Guia Docent

19/20

Facultat de Matemàtiques i Estadística

Curs Fourier

Master in Advanced Mathematics and Mathematical Engineering

Joseph Fourier

21/03/1768 – 16/05/1830

Curs 2019-2020

1768-1830

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Facultat de Matemàtiques i Estadística

MÀSTER MAMME

Sumari

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

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

The **master's degree in Advanced Mathematics and Mathematical Engineering (MAMME)** 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 enroling 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 degree certificate fee, €3,267 (€4,900 for non-EU residents).
More information about fees and payment options
More information about grants and loans

Language of instruction

English

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-exclusive, 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

30

Pre-enrolment

Pre-enrolment closed (consult the new pre-enrolment periods in the academic calendar).
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 graduates are academic research (by pursuing a PhD in mathematics, science or engineering, for instance), mathematical modeling 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 skills

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

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

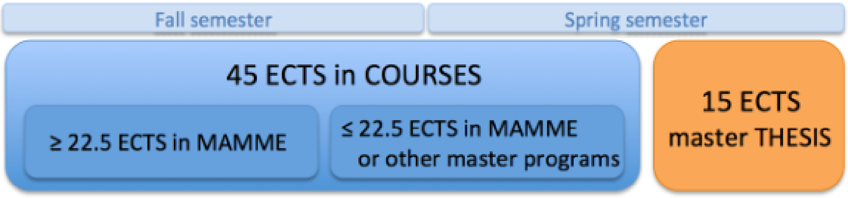
CURRICULUM

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

Master's degree in **Advanced Mathematics** and **Mathematical Engineering**

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

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) [not for academic year 2018-2019]
Algebraic Geometry (Spring term Q2) **[not for academic year 2019-2020]**
Differentiable Manifolds (Spring term Q2) [not for academic year 2015-2016]
Number Theory (Autumn term Q1) [not for academic year 2017-2018]
Non-Commutative Algebra (Autumn term Q1) [not for academic year 2016-2017]

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)

Focus Proposals

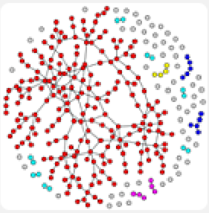
The following is a **NON-EXHAUSTIVE** list of focus proposals that may be considered for the selection of courses in MAMME, including both MAMME courses and courses in other master programs. They are **just examples** for selection of courses, and they will not be mentioned in the master's degree certificate.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

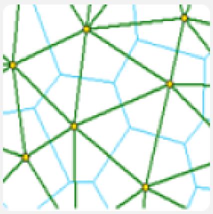
Focus on Discrete Mathematics

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:

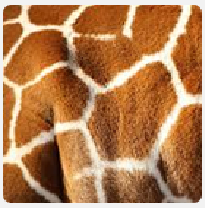
Combinatorics	7.5 ECTS	English	MAMME
Graph Theory	7.5 ECTS	English	MAMME
Codes an Cryptography	7.5 ECTS	English	MAMME
Discrete and Algorithmic Geometry	7.5 ECTS	English	MAMME
Optimización Entera y Combinatoria	5 ECTS	Spanish	Máster Univ. en Estadística e Investigación Operativa, UPC-UB
Algorithmic Methods 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.

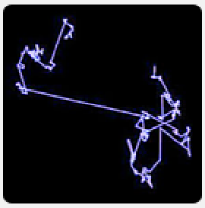
Focus on Partial Differential Equations and Analysis

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:

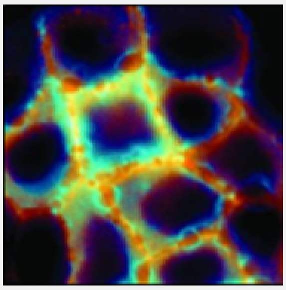
Advanced course in PDEs	7.5 ECTS	English	MAMME
Mathematical Modeling with PDEs	7.5 ECTS	English	MAMME
Numerical Methods for PDEs	7.5 ECTS	English	MAMME
Stochastic Calculus	7.5 ECTS	English	Master in Advanced Mathematics, UB
Complex Analysis	9 ECTS	English	Master in Advanced