9. ISBN 9783540337072.

Course guide
34954 - CC - Codes and Cryptography

Last modified: 05/05/2022

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	749 - MAT - Department of Mathematics.

Degree: MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2022   **ECTS Credits:** 7.5   **Languages:** English

LECTURER

Coordinating lecturer: SIMEON MICHAEL BALL MARKS

Others: Segon quadrimestre:
                                            SIMEON MICHAEL BALL MARKS - A
                                            JAVIER HERRANZ SOTOCA - 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. 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.

Transversal:
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

The course is divided in two parts: codes and cryptography. Each part consists of 26 h of ordinary classes, including theory and problem sessions.

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 importants cryptographic protocols and coding systems are given in the course.

STUDY LOAD

Type	Hours	Percentage
Self study	127,5	68.00
Hours large group	60,0	32.00

Total learning time: 187.5 h

CONTENTS

Introduction

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

Full-or-part-time: 6h 15m
Theory classes: 2h
Self study : 4h 15m

Information and Entropy

Description:
Uncertainty or information. Entropy. Mutual information

Full-or-part-time: 18h 45m
Theory classes: 6h
Self study : 12h 45m

Source codes without memory

Description:
Codes. Average length. Huffman codes. Extensions of a source. Theory of an noiseless communication. Notes of compression.

Full-or-part-time: 12h 30m
Theory classes: 4h
Self study : 8h 30m

Channel coding

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

Full-or-part-time: 18h 45m
Theory classes: 6h
Self study : 12h 45m

Block codes

Description:
Hamming's distance. Detection and correction of errors. Bounds. Linear codes.

Full-or-part-time: 18h 45m
Theory classes: 6h
Self study : 12h 45m

Cyclic codes

Description:
Cyclic codes. Generator and control matrices. Factorization of x^n-1. Roots of a cyclic code. BCH codes. Primitive Reed-Solomon codes. Meggit's decoder.

Full-or-part-time: 18h 45m
Theory classes: 6h
Self study : 12h 45m

Introduction to modern cryptography

Description:
The setting: secure storage and symmetric key encryption. Turing machines and complexity classes. Security definitions. Adversarial models. Reductionist security proofs.

Full-or-part-time: 15h 37m
Theory classes: 5h
Self study : 10h 37m

Symmetric key cryptography

Description:
Symmetric key encryption. Pseudorandom generators. Block ciphers. Message authentication codes.

Full-or-part-time: 15h 38m
Theory classes: 5h
Self study : 10h 38m

Public key encryption

Description:
Definitions and security notions. One way functions. Probabilistic encryption. Main constructions. Homomorphic encryption. Chosen ciphertext security.

Full-or-part-time: 15h 37m
Theory classes: 5h
Self study : 10h 37m

Digital signatures

Description:
Security definitions. RSA and Schnorr signatures.

Full-or-part-time: 15h 38m
Theory classes: 5h
Self study : 10h 38m

Proofs of knowledge and other cryptographic protocols

Description:
Ring signatures. Distributed signatures. Identity and attribute based protocols.

Full-or-part-time: 15h 37m
Theory classes: 5h
Self study : 10h 37m

Multiparty computation

Description:
Secret sharing schemes. Unconditionally and computationally secure multiparty computation.

Full-or-part-time: 15h 38m
Theory classes: 5h
Self study : 10h 38m

GRADING SYSTEM

Exam of coding part (50%) and exam of crypto part (50%). If the average is less than 5 out of 10, there is a chance to pass the subject in a final exam.

EXAMINATION RULES.

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

BIBLIOGRAPHY

Basic:
- Jones, Gareth A., Jones, J. Mary. Information and Coding Theory. Springer, 2000. ISBN 978-1-4471-0361-5.
- Delfs, Hans; Knebl, Helmut. Introduction to cryptography : principles and applications. 2nd ed. Berlin: Springer, 2007. ISBN 9783540492436.
- Katz, Jonathan; Lindell, Yehuda. Introduction to modern cryptography : principles and protocols. Boca Raton: Chapman & Hall, 2008. ISBN 9781584885511.
- Ball, Simeon. A Course in Algebraic Error-Correcting Codes [on line]. Birkhauser, 2020 [Consultation: 25/02/2021]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=6194949. ISBN 978-3-030-41153-4.

Complementary:
- Huffman, W. Cary; Pless, Vera. Fundamentals of error-correcting codes. Cambridge: Cambridge University Press, 2003. ISBN 0521782805.
- Justesen, Jorn; Hoholdt, Tom. A Course in error-correcting codes. Zürich: European Mathematical Society, 2004. ISBN 3037190019.
- Welsh, Dominic. Codes and cryptography. Oxford: Oxford university Press, 1988. ISBN 0198532881.

- Xambó Descamps, Sebastián. Block error-correcting codes : a computational primer. Berlin: Springer, 2003. ISBN 3540003959.
- Goldreich, Oded. Foundations of cryptography : basic tools. New York: Cambridge University Press, 2001. ISBN 0521791723.
- Goldreich, Oded. Foundations of cryptography : basic applications. New York: Cambridge University Press, 2004. ISBN 9780521830843.

Course guide
34955 - COMB - Combinatorics

Last modified: 19/05/2022

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	749 - MAT - Department of Mathematics.

Degree: MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2022   **ECTS Credits:** 7.5   **Languages:** English

LECTURER

Coordinating lecturer: JUAN JOSÉ RUE PERNA

Others: Segon quadrimestre:
PATRCK MORRIS - A
JUAN JOSÉ RUE PERNA - 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.

Transversal:
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.

TEACHING METHODOLOGY

There will be a lecture each week, followed by a problem session.

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.

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STUDY LOAD

Type	Hours	Percentage
Self study	127,5	68.00
Hours large group	60,0	32.00

Total learning time: 187.5 h

CONTENTS

Partially ordered sets

Description:
Sperner's theorem. LYM inequalities. Bollobás's theorem. Erdos-Ko-Rado Theorem. Dilworth's theorem. Applications of Dilworth Theorem. Lattices and distributive lattices. The 4 functions theorem and applications

Full-or-part-time: 24h 40m
Practical classes: 4h
Laboratory classes: 4h
Self study : 16h 40m

Ramsey theory

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

Full-or-part-time: 31h 40m
Theory classes: 5h
Laboratory classes: 5h
Self study : 21h 40m

Probabilistic methods in combinatorics

Description:
First and second moment. Lovász Local Lemma and entropy methods. Applications: Permanents, transversals, hypergraph coloring. Monotone properties and threshold functions.

Full-or-part-time: 18h 30m
Theory classes: 3h
Laboratory classes: 3h
Self study : 12h 30m

Linear algebra methods in combinatorics

Description:
The polynomial method and applications. Fisher's theorem. Applications

Full-or-part-time: 18h 30m
Theory classes: 3h
Laboratory classes: 3h
Self study : 12h 30m

GRADING SYSTEM

Continous evaluation will be based on the weekly solution of exercises. There will be also a final examination. The grading will be based on the continous evaluation during the course (60%) and the final exam (40%).

BIBLIOGRAPHY

Basic:

- Jukna, Stasys. Extremal Combinatorics. 2011. Springer, 2011. ISBN 978-3-642-17363-9.

- Anderson, Ian. Combinatorics of finite sets. Mineola: Dover, 2002. ISBN 0486422577.

- Lovász, László. Combinatorial problems and exercices. 2nd ed. Amsterdam: North-Holland, 1993. ISBN 044481504X.

- Oxley, J. G. Matroid theory [on line]. 2nd ed. Oxford: Oxford University Press, 2011 [Consultation: 15/03/2021]. Available on: http://dx.doi.org/10.1093/acprof:oso/9780198566946.001.0001. ISBN 9780199603398.

- Lint, Jacobus Hendricus van; Wilson, R. M. A Course in combinatorics. 2nd ed. Cambridge: Cambridge University Press, 2001. ISBN 0521803403.

- Alon, Noga; Spencer, Joel H.; Erdös, Paul. The probabilistic method. 3rd ed. New York: Wiley, 2008. ISBN 0471535885.

- Bollobás, Béla; Andrew Thomason (eds.). Combinatorics, geometry, and probability : a tribute to Paul Erdos. Cambridge: Cambridge University Press, 1997. ISBN 0521584728.

- Flajolet P.; Sedgewick R. Analytic combinatorics [on line]. Cambridge: Cambridge University Press, 2009 [Consultation: 19/05/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=412737. ISBN 9780521898065.

- Graham, Ronald L.; Rotschild, B.; Spencer, J. Ramsey theory. 2nd ed. New York: John Wiley & Sons, 1990. ISBN 0471500461.

Course guide
34950 - CALG - Commutative Algebra

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	749 - MAT - Department of Mathematics.

Degree: MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2022   **ECTS Credits:** 7.5   **Languages:** English

LECTURER

Coordinating lecturer: JOSEP ALVAREZ MONTANER

Others: Primer quadrimestre:
JOSEP ALVAREZ MONTANER - A

PRIOR SKILLS

Linear algebra, algebraic structures, topology.

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.

Transversal:
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.

TEACHING METHODOLOGY

Teaching Classes, resolution of problems

LEARNING OBJECTIVES OF THE SUBJECT

Basic course in Commutative Algebra.
An introduction to the theory of rings, ideals and modules.
Some basics on local algebra.

STUDY LOAD

Type	Hours	Percentage
Hours large group	60,0	32.00
Self study	127,5	68.00

Total learning time: 187.5 h

CONTENTS

Rings and ideals

Description:
Basics on ring theory and ideals.
Rings of fractions. Primary decomposition. Chain conditions. Noetherian and Artinian rings.

Full-or-part-time: 28h 20m
Theory classes: 15h
Self study : 13h 20m

Modules

Description:
General properties of modules.
Modules of fractions. Chain conditions. Homomorphisms and tensor product.

Full-or-part-time: 24h
Theory classes: 12h
Self study : 12h

Algebraic varieties

Description:
The spectrum of a ring. Zariski topology.

Full-or-part-time: 24h
Theory classes: 12h
Self study : 12h

Introduction to homological algebra

Description:
Categories and functors. Complexes of modules. Derived functors.

Full-or-part-time: 24h
Theory classes: 12h
Self study : 12h

Local algebra

Description:
Regular sequences. Depth.
Homological characterizations.
Regular rings, Gorenstein rings, Cohen-Macaulay rings

Full-or-part-time: 18h 40m
Theory classes: 9h
Self study : 9h 40m

GRADING SYSTEM

The qualification will be based on:
60% Resolution of assigned exercises and/or projects
40% Final Exam

BIBLIOGRAPHY

Basic:
- Rotman, J.J. An introduction to homological algebra [on line]. Academic Press, 1979 [Consultation: 19/05/2020]. Available on: http://dx.doi.org/10.1007/b98977.
- Bruns, Winfried; Herzog, Jürguen. Cohen-Macaulay rings. Cambridge University Press, 1993.
- Atiyah, Michael Francis; MacDonald, I. G. Introduction to commutative algebra. Reading: Addison-Wesley, 1969. ISBN 0201407515.
- Reid, Miles. Undergraduate commutative algebra. Cambridge: Cambridge University Press, 1995. ISBN 0521452554.
- Eisenbud, David. Commutative algebra : with a view toward algebraic geometry. Corrected 2nd. printing. New York: Springer-Verlag, 1996. ISBN 0387942696.
- Kunz, Ernst. Introduction to commutative algebra and algebraic geometry. Boston: Birkhäuser, ISBN 3764330651.
- Matsumura, Hideyuki. Commutative ring theory. Cambridge: Cambridge University Press, ISBN 0521259169.

Course guide
34959 - CM - Computational Mechanics

Last modified: 19/04/2022

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	749 - MAT - Department of Mathematics.
	751 - DECA - Department of Civil and Environmental Engineering.
	748 - FIS - Department of Physics.
Degree:	MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2022 **ECTS Credits:** 7.5 **Languages:** English

LECTURER

Coordinating lecturer:	JOSE JAVIER MUÑOZ ROMERO
Others:	Segon quadrimestre:
	ALVARO MESEGUER SERRANO - A
	JOSE JAVIER MUÑOZ ROMERO - A
	ANTONIO RODRIGUEZ FERRAN - 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.

Transversal:
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

Four elements will be combined:
-Theory classes, where the main concepts will be presented.
-Practical classes with Matlab code in the computer room, with emphasis on the computational aspects.
-Lists of short assignments.
-Course projects in groups to be presented orally at the end of the course.

Students will work on the assignments and course projects individually or in groups.

LEARNING OBJECTIVES OF THE SUBJECT

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. Some emphasis is put on applications in biomechanical 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 (tensors) and differential operators used in computational mechanics
- Be aware of the different level of complexity of various problems (e.g. linear vs. nonlinear,
static vs. dynamic).

STUDY LOAD

Type	Hours	Percentage
Self study	127,5	68.00
Hours large group	60,0	32.00

Total learning time: 187.5 h

CONTENTS

CONTINUUM MECHANICS

Description:
Motivation. Definition of continuous media. Equation of motion: Eulerian and Lagrangian
descriptions. Time derivatives. Strains: deformation gradient, Green and Euler-Almansi tensors;
elongation and shear; small strains. Stresses: body and surface forces; Cauchy stress tensor.
Balance equations: Reynolds transport theorem; mass balance; momentum balance. Constitutive equations. Applications.

Full-or-part-time: 31h 15m
Theory classes: 8h
Practical classes: 2h
Self study : 21h 15m

COMPUTATIONAL ELASTICITY

Description:
Basic concepts and motivation. Elastic constitutive equation. Displacement formulation: Navier
equations. Two-dimensional elasticity: plane stresses, plane strains and axisymmetry. Weak form
of the elastic problem. Finite element discretisation. Computational aspects. Applications in engineering and biomechanics.

Full-or-part-time: 31h 15m
Theory classes: 8h
Practical classes: 2h
Self study : 21h 15m

COMPUTATIONAL DYNAMICS

Description:
Weak form. Dynamic equation. Space discretisation (finite elements) and time discretisation. Solution methods: generalised eigen value problem and direct time integration. Euler, centred differences, HHT and Newmark methods. Stability, consistency and accuracy of numerical techniques in elastodynamics. Applications and realtion with reduced order techniques (Proper Orthogonal Decomposition).

Full-or-part-time: 31h 15m
Theory classes: 8h
Practical classes: 2h
Self study : 21h 15m

COMPUTATIONAL PLASTICITY, FRACTURE AND VISCOELASTICITY

Description:
Basic concepts and motivation. Non-linear problems. Geometrical and material non-linearity. 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. Phase field formulation and Finite Element discretisation.
Viscoelastic materials. Maxwell and Kelvin-Voigt one-dimensional models. Numerical solution. Extension to multiple dimensions.

Full-or-part-time: 31h 15m
Theory classes: 8h
Practical classes: 2h
Self study : 21h 15m

COMPUTATIONAL FLUID DYNAMICS

Description:
Basic concepts and motivation. Rate-of-deformation and spin tensors. Constitutive equation for
Newtonian fluids. Euler equations for inviscid flow. Navier-Stokes equations for viscous flow in strong form and in weak form.
Reynolds number. Stokes flow and potential flow. Finite element discretisation and numerical solution. Applications.

Full-or-part-time: 31h 15m
Theory classes: 8h
Practical classes: 2h
Self study : 21h 15m

COMPUTATIONAL METHODS FOR WAVE PROBLEMS

Description:
Basic concepts and motivation.
Acoustics: the wave equation. The scalar Helmholtz equation. Vibroacoustics: acoustic fluid-elastic solid interaction.
Computational aspects. Applications.
Electromagnetism: the Maxwell equations. Electrodynamics. The vectorial Helmholtz equation.
Computational aspects. Applications.

Full-or-part-time: 31h 15m
Theory classes: 8h
Practical classes: 2h
Self study : 21h 15m

GRADING SYSTEM

Final exam (40%), assignment problems (30%), and course project (30%, evaluated with an oral presentation and a written report).

BIBLIOGRAPHY

Basic:
- Clough, Ray W.; Penzien, J. Dynamics of structures. 2nd ed. New York: McGraw-Hill, 1993. ISBN 0071132414.
- Donea, Jean M.; Huerta, A. Finite element methods for flow problems. Chichester: John Wiley & Sons, 2003. ISBN 0471496669.
- Ihlenburg, F. Finite element analysis of acoustic scattering [on line]. New York: Springer-Verlag, 1998Available on: http://link.springer.com/book/10.1007%2Fb98828. ISBN 0387983198.
- Mase, G. Thomas; Mase, George E. Continuum mechanics for engineers. 3rd ed. Boca Raton: CRC, 2010.

Complementary:
- Holzapfel, Gerhard A. Nonlinear solid mechanics : a continuum approach for engineering. Chichester: John Wiley & Sons, cop. 2000. ISBN 978-0-471-82319-3.
- Taber, Larry A. Nonlinear theory of elasticity. Applications in Biomechanics. 2008. Singapore: World Scientific Publishing, 2004. ISBN 9812387358.
- Bonet, Javier; Wood, R. D. Nonlinear continuum mechanics for finite element analysis. 2nd ed. Cambridge: Cambridge University Press, 2008. ISBN 9780521838702.
- Marsden, Jerrold E.; Hugues, Thomas J. R. Mathematical foundations of elasticity. New York: Dover, 1994. ISBN 0486678652.
- Simo, J. C.; Hughes, T. J. R. Computational inelasticity [on line]. New York: Springer-Verlag, 1998 [Consultation: 19/05/2020]. Available on: http://link.springer.com/book/10.1007/b98904.
- Zienkiewicz O. C.;Taylor, R. L. The finite element method [on line]. 6th ed. Oxford: Butterworth Heinemann, 2005 [Consultation: 19/05/2020]. Available on: http://www.sciencedirect.com/science/book/9780750664318.
- Bathe, Klaus-Jürgen. Finite element procedures. New Jersey: Prentice-Hall, 1996. ISBN 0133014584.

Course guide
34966 - VD - Differentiable Manifolds

Last modified: 19/04/2022

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	749 - MAT - Department of Mathematics.

Degree:	MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2022 **ECTS Credits:** 7.5 **Languages:** English

LECTURER

Coordinating lecturer: EVA MIRANDA GALCERÁN

Others: Segon quadrimestre:
PAU MIR GARCÍA - A
EVA MIRANDA GALCERÁN - A

PRIOR SKILLS

Basic courses on algebra, calculus, topology and differential equations, and calculus on manifolds. Students from the FME are supposed to have taken "Varietats Diferenciables" (optional 4th year course).

This is not a basic course and the students are assumed to have attended previous courses on differential geometry and smooth manifolds. Students feeling that they may not fulfill the requisites are invited to discuss their case with the lecturers. It is totally possible for prospective students with less knowledge in these topics to follow this course provided they are willing to make up for the gap with individual work during the course and/or by reading some recommended bibliography prior to the beginning of the course.

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.
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.

Transversal:
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.
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

Theory classes and tutorial sessions will be used to present and develop the contents of the course. Along the course the students will be given problems to solve as homework.

LEARNING OBJECTIVES OF THE SUBJECT

The subject focuses on some of the fundamental topics of differential geometry and its applications to different areas including mathematical physics and Dynamical systems.

By the end of the course, students should be able to:
- understand all the ideas developed along the course.
- apply the studied concepts to other areas of pure mathematics, physics and engineering.
- integrate in a research group on these kinds of topics and their applications.
- search and understand the scientific literature on the subject.
- write and present an essay on mathematics.

STUDY LOAD

Type	Hours	Percentage
Hours large group	60,0	32.00
Self study	127,5	68.00

Total learning time: 187.5 h

CONTENTS

Complements in Differential Geometry

Description:
Brief survey of manifold theory and differential geometry including differential forms.
We also plan to talk about differentiable distributions and study its integration via the theorem of Frobenius. This will lead us to introducing several examples of foliations.

Full-or-part-time: 14h 52m
Theory classes: 6h
Self study : 8h 52m

Introduction to Differential Topology

Description:
We present a brief introduction to the theory of Differential Topology which includes basic notions in transversality, singularity theory and Morse theory.

Full-or-part-time: 14h 40m
Theory classes: 8h
Self study : 6h 40m

Introduction to Lie theory

Description:
A Lie group is a group endowed with a smooth manifold structure which is compatible with the group operation. In this chapter we provide an
introduction to the main aspects of the theory of Lie groups and Lie algebras taking matrix Lie groups as starting point.

Full-or-part-time: 16h 20m
Theory classes: 8h
Self study : 8h 20m

Lie group actions on smooth manifolds

Description:
We study Lie group actions on smooth manifolds and relate both geometries via the notions of isotropy group and orbit.

Full-or-part-time: 18h
Theory classes: 4h
Theory classes: 4h
Self study : 5h
Self study : 5h

Basic notions on De Rham Cohomology

Description:
We define De Rham cohomology and compare it to other cohomologies. (Depending on the preliminary knowledge of the students, this chapter may be considered as an APPENDIX)

Full-or-part-time: 8h
Theory classes: 3h
Self study : 5h

Introduction to Symplectic and Poisson Geometry

Description:
We provide a comprehensive introduction to symplectic and Poisson manifolds with special focus on examples. Starting with symplectic manifolds, we will explain Moser's trick and some applications to normal form theorems such as the Darboux theorem and the classification of symplectic surfaces. We introduce the notion of Hamiltonian vector field, symplectic vector field and Hamiltonian System. Special attention will be given to examples provided by the realm of integrable systems. In particular the action-angle theorem of Arnold-Liouville will be presented and the notion of moment map and Hamiltonian group action. We end the chapter introducing the basic concepts in Poisson geometry (a natural generalization of Symplectic geometry) and proving a decomposition theorem (Weinstein's splitting theorem) in terms of a symplectic leaf of the symplectic foliation.

Full-or-part-time: 31h 40m
Theory classes: 15h
Self study : 16h 40m

GRADING SYSTEM

There will be exam(s) which will contribute to the final grade in a 40% and an essay that will contribute to the final grade in another 40%. Students would choose, together with the lecturers, a topic that complements or advances the material taught during the course, according to their mathematical interests. The remaining 20% is reserved to problem solving which can be evaluated by simply solving some assignments of the regular list of problems.

EXAMINATION RULES.

The final grade awarded to the student would we computed as follows:

40% exam(s) + 40% essay+ 20% problem solving

The grade "exam(s)" includes the one of final exam but may also include other examination material such as ATENEA questionnaires or take-home exercises. The choices and number
of exams will depend on several factors including the ratio presential versus online teaching.

BIBLIOGRAPHY

Basic:
- Lee, John M. Introduction to smooth manifolds [on line]. New York: Springer-Verlag, 2003 [Consultation: 19/05/2020]. Available on: https://doi.org/10.1007/978-1-4419-9982-5. ISBN 0387954481.
- Duistermaat, J. J. ; Kolk, Johan A. C. Lie groups. Berlin: Springer-Verlag, 2000. ISBN 3540152938.
- Guillemin, Victor; Pollack, Alan. Differential topology. Reprint of the 1974 original. AMS Chelsea Publishing,
- Bröcker, T.; Jänich, K. Introduction to differential topology. Cambridge University Press, 1982. ISBN 978-0521284707.
- Fegan, H.D.. Introduction to compact lie groups. World Scientific, 1991. ISBN 9810236867.
- Eva Miranda, Pau Mir and Cédric Oms. Notes of the course.
- Knauf, A.. Mathematical Physics: Classical Mechanics. Springer, 2018. ISBN 978-3-662-55774-7.
- Guillemin, V; Sternberg, Shlomo. Symplectic techniques in physics. Repr. with corrections. Cambridge [etc.]: Cambridge University Press, 1990. ISBN 978-0521389907.
- Milnor, John W. Topology from the differentiable viewpoint. Rev. ed. Princenton: Princeton University Press, 1997. ISBN 978-0691048338.
- Munkres, J.R. Elementary differential topology. ISBN 978-0691090931.
- Warner, Frank W. Foundations of differentiable manifolds and Lie groups. New York [etc.]: Springer, cop. 1983. ISBN 9780387908946.
- Tu, Loring W. An Introduction to manifolds [on line]. 2nd ed. New York: Springer, cop. 2011 [Consultation: 19/05/2020]. Available on: https://doi.org/10.1007/978-1-4419-7400-6. ISBN 9781441973993.
- Cannas da Silva, Anna. Lectures on symplectic geometry [on line]. Springer-Verlag, 2008 [Consultation: 19/05/2020]. Available on: https://link.springer.com/book/10.1007/978-3-540-45330-7.

Complementary:
- Bott, Raoul; Tu, Loring W. Differential forms in algebraic topology. New York: Springer-Verlag, 1982. ISBN 0387906134.
- Audin, Michèle; Damian, Mihai. Morse theory and Floer homology. New York: Springer, [2014]. ISBN 978-1447154952.
- Gallier, Jean;Quaintance, Jocelyn. Notes on differential geometry and Lie groups [on line]. University of Pennsylvania, 2016 [Consultation: 19/05/2020]. Available on: http://www.cis.upenn.edu/~jean/gbooks/manif.html.
- Nakahara, Mikio. Geometry, topology, and physics. 2nd ed. New York [etc.]: Taylor & Francis, cop. 2003. ISBN 0750306068.
- Audin, Michèle. Torus actions on symplectic manifolds. 2nd ed. Birkhäuser, 2004.
- Warner, Frank W. Foundations of differentiable manifolds and lie groups. New York, NY [etc.]: Springer-Verlag, cop. 1971. ISBN 0387908943.
- Olver, Peter J. Applications of Lie groups to differential equations. New York: Springer-Verlag, 1986. ISBN 0387940073.

RESOURCES

Other resources:
Notes on the Geometry and Dynamics of singular symplectic manifolds (notes on the FSMP course by Eva Miranda)

Course on youtube by Professor Eva Miranda on Lie group actions
https://www.youtube.com/channel/UC8Fzyf58s0EiZ-gdYgz2ghw?view_as=subscriber
Course on youtube by Professor Eva Miranda on Symplectic and Poisson Geometry
https://www.youtube.com/channel/UC8Fzyf58s0EiZ-gdYgz2ghw?view_as=subscriber

Course guide
34956 - DG - Discrete and Algorithmic Geometry

Last modified: 05/05/2022

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	749 - MAT - Department of Mathematics.

Degree:	MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2022   **ECTS Credits:** 7.5   **Languages:** English

LECTURER

Coordinating lecturer:	CLEMENS HUEMER
Others:	Primer quadrimestre: CLEMENS HUEMER - A JULIAN THORALF PFEIFLE - A RODRIGO IGNACIO SILVEIRA ISOBA - 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. 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.

Transversal:
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

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

Type	Hours	Percentage
Self study	127,5	68.00
Hours large group	60,0	32.00

Total learning time: 187.5 h

CONTENTS

Preliminaries

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

Full-or-part-time: 12h 30m
Theory classes: 4h
Self study : 8h 30m

Convexity

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

Full-or-part-time: 19h
Theory classes: 4h
Laboratory classes: 2h
Self study : 13h

Decompositions and arrangements

Description:
Subdivisions and triangulations of point sets and polygons. Visibility and motion planning. Duality. Special decompositions in dimension 2. The zone theorem. Incremental construction and randomized algorithms. Complexity. Levels and k-sets.

Full-or-part-time: 31h
Theory classes: 7h
Laboratory classes: 3h
Self study : 21h

Proximity Structures

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

Full-or-part-time: 31h
Theory classes: 7h
Laboratory classes: 3h
Self study : 21h

Polytopes and Subdivisions of Point Sets

Description:
Homogeneous coordinates. Polytopes: faces and boundary structure; examples; operations on
polytopes (polarity, products, etc.). Point sets: subdivisions and triangulations (including Delaunay and Voronoi).

Full-or-part-time: 38h
Theory classes: 10h
Laboratory classes: 3h
Self study : 25h

Topological Data Analysis

Description:
Homology: Simplicial homology, cell complexes.
Persistent homology: persistent Betti numbers, barcodes
Discrete Morse Theory: simplicial collapses, acyclic matchings, critical cells
Applications

Full-or-part-time: 48h
Theory classes: 12h
Laboratory classes: 4h
Self study : 32h

Software

Description:
Polymake, Curved Spaces, etc.

Full-or-part-time: 9h
Laboratory classes: 2h
Self study : 7h

GRADING SYSTEM

The course consists in two parts, each contributes with 50 % to the final grade.
For each part: Students will obtain marks by turning in their solutions to problems from the problem sets (50%), by presenting solutions to problems or a research paper (15 %), and there will be an exam (35 %).

BIBLIOGRAPHY

Basic:
- Boissonnat, J. D.; Yvinec, M. Algorithmic geometry. Cambridge: Cambridge University Press, 1997. ISBN 0521565294.
- Edelsbrunner, Herbert. Algorithms in combinatorial geometry. Berlin: Springer-Verlag, 1987. ISBN 354013722X.
- Matousek, Jirí. Lectures on discrete geometry. New York: Springer, 2002. ISBN 0387953736.
- Pach, János; Agarwal, Pankaj K. Combinatorial geometry. New York: John Wiley & Sons, cop. 1995. ISBN 0471588903.
- Ziegler, Günter M. Lectures on polytopes. New York: Springer-Verlag, 1995. ISBN 038794365X.
- Berg, Mark de; Cheong, Otfried; Kreveld, Marc van; Overmars, Mark. Computational geometry: algorithms and applications [on line]. 3rd ed. revised. Berlin: Springer, 2008 [Consultation: 18/11/2020]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=6311912. ISBN 9783540779735.
- Rabadán, Raúl; Blumberg, Andrew J. Topological data analysis for genomics and evolution. Cambridge University Press, 2020. ISBN 9781107159549.
- Edelsbrunner, Herbert; Harer, John. Computational Topology : an introduction. American Mathematical Society, cop. 2010. ISBN 9780821849255.

Complementary:
- Bokowski, Jürgen. Computational oriented matroids : equivalence classes of matrices within a natural framework. Cambridge: Cambridge University Press, 2006. ISBN 9780521849302.
- Conway, John Horton; Sloane, N. J. A. Sphere packings, lattices and groups. 3rd ed. Berlin: Springer, 1999. ISBN 0387985859.
- Schurmann, Achill. Computational geometry of positive definite quadratic forms : polyhedral reduction theories, algorithms, and applications. Providence: American Mathematical Society, 2009. ISBN 9780821847350.
- Weeks, Jeffrey R. The shape of space. 2nd. ed. New York: M. Dekker, 2002. ISBN 0824707095.
- Richter-Gebert, Jürgen. Perspectives on projective geometry: a guided tour through real and complex geometry [on line]. Berlin: Springer, 2011 [Consultation: 19/05/2020]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-3-642-17286-1. ISBN 9783642172854.
- Beck, Matthias; Robins, Sinai. Computing the continuous discretely : integer-point enumeration in polyhedra [on line]. New York: Springer, cop. 2007 [Consultation: 20/05/2020]. Available on: http://dx.doi.org/10.1007/978-0-387-46112-0. ISBN 9780387291390.

RESOURCES

Audiovisual material:

- Mathfilm festival 2008 [Enregistrament vídeo]: a collection of mathematical videos. Berlin : Springer, 2008.
https://discovery.upc.edu/discovery/fulldisplay?docid=alma991003546329706711&context=L&vid=34CSUC_UPC:VU1&lang=ca
- Videomath Festival at International Congress of Mathematicians, Berlin, Germany 1998 [Enregistrament vídeo] / edited and produced Hans Christian Hege, Konrad Polthier. [Berlin] : Springer, 1998.
https://discovery.upc.edu/discovery/fulldisplay?docid=alma991001865709706711&context=L&vid=34CSUC_UPC:VU1&lang=ca
- Not knot [Enregistrament vídeo] / directed by Charlie Gunn and Delle Maxwell ; [written by David Epstein ... [et al.]]. Minnesota : Geometry Center, University of Minnesota, 1991.
https://discovery.upc.edu/discovery/fulldisplay?docid=alma991001445799706711&context=L&vid=34CSUC_UPC:VU1&lang=ca
- Flatland [Enregistrament vídeo] : a journey of many dimensions / written by Seth Caplan, Dano Johnson, Jeffrey Travis ; directed by Jeffrey Travis, Dano Johnson. [S.l.] : Flat World Productions, cop. 2007.
https://discovery.upc.edu/discovery/fulldisplay?docid=alma991003683649706711&context=L&vid=34CSUC_UPC:VU1&lang=ca

Course guide
34957 - GT - Graph Theory

Last modified: 25/05/2022

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	749 - MAT - Department of Mathematics.

Degree:	MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2022   **ECTS Credits:** 7.5   **Languages:** English

LECTURER

Coordinating lecturer:	GUILLEM PERARNAU LLOBET
Others:	Primer quadrimestre:
	GUILLEM PERARNAU LLOBET - A
	ORIOL SERRA ALBO - A

PRIOR SKILLS

Elementary Calculus and Linear Algebra; basic notions and skills 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. 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.

Transversal:
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

Combination of theoretical lectures and exercise classes, with student presenting their solutions to the proposed problems. The active participation of students is a requirement for the course assessment.

LEARNING OBJECTIVES OF THE SUBJECT

Basics of Graph Theory.
Graphs on surfaces and minors.
Random graphs.
Applications of random graphs: the probabilistic method.
Spectral techniques to the study of graphs.
Applications of spectral techniques: expansion and random walks.

STUDY LOAD

Type	Hours	Percentage
Self study	127,5	68.00
Hours large group	60,0	32.00

Total learning time: 187.5 h

CONTENTS

Spectral graph theory

Description:
Introduction to spectral graph theory, graph expanders and applications to random walks on graphs.

Specific objectives:
Adjacency and Laplacian matrices. Courant-Fischer Theorem. Interlacing. Cospectral graphs. Graph invariants: independence number, chromatic number, diameter,... Spectral gap and second largest eigenvalue. Isoperimetry and Cheeger's inequality. Matrix tree theorem. Shannon capacity. Random walks in graphs.

Related competencies :
MAMME-CE2. MODELLING. Formulate, analyse and validate mathematical models of practical problems by using the appropriate mathematical tools.
MAMME-CE1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
MAMME-CE3. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
MAMME-CE4. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.
07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
04 COE. 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.
03 TLG. 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.
05 TEQ. 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.
06 URI. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.

Full-or-part-time: 16h
Theory classes: 16h

Minors and treewidth

Description:
Introduction to structural graph theory.

Specific objectives:
Minors. Minor closed classes. Well quasi-ordering. Graph minor theorem for trees. Tree decomposition. Treewidth.. Classes defined by forbidden minors. Serie-Parallel graphs.

Related competencies :
MAMME-CE2. MODELLING. Formulate, analyse and validate mathematical models of practical problems by using the appropriate mathematical tools.
MAMME-CE1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
MAMME-CE3. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
MAMME-CE4. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.
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Full-or-part-time: 8h
Theory classes: 8h

Graphs on surfaces

Description:
Introduction to planar graphs and graphs embedded in other surfaces.

Specific objectives:
Planar graphs. Kuratowski theorem. Triangulations. Graphs on surfaces. Genus. Euler formula. Planar separator theorem

Related competencies :
MAMME-CE2. MODELLING. Formulate, analyse and validate mathematical models of practical problems by using the appropriate mathematical tools.
MAMME-CE1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
MAMME-CE3. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
MAMME-CE4. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.
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03 TLG. 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.
05 TEQ. 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.
06 URI. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.

Full-or-part-time: 4h
Theory classes: 4h

Random graphs

Description:
Introduction to classical model of random graphs and its main combinatorial properties.

Specific objectives:
Erdos-Rényi model of random graphs.
Properties of almost all graphs.
First and second moment methods.
The probabilistic method.
Threshold functions.
Method of Moments
Chernoff's inequality
Component phase transitions

Related competencies :
MAMME-CE2. MODELLING. Formulate, analyse and validate mathematical models of practical problems by using the appropriate mathematical tools.
MAMME-CE1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
MAMME-CE3. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
MAMME-CE4. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.
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06 URI. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.

Full-or-part-time: 12h
Theory classes: 12h

An introduction to Graph Theory

Description:
Introduction to random graphs, main properties and classical theorems.

Specific objectives:
Basic terminology and notation
Paths and cycles
Distance and Diameter
Connectivity
Trees
Matchings
Colorings

Related competencies :
MAMME-CE2. MODELLING. Formulate, analyse and validate mathematical models of practical problems by using the appropriate mathematical tools.
MAMME-CE1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
MAMME-CE3. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
MAMME-CE4. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.
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03 TLG. 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.
05 TEQ. 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.
06 URI. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.

Full-or-part-time: 12h
Theory classes: 12h

GRADING SYSTEM

The assessment of the course is as follows:
- weekly work on the proposed problems and their presentation during the lectures, 30% of the mark
- a final comprehensive exam on the course topics, 70% of the mark

EXAMINATION RULES.

The active participation in the course is a requirement for the final assessment.

BIBLIOGRAPHY

Basic:

- Alon, Noga; Spencer Joel. The Probabilistic Method. 2016. Wiley,
- Brouwer, A. E; Haemers, W. H. Spectra of Graphs [on line]. New York [etc.]: Springer, cop. 2012 [Consultation: 18/11/2020]. Available on: https://doi.org/10.1007/978-1-4614-1939-6. ISBN 978-1-4614-1938-9.
- Diestel, Reinhard. Graph theory. 3rd ed. Berlin: Springer, 2005. ISBN 3540261826.
- Hell, Pavol; Nesetril, Jaroslav. Graphs and homomorphisms. Oxford: Oxford University Press, 2004. ISBN 0198528175.
- Frieze, Alan; Karonski, Michal. Introduction to random graphs [on line]. Cambridge, [etc.]: Cambridge University Press, cop. 2016 [Consultation: 18/11/2020]. Available on: https://doi.org/10.1017/CBO9781316339831. ISBN 978-1107118508.

Complementary:

- Biggs, Norman L. Algebraic graph theory. 2nd ed. New York: Cambridge University Press, 1993. ISBN 0521458978.
- Chung, Fan R. K. Spectral Graph Theory. Providence: American Mathematical Society, 1997. ISBN 0821803158.

Course guide
34962 - HS - Hamiltonian Systems

Last modified: 25/05/2022

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	749 - MAT - Department of Mathematics.

Degree:	MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2022   **ECTS Credits:** 7.5   **Languages:** English

LECTURER

Coordinating lecturer:	PAU MARTIN DE LA TORRE
Others:	Segon quadrimestre: AMADEU DELSHAMS I VALDES - A PAU MARTIN DE LA TORRE - 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.
4. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.

Transversal:
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

Standard exposition in front of the blackboard, resolution of exercices, completion of a project and attendance to the JISD summer school http://www.ma1.upc.edu/recerca/jisd

LEARNING OBJECTIVES OF THE SUBJECT

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

STUDY LOAD

Type	Hours	Percentage
Hours large group	60,0	32.00
Self study	127,5	68.00

Total learning time: 187.5 h

CONTENTS

Hamiltonian formalism

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

Full-or-part-time: 28h
Theory classes: 10h
Self study : 18h

Celestial mechanics

Description:
The two body problem, first integrals. Resolution. The three body problem, different coordinates. The restricted three body problem. Central configurations. Periodic orbits, invariant manifolds.

Full-or-part-time: 34h
Theory classes: 12h
Self study : 22h

Geometric theory and invariant objects of Hamiltonian systems

Description:
Continuous and discrete dynamical systems, Poincaré map. Flow box Theorem. Noether Theorem. Periodic orbits. Continuation of periodic orbits. Lyapunov Center Theorem.

Full-or-part-time: 24h
Theory classes: 8h
Self study : 16h

Integrable systems

Description:
Complete integrability and Liouville-Arnold theorem. Action-Angle coordinates. Quasi-periodic flows on a torus, resonances.

Full-or-part-time: 10h
Theory classes: 4h
Self study : 6h

Quasi-integrable Hamiltonian systems

Description:
Examples of quasi-integrable systems. Small divisors and Diophantine inequalities. Averaging Theory. Lie Method. KAM Theory (Kolmogorov-Arnold Moser). Effective stability and Nekhoroshev theorem. Melnikov Potential. Arnold diffusion.

Full-or-part-time: 26h
Theory classes: 8h
Self study : 18h

Lagrangian systems and variational methods

Description:
Lagrangian systems. Legendre transformation. Principle of minimal action. Twist maps. Existence of periodic orbits. Aubry-Mather Theory.

Full-or-part-time: 12h
Theory classes: 4h
Self study : 8h

Hamiltonian Partial Differential Equations

Description:
Linear Hamiltonian Partial Differential Equations. Examples. Periodic, quasi-periodic and almost-periodic solutions. Nonlinear Hamiltonian Partial Differential Equations. Lyapunov stability/instability of invariant objects. Transfer of energy.

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

- Interactions between Dynamical Systems and Partial Differential Equations

Description:
Summer School and Research workshop on topics between Dynamical Systems and Partial Differential Equations

Full-or-part-time: 49h 30m
Theory classes: 12h
Self study : 37h 30m

ACTIVITIES

JISD summer school

Description:
Attendance to the JISD summer school

Specific objectives:
To learn from oustanding 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.

GRADING SYSTEM

The students have to do some problems (60%) and a research work (25%). There will be also a final exam covering on the theoretical part of the subject (15%). Moreover, they will attend the JISD.

BIBLIOGRAPHY

Basic:

- Kanuf, Andreas. Mathematical physics: Classical mechanics. 1. Springer-Verlag, 2018. ISBN 978-3-662-55772-3.

- Marsden, Jerrold E; Ratiu, Tudor S. Introduction to mechanics and symmetry : a basic exposition of classical mechanical systems. 2a ed. New York [etc.]: Springer, 1999. ISBN 978-0-387-98643-2.

- Arnol'd, V. I.; Kozlov, Valerii V.; Neishtadt, Anatoly I. Mathematical aspects of classical and celestial mechanics [on line]. 3rd ed. Berlin: Springer-Verlag, 2006 [Consultation: 19/05/2020]. Available on: http://dx.doi.org/10.1007/978-3-540-48926-9. ISBN 3540282467.

- Katok, Anatole; Hasselblatt, Boris. Introduction to the modern theory of dynamical systems. Cambridge [etc.]: Cambridge University Press, 1997. ISBN 9780521575577.

- Celletti, Alessandra. Stability and chaos in celestial mechanics [on line]. Springer-Praxis, 2010 [Consultation: 19/05/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=993277. ISBN 978-3-540-85145-5.

- Treschev, Dmitry; Zubelevich, Oleg. Introduction to the perturbation theory of Hamiltonian systems [on line]. Berlin: Springer Verlag, 2010 [Consultation: 19/05/2020]. Available on: http://dx.doi.org/10.1007/978-3-642-03028-4. ISBN 978-3-642-03027-7.

- Meyer, Kenneth R.; Hall, Glen R.; Offin, Dan. Introduction to Hamiltonian dynamical systems and the n-body problem [on line]. 2nd ed. New York: Springer-Verlag, 2009 [Consultation: 19/05/2020]. Available on: http://dx.doi.org/10.1007/978-0-387-09724-4. ISBN 978-0-387-09723-7.

- Berti, Massimiliano. Nonlinear Oscillations of Hamiltonian PDEs [on line]. Boston, MA: Birkhäuser Boston, Inc., 2007 [Consultation: 19/05/2020]. Available on: http://dx.doi.org/10.1007/978-0-8176-4681-3. ISBN 978-0-8176-4680-6.

- Wintner, Aurel. The analytical foundations of celestial mechanics. Dover Publications, ISBN 978-0486780603.

RESOURCES

Hyperlink:

- Grup de sistemes dinàmicshttps://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

Course guide
200900 - ML - Machine Learning

Last modified: 19/04/2022

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	723 - CS - Department of Computer Science.
	715 - EIO - Department of Statistics and Operations Research.
Degree:	MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).
	MASTER'S DEGREE IN STATISTICS AND OPERATIONS RESEARCH (Syllabus 2013). (Optional subject).

Academic year: 2022   **ECTS Credits:** 7.5   **Languages:** English

LECTURER

Coordinating lecturer:	LUIS ANTONIO BELANCHE MUÑOZ
Others:	Segon quadrimestre:
	LUIS ANTONIO BELANCHE MUÑOZ - A
	PEDRO FRANCISCO DELICADO USEROS - A

PRIOR SKILLS

The student should have knowledge of fundamental mathematical topics, such as linear algebra, calculus, probability distributions, optimization and basic (linear) statistical methods.

REQUIREMENTS

The student should have knowledge of basic machine learning concepts. These concepts can be acquired simultaneously, for example being enrolled in the "Statistical Learning" subject offered in the MESIO master.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
MAMME-CE2. MODELLING. Formulate, analyse and validate mathematical models of practical problems by using the appropriate mathematical tools.
MAMME-CE4. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.

TEACHING METHODOLOGY

On-Site Learning: On-site learning will be organized into theoretical-practical sessions. All these sessions will be held in a standard classroom, although students should bring their own laptops. Lectures will normally combine a 75% of expository classes and another 25% of guided practical work. In the expository part of the sessions, the theoretical aspects are presented and discussed and accompanied by practical examples, using slides that will be previously supplied to the student. The fundamental work environment of the practical part of the sessions will be R, of which an intermediate knowledge is presumed (use of the environment and basic programming).

Off-Site Learning: Off-site learning will consist of the study and resolution of (mainly practical) problems that the student should turn in throughout the course. Some of these exercises will require completion of programming tasks in R and preparation of short reports using RMarkdown (or a similar tool).

LEARNING OBJECTIVES OF THE SUBJECT

Upon completion of the course, the student should have acquired advanced competences on the general topics of statistical machine learning and unsupervised topics, specially data visualization. In particular, the student should be able to produce machine learning solutions for many complex problems, including those in which a reduction of dimension is necessary, those where the data comes as variables of different mixed types, or those where the number of variables greatly exceeds the number of observations, such as problems typically found in genomics.

STUDY LOAD

Type	Hours	Percentage
Self study	127,5	68.00
Hours large group	60,0	32.00

Total learning time: 187.5 h

CONTENTS

Introduction to unsupervised learning

Description:
Definition and illustrative examples of unsupervised learning

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

Nonlinear dimensionality reduction

Description:
a. Principal curves.
b. Local Multidimensional Scaling.
c. ISOMAP.
d. t-Stochastic Neighbor Embedding.
e. Applications

Full-or-part-time: 8h
Theory classes: 4h
Laboratory classes: 4h

Dimensionality reduction with sparsity

Description:
a. Matrix decompositions, approximations, and completion.
b. Sparse Principal Components and Canonical Correlation.
c. Applications

Full-or-part-time: 8h
Theory classes: 4h
Laboratory classes: 4h

General introduction to machine learning

Description:
Introduction to Bayesian thinking for machine learning. Learning by solving a regularized problem. Illustrative example.

Full-or-part-time: 5h
Theory classes: 2h
Practical classes: 3h

Learning in functional spaces

Description:
Reproducing kernel Hilbert spaces. The representer theorem. Example 1: Kernel ridge regression. Example 2: The Perceptron and the kernel Perceptron.

Full-or-part-time: 8h
Theory classes: 4h
Practical classes: 4h

Kernel functions in R^d

Description:
Description and demonstration of fundamental kernel functions in R^d. Polynomial and Gaussian kernels. General properties of kernel functions.

Full-or-part-time: 4h
Theory classes: 2h
Practical classes: 2h

The support vector machine for classification, regression and novelty detection

Description:
The support vector machine (SVM) is the flagship in kernel methods. Its versions for classification, regression and novelty detection are explained and demonstrated.

Full-or-part-time: 6h
Theory classes: 4h
Practical classes: 2h

Kernel functions for diferent data types

Description:
Some kernel functions for different data types are presented and demonstrated, such as text, trees, graphs, categorical variables, and others.

Full-or-part-time: 6h
Theory classes: 4h
Practical classes: 2h

Other kernel-based learning algorithms

Description:
Additional kernel-based learning methods are explained, such as kernel PCA and kernel FDA. These are illustrated in several application examples.

Full-or-part-time: 5h
Theory classes: 3h
Practical classes: 2h

Advanced ideas and techniques in kernel-based learning methods

Description:
Other advanced methods are briefly introduced, such as the RVM and GPs. Nyström acceleration and random Fourier features. Introduction to the idea of Deep Kernel Learning

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

GRADING SYSTEM

The grading method will be based in two basic marks, as follows:

1) Pr done through the course: 50%
2) Final exam: 50%

The practical work will consist in a term project as well as several exercises, all of which can be done in groups (their fornat will be specified onsite), but the exam is completed as an individual task.

EXAMINATION RULES.

The precise format for the exam will be specified with sufficient advance. It may include restrictions on the allowed knowledge sources, such as written notes, books, internet connection, etc.

BIBLIOGRAPHY

Basic:
- Hastie, Trevor; Tibshirani, Robert; Wainwright, Martin. Statistical learning with sparsity : The Lasso and Generalizations [on line]. CRC raton, 2015 [Consultation: 30/06/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=4087701. ISBN 78-1-4987-1216.
- Bishop, Christopher M. Pattern recognition and machine learning. New York: Springer, cop. 2006. ISBN 978-0387310732.
- Vapnik, Vladimir Naumovich. The Nature of statistical learning theory. 2nd ed. New York ; Barcelona [etc.]: Springer, cop. 2000. ISBN 978-0387987804.
- Kung, S. Y. Kernel Methods and Machine Learning [on line]. Cambridge University Press, 2014Available on: https://doi.org/10.1017/CBO9781139176224.
- Schölkopf, Bernhard; Smola, Alexander J. Learning with Kernels : support vector machines, regularization, optimization, and beyond. Cambridge ; London: The MIT Press, cop. 2002. ISBN 9780262194754.
- Hastie, Trevor; Tibshirani, Robert; Friedman, Jerome. The Elements of Statistical Learning : Data Mining, Inference, and Prediction [on line]. 2nd ed. New York, NY: Springer New York, 2009Available on: http://dx.doi.org/10.1007/978-0-387-84858-7. ISBN 978-0-387-84858-7.

Complementary:
- Smola, Alexander J. Advances in large margin classifiers [on line]. Cambridge, Mass.: MIT Press, 2000 [Consultation: 13/07/2022]. Available on:

https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=5966303. ISBN 9780262194488.

Course guide
34958 - MMPDE - Mathematical Modelling with Partial Differential Equations

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	749 - MAT - Department of Mathematics.
	751 - DECA - Department of Civil and Environmental Engineering.
Degree:	MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2022   **ECTS Credits:** 7.5   **Languages:** English

LECTURER

Coordinating lecturer:	SONIA FERNANDEZ MENDEZ
Others:	Primer quadrimestre:
	JEZABEL CURBELO HERNANDEZ - A
	SONIA FERNANDEZ MENDEZ - A
	JAIME HARO CASES - A
	JOSE JAVIER MUÑOZ ROMERO - A

PRIOR SKILLS

Good knowledge of Calculus techniques, including integral theorems. Elementary solution of PDEs and ODEs.

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.

Transversal:
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

The course mainly consists of theoretical lectures, but it also includes problem solving and computer sessions, with given finite differences codes to illustrate the behaviour of the models.

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BARCELONATECH

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.
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.

STUDY LOAD

Type	Hours	Percentage
Hours large group	60,0	32.00
Self study	127,5	68.00

Total learning time: 187.5 h

CONTENTS

1 Heat conduction and diffusion

Description:
Review of Vector Calculus, Fick and Fourier laws, random walks, self-similar solutions. Boundary conditions, energy functionals.

Full-or-part-time: 10h
Theory classes: 10h

2 Potentials in physics and technology

Description:
Classical gravitation. Electrostatics.

Full-or-part-time: 10h
Theory classes: 10h

3 Transients in continuous media

Description:
Steffan Problem: sharp interface model and phase-field model. Reaction-diffusion. Conservation laws: elasticity, viscoelasticity, wave equation, electromagnetics, Burger's equation.

Full-or-part-time: 20h
Theory classes: 20h

4. Fluid Mechanics

Description:
Euler equations and potential flows. Complex analysis methods in plane potential flows. Viscous flows. Acoustics, surface gravity waves, inertial waves.

Full-or-part-time: 20h
Theory classes: 20h

GRADING SYSTEM

60% continuous assessment (assignments and exercises) and 40% exam.

BIBLIOGRAPHY

Basic:
- Howison, Sam. Practical applied mathematics : modelling, analysis, approximation. New York: Cambridge University Press, 2005. ISBN 0521603692.
- Ockendon, J.R. [et al.]. Applied partial differential equations. Revised ed. Oxford: Oxford University Press, 2003. ISBN 0198527713.
- Witelsky, T.; Bowen, M. Methods of mathematical modelling. Cham (Switzerland): Springer, 2015. ISBN 978-3-319-23041-2.
- Chorin, A. J.; Marsden, J.E. A Mathematical Introduction to Fluid Mechanics. 3rd ed. Springer, ISBN 978-0387979182.

Complementary:
- Friedman, A.; Litman, W. Industrial mathematics : a course in solving real-world problems. Philadelphia: SIAM, 1994. ISBN 0898713242.
- Fowler, A.C. Mathematical models in the applied sciences. Cambridge: Cambridge University Press, 1997. ISBN 0521467039.
- Salsa, Sandro. Partial differential equations in action : from modelling to theory [on line]. Milan [etc.]: Springer, cop. 2008 [Consultation: 19/05/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=3062992. ISBN 9788847007512.
- LeVeque, Randall J. Finite Difference Methods for Ordinary and Partial Differential Equations: Steady State and Time Dependent Problems [on line]. SIAM, 2007Available on: https://faculty.washington.edu/rjl/fdmbook/. ISBN 978-0-898716-29-0.
- Dacorogna, Bernard. Introduction to the calculus of variations [on line]. 2015 [Consultation: 09/06/2021]. Available on: https://www.worldscientific.com/worldscibooks/10.1142/p967#t=toc. ISBN 978-1-78326-553-4.

Course guide
34960 - MMB - Mathematical Models in Biology

Last modified: 21/05/2022

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	749 - MAT - Department of Mathematics.

Degree: MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2022   **ECTS Credits:** 7.5   **Languages:** English

LECTURER

Coordinating lecturer: GEMMA HUGUET CASADES

Others: Primer quadrimestre:
JESUS FERNANDEZ SANCHEZ - A
GEMMA HUGUET CASADES - 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.

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.

Transversal:
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

The course will be structured in five blocks each consisting of a brief introduction through theoretical lectures, the development of a short project in groups and wrap-up sessions with oral presentations, discussion and complementary lectures. The central part intended to develop the short project will held at the computer lab.

LEARNING OBJECTIVES OF THE SUBJECT

This course is an introduction to the most common mathematical models in biology: in populations dynamics, ecology, neurophysiology, 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.
* Understand different gene prediction, alignment and phylogenetic reconstruction methods.
* Compare the predictions given by the models with real data.
* Communicate results in interdisciplinary teams.

STUDY LOAD

Type	Hours	Percentage
Hours large group	60,0	32.00
Self study	127,5	68.00

Total learning time: 187.5 h

CONTENTS

Mathematical models in phylogenetics

Description:
1. Brief introduction to genomics and phylogenetics (genome, gen structure, alignments, evolution of species...). Retrieving genomic sequences and alignments.
2. Markov models of molecular evolution (Jukes-Cantor, Kimura, Felsenstein hierarchy...), phylogenetic trees, branch lengths.
3. Phylogenetic tree reconstruction: distance and character based methods.
4. Genomics: Markov chains and Hidden Markov models for gene prediction. Tropical arithmetics and Viterbi algorithm. Forward and Expectation-Maximization algorithms. Multiple sequence alignment.

Full-or-part-time: 75h
Theory classes: 12h
Laboratory classes: 12h
Self study : 51h

Mathematical Models in Neuroscience

Description:
1. Membrane biophysics.
2. Excitability and action potentials: the Hodgkin-Huxley model, the Morris-Lecar model, integrate & fire models.
3. Bursting oscillations.
4. Synaptic transmission and dynamics.
5. Neuronal networks. Firing rate models. Wilson-Cowan equations.
6. Applications to cognitive tasks (working memory, decision making and visual perception).
7. Recurrent Neural Networks.
8. Statistical Models.

Full-or-part-time: 100h
Theory classes: 16h
Laboratory classes: 16h
Self study : 68h

Models of Population Dynamics

Description:
1. Modelling interactions among populations with differential equations. Stability and bifurcations.
2. One-dimensional discrete models. Chaos in biological systems.
3. Paradigms of population dynamics in current research.

Full-or-part-time: 12h 30m
Theory classes: 2h
Laboratory classes: 2h
Self study : 8h 30m

GRADING SYSTEM

50%: Each of the five blocks will give a part (10%) of the qualification, based on the perfomance on the short-projects.
20%: Overall evaluation of the participation, interest and proficiency evinced along the course.
30%: Final exam aiming at validating the acquisition of the most basic concepts of each block.

BIBLIOGRAPHY

Basic:
- Murray, J.D. Mathematical biology [on line]. 3rd ed. Berlin: Springer, 2002 [Consultation: 19/05/2020]. Available on: http://link.springer.com/book/10.1007/b98868 (v. 1) http://link.springer.com/book/10.1007/b98869 (v. 2). ISBN 978-0-387-95223-9.
- Izhikevich, Eugene M. Dynamical systems in neuroscience : the geometry of excitability and bursting. Cambridge: MIT Press, 2007. ISBN 0262090430.
- Ermentrout, Bard G.; Terman, David H. Mathematical foundations of neuroscience [on line]. New York: Springer, 2010 [Consultation: 19/05/2020]. Available on: http://dx.doi.org/10.1007/978-0-387-87708-2. ISBN 978-0-387-87708-2.
- Keeling, Matthew J.; Rohani, Pejman. Modeling infectious diseases in humans and animals. Princeton: Princeton University Press, cop. 2008. ISBN 9780691116174.
- Allman, Elizabeth S.; Rhodes, John A. Mathematical models in biology: an introduction. Cambridge: Cambridge University Press, 2004. ISBN 9780521819800.
- Istas, Jacques. Mathematical modeling for the life sciences [on line]. Berlin: Springer, 2005 [Consultation: 26/06/2020]. Available on: http://dx.doi.org/10.1007/3-540-27877-X. ISBN 354025305X.

Complementary:
- Bacaër, N.; Bravo de la Parra, R.; Ripoll, J. Breve historia de los modelos matemáticos en dinámica de poblaciones [on line].

[Consultation: 09/06/2021]. Available on: http://www3.uah.es/rafael_bravo/BreveHistoria.pdf. ISBN 9791034365883.

- Stein, William A. [et al.]. Sage mathematics software (Version 4.4.2) [on line]. 2010 [Consultation: 23/11/2012]. Available on: http://www.sagemath.org/.

- Pachter, Lior; Sturmfels, Bernd. Algebraic statistics for computational biology. Cambridge: Cambridge University Press, 2005. ISBN 0521857007.

- Keener, James P.; Sneyd, James. Mathematical physiology. Vol 1 [on line]. 2nd ed. New York: Springer Verlag, 2009 [Consultation: 19/05/2020]. Available on: http://dx.doi.org/10.1007/978-0-387-75847-3. ISBN 9780387758466.

- Durbin, Richard [et al.]. Biological sequence analysis : probabilistic models of proteins and nucleic acids [on line]. Cambridge: Cambridge University Press, 1998 [Consultation: 19/05/2020]. Available on: https://ebookcentral.proquest.com/lib/csuc-ebooks/detail.action?docID=320915. ISBN 0521629713.

- Feng, Jianfeng. Computational neuroscience : a comprehensive approach [on line]. Boca Raton: Chapman & Hall/CRC, 2004 [Consultation: 23/11/2012]. Available on: http://nba.uth.tmc.edu/homepage/cnjclub/2007summer/renart_chapter.pdf.

- Steel, Mike. Phylogeny: Discrete and random processes in evolution [on line]. CBMS-NSF Regional conference series in Applied Mathematics, SIAM, 2016 [Consultation: 14/06/2020]. Available on: https://my.siam.org/Store/Product/viewproduct/?ProductId=27861264. ISBN 978-1-611974-47-8.

- Miller, Paul. An Introductory course in computational neuroscience. Cambridge, Masachusetts: The MIT Press, [2018]. ISBN 9780262038256.

- Felsenstein, Joseph. Inferring phylogenies. Sunderland, Massachusetts: Sinauer Associates, cop. 2004. ISBN 978-0878931774.

Course guide
34951 - NCA - Non-Commutative Algebra

Last modified: 19/04/2022

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	749 - MAT - Department of Mathematics.

Degree:	MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2022 **ECTS Credits:** 7.5 **Languages:** English

LECTURER

Coordinating lecturer:	ENRIC VENTURA CAPELL
Others:	Primer quadrimestre:
	JOSE BURILLO PUIG - A
	JORGE DELGADO RODRÍGUEZ - A
	ENRIC VENTURA CAPELL - A

PRIOR SKILLS

The concept of group and subgroup, and the concept of homomorphism. Basic algebraic properties, binary operations and their properties. Equivalence relations and related set-theoretic properties.

REQUIREMENTS

The basic algebra courses from the 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.

Transversal:
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.

TEACHING METHODOLOGY

Classes follow the traditional structure of lecture by the professor, together with the assignment of problems and exercises for the students to solve and present, either in written or in oral form.

LEARNING OBJECTIVES OF THE SUBJECT

The main goal is to introduce the student into the basic ideas and techniques of non-commutative algebra, to the extend of being able to enroll himself/herself into some initial research project in the area, if there is interest to do so.

Non-commutative algebra plays a significant role in the research panorama in modern mathematics and students of any degree in mathematics have been introduced to it. The main goal of the present topic is to go a bit deeper into this area of mathematics, offering a general but consistent introduction into the topic.

We'll center our attention towards the so-called "Geometric Group Theory", a relatively young and very active research area. This election is done because it allows to go, within a full semester, from the basics of the theory to the description, with a good level of details and context, of some open problems that are currently being object of active research today.

STUDY LOAD

Type	Hours	Percentage
Self study	127,5	68.00
Hours large group	60,0	32.00

Total learning time: 187.5 h

CONTENTS

Generalities about infinite groups

Description:
The free group: basic definitions.
Presentations: generators and relations.
Short exact sequences, direct and semidirect products.
Free products, amalagams, HNN extensions.

Full-or-part-time: 45h
Theory classes: 15h
Self study : 30h

Cayley graphs and growth of groups

Description:
Cayley graph and growth of a group
Quasi-isometries, geometric properties
Growth of groups: polynomial, intermediate, exponential, uniformly exponential
Gromow theorem

Full-or-part-time: 45h
Theory classes: 15h
Self study : 30h

Hyperbolic groups

Description:
Several definitions of hyperbolicity for groups
Hyperbolic groups admit a Dehn presentation
Centralizers in hyperbolic groups
Characterization of hyperbolic groups as those having linear Dehn function

Full-or-part-time: 45h
Theory classes: 15h
Self study : 30h

Algorithmic problems in groups

Description:
The three classical algorithmic problems in group theory: word, conjugacy and isomorphism problems.
Resolution in simple cases: abelian, free, free-like constructions, residually finite, etc.
Tietze transformations, an attack to the isomorphism problem
Some unsolvability results: Novikov, Miller, Mihailova, etc.

Full-or-part-time: 45h
Theory classes: 15h
Self study : 30h

GRADING SYSTEM

Students will have to present in written and/or oral form the exercises assigned along the development of the course.

At the end of the course, each student (indivually or in small groups) will choose a topic in Geometric Group Theory of his/her interest (from an offered list, or proposed by himself/herself and validated by the teacher), and write a project on it, preparing both a writen document (15-20 pages) and a one-two hours lecture on it.

BIBLIOGRAPHY

Basic:
- Rotman, Joseph. An introduction to the theroy of groups. 4th ed. New York: Springer, 1995. ISBN 3-540-94285-8.
- Bogopolskij, Oleg Vladimirovic. Introduction to group theory. Zürich: European Mathematical Society, 2008. ISBN 9783037190418.
- Lyndon, Roger C.; Schupp, Paul E. Combinatorial group theory. 2nd ed. Berlin: Springer, 2001. ISBN 978-3540411581.
- Loh, Clara. Geometric group theory : an introduction [on line]. Universitext. Springer, 2017 [Consultation: 21/06/2021]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=6312482. ISBN 978-3-319-72253-5.

Complementary:
- Epstein, David B.A. [et al.]. Word processing in groups. Boston: Jones and Bartlett, 1992. ISBN 978-0867202441.
- Ghys, E.; La Harpe, P. de. Sur les groupes hyperboliques d'après Mikhael Gromov. Boston: Birkhäuser, 1990. ISBN 978-0817635084.

RESOURCES

Other resources:
Several interesting papers and notes by Chuck Miller:

https://researchers.ms.unimelb.edu.au/ cfm/papers

Course guide
34953 - NT - Number Theory

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	749 - MAT - Department of Mathematics.

Degree:	MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2022   **ECTS Credits:** 7.5   **Languages:** English

LECTURER

Coordinating lecturer:	ANA RIO DOVAL
Others:	Primer quadrimestre: JOAN CARLES LARIO LOYO - A ANA RIO DOVAL - A

PRIOR SKILLS

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

REQUIREMENTS

Basic material covered in any standard courses on arithmetic, group theory and Galois theory.

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.

Transversal:
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.

TEACHING METHODOLOGY

Most of the lectures will take place on the blackboard (replaced by online lessons if necessary), 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) Number theory in function fields.
2) Cyclotomic theory.

STUDY LOAD

Type	Hours	Percentage
Hours large group	60,0	32.00
Self study	127,5	68.00

Total learning time: 187.5 h

CONTENTS

Algebraic Number Theory

Description:
Introduction
Cyclotomic extensions
Cyclotomic polynomials

Full-or-part-time: 10h
Theory classes: 10h

Number Theory in function fields

Description:
Functions fields over finite fields
Carlitz polynomials
Carlitz extensions

Full-or-part-time: 10h
Theory classes: 10h

Cyclotomic Theory

Description:
Cyclotomic integers
Cyclotomic units
Unique factorization
Class numbers
Galois action
Kronecker-Weber theorem
Regular polygons
Fermat equation
Quadratic reciprocity

Carlitz modules
Galois action
Carlitz-Hayes theorem
Cyclotomic and Carlitz analogies
Quadratic reciprocity
Drinfeld modules

Full-or-part-time: 40h
Theory classes: 40h

GRADING SYSTEM

There will be a final exam.

EXAMINATION RULES.

Solved exercises and works must be delivered according to schedule.

BIBLIOGRAPHY

Basic:
- Marcus, D. A.. Number fields [on line]. 2a. Springer, 2018 [Consultation: 21/06/2021]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=6315071. ISBN 978-3-319-90232-6.
- Washington, Lawrence C. Introduction to cyclotomic fields. 2a. Springer, 1997. ISBN 978-0-387-94762-4.
- Samuel, Pierre. Algebraic theory of numbers [on line]. Dover, 2008 [Consultation: 21/06/2021]. Available on: http://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=1152495. ISBN 978-0486466668.
- Lang, Serge. Cyclotomic Fields I and II. 2a. Springer, 1990. ISBN 978-0-387-96671-7.
- Weiss, Edwin. Algebraic Number Theory [on line]. Dover, 2012 [Consultation: 21/06/2021]. Available on: http://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=1151112. ISBN 9780486154367.
- Goss, David. Basic structures of function field arithmetic. Springer, 1998. ISBN 978-3-540-63541-3.
- Rosen, Michael. Number theory in function fields [on line]. Springer, 2002 [Consultation: 18/11/2020]. Available on: http://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=2536816. ISBN 978-0387953359.

RESOURCES

Computer material:
- SAGE. Mathematical Software
- Matlab. Mathematical software

Course guide
34964 - NMDS - Numerical Methods for Dynamical Systems

Last modified: 19/04/2022

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	749 - MAT - Department of Mathematics.

Degree:	MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2022   **ECTS Credits:** 7.5   **Languages:** English

LECTURER

Coordinating lecturer:	MERCEDES OLLE TORNER
Others:	Primer quadrimestre: 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:
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.

Transversal:
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

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 dessigned to solve particular problems in dynamical systems

STUDY LOAD

Type	Hours	Percentage
Hours large group	60,0	32.00
Self study	127,5	68.00

Total learning time: 187.5 h

CONTENTS

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

Full-or-part-time: 4h
Theory classes: 2h
Practical classes: 2h

Dynamical systems: introduction, definitions. Continuous and discrete dynamical systems. Orbit generation. Numerical computation of Poincare maps. Examples.

Full-or-part-time: 6h
Theory classes: 3h
Practical classes: 3h

Computation and stability of fixed points. Vector fields and maps. Implementation and examples.

Full-or-part-time: 10h
Theory classes: 5h
Practical classes: 5h

Computation of tori: representation, computation and continuation. Implementation and examples.

Full-or-part-time: 15h
Theory classes: 7h 30m
Practical classes: 7h 30m

Analysis of bifurcations. Some examples.

Full-or-part-time: 15h
Theory classes: 7h 30m
Practical classes: 7h 30m

GRADING SYSTEM

65% of the qualification will be obtained from the practical assignments done and 35% from short exams.

EXAMINATION RULES.

No rules, in principle.

BIBLIOGRAPHY

Basic:
- Strogatz, S.H.. Nonlinear dynamics and chaos : with applications to physics, biology, chemistry, and engineering [on line]. 2nd ed. CRC Press, Taylor and Francis Group, 2018 [Consultation: 26/06/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=1181622.
- Lichtenberg, Allan J; Lieberman, M. A. Regular and stochastic motion. New York: Springer-Verlag, 1983. ISBN 0387907076.
- Press, William H. Numerical recipes in C : the art of scientific computing. 2nd. Cambridge: Cambridge University Press, 1992.
- Arrowsmith, D. K; Place, C. M. An introduction to dynamical systems. Cambridge: Cambridge University Press, 1990. ISBN 0521303621.
- Particular articles related to the topics of the course and some notes from suitable web pages.
- Stuart, A.M. ; Humphries, A. R. Dynamical systems and numerical analysis. Cambridge University Press, 1996.

Course guide
34965 - NMPDE - Numerical Methods for Partial Differential Equations

Last modified: 19/04/2022

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	751 - DECA - Department of Civil and Environmental Engineering.

Degree: MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2022   **ECTS Credits:** 7.5   **Languages:** English

LECTURER

Coordinating lecturer: SONIA FERNANDEZ MENDEZ

Others: Primer quadrimestre:
                                  SONIA FERNANDEZ MENDEZ - A
                                  ABEL GARGALLO PEIRO - 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.

Transversal:
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.

LEARNING OBJECTIVES OF THE SUBJECT

This course is an introduction to numerical methods for the solution of partial differential equations, with application to applied sciences, engineering and biosciences.

The course recalls the theoretical basis of the Finite Element Method (FEM) for the solution of elliptic and parabolic equations, an introduction to stabilization techniques for convection-dominated problems and the FEM for compressible flow problems, and for wave problems.

The course will include frontal lectures and exercises, as well as computer sessions aimed at introducing the bases of the programming of the numerical methods.

STUDY LOAD

Type	Hours	Percentage
Self study	127,5	68.00
Hours large group	60,0	32.00

Total learning time: 187.5 h

CONTENTS

Fundamentals of Finite Element Methods (FEM)

Description:
Basic concepts of the Finite Element Method (FEM) for elliptic and parabolic equations: strong and weak form, discretization, implementation, functional analysis tools, error bounds and convergence.
Application to the numerical modelling of flow in porous medium, and potential flow.
Introduction to a posteriori error estimation and adaptivity.
Time integration for transient problems.
Solution of the convection-diffusion equation. Stabilized formulations for convection dominated problems.
Numerical solution of linear elasticity problems.

Full-or-part-time: 32h
Theory classes: 16h
Laboratory classes: 16h

FEM for incompressible flow problems

Description:
Weak form and discretization of the Stokes equations. Stable FEM discretizations for incompressible flow problems: LBB condition. Introduction to the numerical solution of the incompressible Navier-Stokes equations.

Full-or-part-time: 14h
Theory classes: 7h
Practical classes: 7h

FEM for wave problems

Description:
FEM solution of Helmholtz equation. Non-reflecting boundary conditions. Application to acoustics.
Introduction to DG for first order conservation laws.

Full-or-part-time: 14h
Theory classes: 7h
Laboratory classes: 7h

GRADING SYSTEM

Exams (50%) and continuous assesment (exercises, projects and/or oral presentations) (50%).

BIBLIOGRAPHY

Basic:
- Quarteroni, Alfio. Numerical Models for Differential Problems [on line]. Springer, 2009 [Consultation: 19/05/2020]. Available on: http://dx.doi.org/10.1007/978-88-470-1071-0.
- Wait, R.; Mitchell, A. R. Finite element analysis and applications. Chichester: John Wiley, 1985. ISBN 0471906778.
- Zienkiewicz, O.C.; Taylor, R. L. The finite element method [on line]. 6th ed. Oxford: Butterworth Heinemann, 2005 [Consultation: 19/05/2020]. Available on: http://www.sciencedirect.com/science/book/9780750664318.
- Donea, Jean M; Huerta, A. Finite element methods for flow problems [on line]. Chichester: John Wiley & Sons, 2003 [Consultation: 19/05/2020]. Available on: https://onlinelibrary.wiley.com/doi/book/10.1002/0470013826. ISBN 0471496669.
- Ainsworth, M.; Oden, J. T. A posteriori error estimation in finite element analysis. New York: John Wiley & sons, 2000. ISBN 047129411X.

Complementary:
- Hoffman, Joe D. Numerical methods for engineers and scientists. 2nd ed. rev. and exp. New York: Marcel Dekker, 2001. ISBN 0824704436.
- Johnson, Claes. Numerical solution of partial differential equations by the finite element. Mineola, New York: Dover Publications, 2009. ISBN 9780486469003.
- Strang, G.; Fix, G. J. An analysis of the finite element method. Englewood Cliffs, NJ: Prentice-Hall, 1973. ISBN 0130329460.
- Trefethen, Lloyd N.; Bau, David. Numerical linear algebra. Philadelphia: SIAM, 1997. ISBN 9780898713619.

Course guide
34961 - QQMDS - Quantitative and Qualitative Methods in Dynamical Systems

Last modified: 19/04/2022

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	749 - MAT - Department of Mathematics.
Degree:	MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2022   **ECTS Credits:** 7.5   **Languages:** English

LECTURER

Coordinating lecturer:	PAU MARTIN DE LA TORRE
Others:	Primer quadrimestre: INMACULADA CONCEPCION BALDOMA BARRACA - A PAU MARTIN DE LA TORRE - A

PRIOR SKILLS

Good knowledge of calculus, algebra and differential equations. It is strongly recommended a good understanding of the basic theory of ordinary differential equations as well as a basic knowledge of dynamical systems from a local point of view.

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.

Transversal:
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

We do not 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 kind of systems and we will mainly focus in the use of perturvatives techniques to study a dynamical system globally.

LEARNING OBJECTIVES OF THE SUBJECT

STUDY LOAD

Type	Hours	Percentage
Hours large group	60,0	32.00
Self study	127,5	68.00

Total learning time: 187.5 h

CONTENTS

Invariant objects in Dynamical Systems

Description:
Continuous and discrete Dynamical Systems.
Poincaré map.
Local behaviour of hyperbolic invariant objects. Conjugation.
Invariant manifolds.

Full-or-part-time: 10h
Theory classes: 10h

Normal forms

Description:
Poincaré-Dulac normal forms. Convergence: Poincaré and Siegel domains.

Full-or-part-time: 10h
Theory classes: 10h

Perturbation theory in Dynamical Systems

Description:
Clasic perturbation theory. Averaging theory. Perturbed homoclinic orbits in the plane. Melnikov method. Singular pertubation theory.

Full-or-part-time: 15h
Theory classes: 15h

Bifurcations

Description:
Local bifurcations for planar vector fields and real maps. Saddle node and Hopf bifurcations.

Full-or-part-time: 10h
Theory classes: 10h

Homoclinic points and chaotic Dynamics

Description:
Smale horseshoe. Homoclinic points and bifurcations. Hyperbolic sets and transversal homoclinic points. Dynamical systems with chaotic dynamics. Newhouse phenomenum.

Full-or-part-time: 10h
Theory classes: 10h

Non-smooth systems

Description:
Introduction to non-smooth diferential equations. Definition and motivating examples.
Filipov's convention.

Full-or-part-time: 5h
Theory classes: 5h

GRADING SYSTEM

The students have to do some problems (60%) and a research work (25%). There will be also a final exam covering on the theoretical part of the subject (15%). On the other hand they will attend the winter courses "Recent trends in non-linear science" and produce a document about them.

EXAMINATION RULES.

There will be a final exam covering the theoretical part of the course.

BIBLIOGRAPHY

Basic:
- Hirsch, Morris W.; Smale, Stephen; Devaney, Robert L. Differential equations, dynamical systems, and an introduction to chaos. 3rd Edition. Oxford: Elsevier, 2013. ISBN 9780123820105.
- Hasselblatt, Boris; Katok, A. B. A First course in dynamics : with a panorama of recent developments. Cambridge [etc.]: Cambridge University Press, 2003. ISBN 0-521-58304-7.
- Arrowsmith, D. K; Place, C. M. An Introduction to dynamical systems. Cambridge [England] ; New York: Cambridge University Press, 1990. ISBN 0-521-30362-1.
- Guckenheimer, John; Holmes, Philip. Nonlinear oscillations, dynamical systems, and bifurcations of vector fields. New York, NY [etc.]: Springer-Verlag, 1983. ISBN 0-387-90819-6.
- Katok, Anatole; Hasselblatt, Boris. Introduction to the modern theory of dynamical systems. Cambridge [etc.]: Cambridge University Press, 1995. ISBN 0-521-34187-6.

Course guide
200901 - SAGDM - Seminar on Algebra, Geometry and Discrete Mathematics

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	749 - MAT - Department of Mathematics.

Degree:	MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2022   **ECTS Credits:** 3.0   **Languages:** English

LECTURER

Coordinating lecturer:	JUAN JOSÉ RUE PERNA
Others:	Segon quadrimestre: JUAN JOSÉ RUE PERNA - A

PRIOR SKILLS

The student must know the basics on graph theory. Additionally, it is necessary to have some knowledge on probability theory, group theory and arithmetics.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
MAMME-CE1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
MAMME-CE3. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
MAMME-CE4. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.

TEACHING METHODOLOGY

This seminar will be based on the presentation (from the responsible and the students) of material in the context of the theory of expanders. This material will be taken from specialized books and research papers.

LEARNING OBJECTIVES OF THE SUBJECT

The main objective of the seminar is to show an area of □□□□mathematics that intersects both algebra and geometry, discrete mathematics and other related areas, such as computer science, low-dimensional geometry and probability theory, among others.

The main objective is to get the student to gain a basic knowledge of expander theory, as well as the various applications in various branches of contemporary mathematics. In this direction, the student will also be encouraged to learn to conduct technical talks in public and in the preparation of technical scientific documents.

STUDY LOAD

Type	Hours	Percentage
Hours large group	24,0	32.00
Self study	51,0	68.00

Total learning time: 75 h

CONTENTS

Spectral graph Theory and expanders

Description:
- Spectral graph theory.
- Spectral bounds: spectral gap, Mixing Lemma, Alon-Boppana. Ramanujan graphs.
- Existence of graph expanders: Margulis construction. Probabilistic contructions.

Full-or-part-time: 20h
Theory classes: 6h 40m
Self study : 13h 20m

Graph expanders and group theory

Description:
- Cayley graphs. Properties
- Random walks in Cayley graphs.
- Kazhan Property (T) and relation with expansion phenomena

Full-or-part-time: 9h 20m
Theory classes: 6h
Self study : 3h 20m

Graf expanders and Number Theory

Description:
- Sum-product phenomena. Balog-Szemerédi-Gowers Theorem.
- Classical algebraic groups and quasi-random groups.
- Expansion in SL2(Fq): Helfgott Theorem and Bourgain-Gamburd

Full-or-part-time: 12h
Theory classes: 6h
Self study : 6h

Other applications of graph expanders

Description:
- Applications in knot theory: the Barzdin-Kolmogorov theorem
- Applications in theoretical computer science: design of concentrators
- Applications in theoretical computing: design of algorithms
- Applications in algebraic number theory: elliptic curves

Full-or-part-time: 12h
Theory classes: 6h
Self study : 6h

GRADING SYSTEM

The grading of this seminar will be based on three points: (CA) Continuous evaluation, (MP) Material preparation and (PT) presentation.

(CA): will be based on the understanding of the material, as well as the meetings that will be held between the student and the responsible to prepare the student's presentation (or presentations). It will also include the fact of being active during the seminar sessions.
(MP): preparation of both the presentation, its good preparation and the summary sheet.
(PT): presentation. This will include questions from the teacher and students.

Overall grading of the seminar: 30% (CA)+20% (MP)+50% (PT)

BIBLIOGRAPHY

Basic:
- Kowalski, Emmanuel. An introduction to expander graphs. Sócieté Mathématique de France, 2019.
- Krebs, Mike; Shaheen, Anthony. Expander families and Cayley graphs : A beginner's guide [on line]. Oxford University Press, 2011 [Consultation: 21/06/2021]. Available on: http://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=422166.
- Davidoff,Giuliana; Sarnak, Peter; Valette, Alain. Elementary number theory, group theory and Ramanujan graphs [on line]. London Mathematical Society, 2003Available on: https://doi.org/10.1017/CBO9780511615825.
- SHLOMO HOORY, NATHAN LINIAL, AND AVI WIGDERSON. "Expander graphs and their applications". Bulletin of the American Mathematical Society [on line]. [Consultation: 25/06/2020]. Available on: https://www.cse.huji.ac.il/~nati/PAPERS/expander survey.pdf.

Complementary:
- Lubotzky, Alex. Discrete groups, expanding graphs and invariant measures. Birkhäuser, 1994.

Course guide
200902 - SADEM - Seminar on Analysis, Differential Equations and Modelling

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	748 - FIS - Department of Physics.
	749 - MAT - Department of Mathematics.

Degree:	MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2022   **ECTS Credits:** 3.0   **Languages:** English

LECTURER

Coordinating lecturer:	GEMMA HUGUET CASADES
Others:	Segon quadrimestre:
	GEMMA HUGUET CASADES - A
	JOSEP JOAQUIM MASDEMONT SOLER - A
	ALVARO MESEGUER SERRANO - A
	JOSE JAVIER MUÑOZ ROMERO - A

PRIOR SKILLS

It is important to have some background in one of the following areas: Dynamical Systems, Partial Differential Equations, Numerical methods and discretisation methods for PDEs.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
MAMME-CE1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
MAMME-CE2. MODELLING. Formulate, analyse and validate mathematical models of practical problems by using the appropriate mathematical tools.
MAMME-CE3. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
MAMME-CE4. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.

TEACHING METHODOLOGY

Students will present a topic related to Mathematical Analysis for Oscillatory Systems autonomously on a seminar format. This material will be taken from specialized books and research papers.
There will be some meetings between the instructor and the students before the oral presentation.
Students must prepare an abstract/report of the seminar to help the rest of the students attending the seminar to understand the topic.
Students must attend at least 90% of the lectures and be active in all the presentations.

LEARNING OBJECTIVES OF THE SUBJECT

The main goal is to provide the students with a basic knowledge on mathematical methods for the analysis for oscillatory systems, as well as, several applications in different branches of applied mathematics. The topic intersects with dynamical systems, partial differential equations as well as numerical methods, amongst others.

Additionally, the students will learn how to conduct technical talks in public and prepare technical scientific documents.

STUDY LOAD

Type	Hours	Percentage
Self study	51,0	68.00
Hours large group	24,0	32.00

Total learning time: 75 h

CONTENTS

Mathematical tools for periodic orbits and stability analysis

Description:
Poincaré Section. Perturbation analysis. Characteristic equations

Full-or-part-time: 15h
Theory classes: 4h
Self study : 11h

Biological oscillators

Description:
Reaction-Diffusion equations and Turing patterns. Biological oscillators in neural systems. Electrical + ion concentration fields. Hodgkin-Huxley equations.

Full-or-part-time: 30h
Theory classes: 10h
Self study : 20h

Oscillations in mechanics

Description:
Chemo-mechanical oscillators in elasticity. Delay systems in mechanics and biology. Wave Propagation in solids and fluids: acoustics, surface waves, etc. Periodic orbits in celestial mechanics.

Full-or-part-time: 30h
Theory classes: 10h
Self study : 20h

GRADING SYSTEM

The grading of this seminar will be based on three aspects: (C) Continuous evaluation, (M) Material preparation and (P) Presentation.

(C): the grade will be based on the understanding of the material, as well as the meetings that will be held between the student and the instructor to prepare the student's presentation (or presentations). The goal of the seminar is to ensure that the audience understands the lectures and its technicalities.
(M): the grade will be based on the quality of both the presentation slides and the abstract/report.
(P): the grade will be based on the clarity of the presentation. This will include questions from the teacher and students.

Overall grading of the seminar: 30% (C) + 20% (M) + 50% (P)

BIBLIOGRAPHY

Basic:
- Murray, J. D. Mathematical biology [on line]. 3rd ed. New York [etc.]: Springer, 2002-2003Available on: https://link.springer.com/book/10.1007/b98868 (v.1) - https://link.springer.com/book/10.1007/b98869 (v.2). ISBN 978-0-387-22437-4.
- Strogatz, Steven H. Nonlinear dynamics and chaos : with applications to physics, biology, chemistry and engineering [on line]. 2nd ed. CRC Press, Taylor, 2018Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=1181622.
- Keener, James; Sneyd, James. Mathematical Physiology [on line]. New York, NY: Springer New York, 2009 [Consultation: 25/06/2020]. Available on: http://dx.doi.org/10.1007/978-0-387-75847-3 (v.1) - http://dx.doi.org/10.1007/978-0-387-79388-7 (v.2). ISBN 978-0-387-75847-3.
- Guckenheimer, John; Holmes, Philip. Nonlinear oscillations, dynamical systems, and bifurcations of vector fields. New York, NY [etc.]: Springer-Verlag, 1983. ISBN 0387908196.
- Erneux, Thomas. Applied Delay Differential Equations [on line]. New York, NY: Springer New York, 2009Available on: http://dx.doi.org/10.1007/978-0-387-74372-1. ISBN 978-0-387-74372-1.

Master's degree in Advanced Mathematics and Mathematical Engineering (MAMME)

El **master's degree in Advanced Mathematics and Mathematical Engineering (MAMME)** (**màster universitari en Matemàtica Avançada i Enginyeria Matemàtica)** (**web del màster**) és un programa de màster ofertat per la Facultat de Matemàtiques i Estadística (FME) de 60 ECTS, dividits en 45 ECTS de cursos, més 15 ECTS de tesi de màster.

L'oferta de cursos permet als nostres estudiants dissenyar el seu currículum amb dues possibles orientacions: un currículum en matemàtica pura (orientat a recerca en matemàtica fonamental) o un currículum en matemàtica aplicada (preparant els estudiants per a recerca en matemàtica aplicada, y per a treballar en equips interdisciplinaris en col·laboració amb enginyers, físics, biòlegs, economistes, etc).

El MAMME ofereix també la possibilitat de cursar fins a 22.5 ECTS a altres màsters en matemàtiques o estadística, o a altres màsters de la UPC, permetent dissenyar un currículum interdisciplinari basat en la selecció de cursos en màsters en enginyeria o ciències aplicades.
Veure les propostes de focalització a http://mamme.masters.upc.edu/en.

DADES GENERALS

Durada i inici
Un curs acadèmic, 60 crèdits ECTS. Inici: setembre i febrer

Horaris i modalitat
Tarda. Presencial

Preus i beques
Preu aproximat del màster sense despeses addicionals, 1.660 € (4.150 € per a no residents a la UE).
Més informació sobre preus i pagament de la matrícula
Més informació de beques i ajuts

Idiomes
Anglès

Informació sobre l'ús de llengües a l'aula i els drets lingüístics de l'estudiantat.

Lloc d'impartició

Facultat de Matemàtiques i Estadística (FME)

Títol oficial
Inscrit en el registre del Ministeri d'Educació, Cultura i Esport

ACCÉS

Requisits generals
Requisits acadèmics d'accés a un màster

Places
30 places setembre i 3 places al febrer

Preinscripció
Període de preinscripció obert.
Termini previst: fins al 30/11/2022.
Com es formalitza la preinscripció?

Admissió i matrícula
   Com es formalitza la matrícula?

Legalització de documents
   Els documents expedits per estats no membres de la Unió Europea ni signataris de l'Acord sobre l'espai econòmic europeu han d'estar legalitzats per via diplomàtica o amb la postil·la corresponent.

ACORDS DE DOBLE TITULACIÓ

Amb altres universitats internacionals
- Master's degree in Advanced Mathematics and Mathematical Engineering (FME) + Master of Science in Applied Mathematics (Illinois Institute of Technology). (Flux solament de l'FME a Illinois)

SORTIDES PROFESSIONALS

Sortides professionals

Algunes de les sortides professionals dels titulats i titulades d'aquest màster són la recerca acadèmica (fent un doctorat en matemàtiques, ciència o enginyeria, per exemple), la modelització matemàtica en la indústria, les finances, l'estadística i la recerca aplicada (centres de recerca biomèdica, visió per ordinador, etc.).

Competències

Competències transversals

Les competències transversals descriuen allò que un titulat o titulada ha de saber o ha de ser capaç de fer en acabar el procés d'aprenentatge, amb independència de la titulació. **Les competències transversals establertes a la UPC** són emprenedoria i innovació, sostenibilitat i compromís social, coneixement d'una tercera llengua (preferentment l'anglès), treball en equip i ús solvent dels recursos d'informació.

Competències específiques

1. (Recerca). Llegir i comprendre articles avançats de recerca en matemàtiques. Utilitzar tècniques de recerca en matemàtiques per produir i transmetre nous resultats.
2. (Modelització). Formular, analitzar i validar models matemàtics de problemes pràctics utilitzant les eines matemàtiques més adequades.
3. (Càlcul). Obtenir solucions (exactes o aproximades) a aquests models amb els recursos disponibles, incloent-hi mitjans computacionals.
4. (Avaluació crítica). Discutir la validesa, l'abast i la importància d'aquestes solucions; presentar resultats i defensar conclusions.
5. (Docència). Ensenyar matemàtiques a nivell universitari.

ORGANITZACIÓ ACADÈMICA: NORMATIVES, CALENDARIS

Centre docent UPC
   Facultat de Matemàtiques i Estadística (FME)

Responsable acadèmic del programa
   Juan José Rue Perna

Calendari acadèmic
   Calendari acadèmic dels estudis universitaris de la UPC

Normatives acadèmiques
   Normativa acadèmica dels estudis de màster de la UPC

PLA D'ESTUDIS		
Assignatures	**crèdits ECTS**	**Tipus**
PRIMER QUADRIMESTRE		
Àlgebra Commutativa	7.5	Optativa
Àlgebra No Commutativa	7.5	Optativa
Geometria Discreta i Algorítmica	7.5	Optativa
Mètodes Numèrics per a Equacions en Derivades Parcials	7.5	Optativa
Mètodes Numèrics per a Sistemes Dinàmics	7.5	Optativa
Mètodes Quantitatius i Qualitatius en Sistemes Dinàmics	7.5	Optativa
Modelització Matemàtica amb Equacions en Derivades Parcials	7.5	Optativa
Models Matemàtics en Biologia	7.5	Optativa
Teoria de Grafs	7.5	Optativa
Teoria de Nombres	7.5	Optativa
SEGON QUADRIMESTRE		
Aprenentatge Automàtic	7.5	Optativa
Codis i Criptografia	7.5	Optativa
Combinatòria	7.5	Optativa
Curs Avançat d'Equacions en Derivades Parcials	7.5	Optativa
Geometria Algebraica	7.5	Optativa
Mecànica Computacional	7.5	Optativa
Seminari d'Àlgebra, Geometria i Matemàtica Discreta	3	Optativa
Seminari d'Anàlisis, Equacions Diferencials i Modelització	3	Optativa
Sistemes Hamiltonians	7.5	Optativa
Varietats Diferenciables	7.5	Optativa

Master's degree in Advanced Mathematics and Mathematical Engineering (MAMME)

El **master's degree in Advanced Mathematics and Mathematical Engineering (MAMME)** (**máster universitario en Matemática Avanzada e Ingeniería Matemática)** (**web del máster**) es un programa de máster ofrecido por la Facultad de Matemáticas y Estadística (FME) de 60 ECTS, divididos en 45 ECTS de cursos, más 15 ECTS de tesis de máster.

La oferta de cursos permite a nuestros estudiantes diseñar su currículum con dos posibles orientaciones diferentes: un currículum en matemática pura (orientado a investigación en matemática fundamental) o un currículum en matemática aplicada (preparando los estudiantes para investigación en matemática aplicada, y para trabajar en equipos interdisciplinares en colaboración con ingenieros, físicos, biólogos, economistas, etc).

Además, MAMME ofrece la posibilidad de cursar hasta 22.5 ECTS en otros másteres en matemáticas o estadística, o en otros másteres de la UPC, permitiendo diseñar un currículum interdisciplinar basado en la selección de cursos en másteres en ingeniería o ciencias aplicadas.
Vea las propuestas de focalización en http://mamme.masters.upc.edu/en.

DATOS GENERALES

Duración e inicio
Un curso académico, 60 créditos ECTS. Inicio septiembre y febrero

Horarios y modalidad
Tarde. Presencial

Precios y becas
Precio aproximado del máster sin gastos adicionales, 1.660 € (4.150 € para no residentes en la UE).
Más información sobre precios y pago de la matrícula
Más información de becas y ayudas

Idiomas
Inglés

Información sobre el uso de lenguas en el aula y los derechos lingüísticos de los estudiantes.

Lugar de impartición

Facultad de Matemáticas y Estadística (FME)

Título oficial
Inscrito en el registro del Ministerio de Educación, Cultura y Deporte

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ACCESO

Requisitos generales
Requisitos académicos de acceso a un máster

Plazas
33

Preinscripción
Periodo de preinscripción abierto.
Fecha límite prevista: hasta el 30/11/2022.

    [¿Cómo se formaliza la preinscripción?](#)

Matrícula
    [¿Cómo se formaliza la matrícula?](#)

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ACUERDOS DE DOBLE TITULACIÓN

Con otras universidades internacionales

- *Master in Advanced Mathematics & Mathematical Engineering* (FME) + *Master of Science in Applied Mathematics* (Illinois Institute of Technology). (Flujo sólo de la FME en Illinois)

SALIDAS PROFESIONALES

Salidas profesionales

Algunas de las salidas profesionales de los titulados de este máster son la investigación académica (haciendo un doctorado en matemáticas, ciencia o ingeniería, por ejemplo), la modelización matemática en la industria, las finanzas, la estadística y la investigación aplicada (centros de investigación biomédica, visión por ordenador, etc.).

Competencias

Competencias transversales

Las competencias transversales describen aquello que un titulado o titulada es capaz de saber o hacer al concluir su proceso de aprendizaje, con independencia de la titulación. **Las competencias transversales establecidas en la UPC** son la capacidad de espíritu empresarial e innovación, sostenibilidad y compromiso social, conocimiento de una tercera lengua (preferentemente el inglés), trabajo en equipo y uso solvente de los recursos de información.

Competencias específicas

1. (Investigación). Leer y comprender artículos avanzados de investigación en matemáticas. Utilizar técnicas de investigación en matemáticas para producir y transmitir nuevos resultados.
2. (Modelización). Formular, analizar y validar modelos matemáticos de problemas prácticos utilizando las herramientas matemáticas más adecuadas.
3. (Cálculo). Obtener soluciones (exactas o aproximadas) a estos modelos con los recursos disponibles, incluyendo medios computacionales.
4. (Evaluación crítica). Discutir la validez, el alcance y la importancia de estas soluciones; presentar resultados y defender conclusiones.
5. (Docencia). Enseñar matemáticas a nivel universitario.

ORGANIZACIÓN ACADÉMICA: NORMATIVAS, CALENDARIOS

Centro docente UPC
    [Facultad de Matemáticas y Estadística (FME)](#)

Responsable académico del programa
    [Juan José Rue Perna](#)

Calendario académico
    [Calendario académico de los estudios universitarios de la UPC](#)

Normativas académicas
    [Normativa académica de los estudios de máster de la UPC](#)

Asignaturas	créditos ECTS	Tipo
PRIMER CUATRIMESTRE		
Álgebra Conmutativa	7.5	Optativa
Álgebra No Conmutativa	7.5	Optativa
Geometría Discreta y Algorítmica	7.5	Optativa
Métodos Cuantitativos y Cualitativos en Sistemas Dinámicos	7.5	Optativa
Métodos Numéricos para Ecuaciones en Derivadas Parciales	7.5	Optativa
Métodos Numéricos para Sistemas Dinámicos	7.5	Optativa
Modelización Matemática con Ecuaciones en Derivadas Parciales	7.5	Optativa
Modelos Matemáticos en Biología	7.5	Optativa
Teoría de Grafos	7.5	Optativa
Teoría de Números	7.5	Optativa
SEGUNDO CUATRIMESTRE		
Aprendizaje Automático	7.5	Optativa
Códigos y Criptografía	7.5	Optativa
Combinatoria	7.5	Optativa
Curso Avanzado de Ecuaciones en Derivadas Parciales	7.5	Optativa
Geometría Algebraica	7.5	Optativa
Mecánica Computacional	7.5	Optativa
Seminario de Álgebra, Geometría y Matemática Discreta	3	Optativa
Seminario de Análisis, Ecuaciones Diferenciales y Modelización	3	Optativa
Sistemas Hamiltonianos	7.5	Optativa
Variedades Diferenciables	7.5	Optativa

Octubre 2022. UPC. Universitat Politècnica de Catalunya · BarcelonaTech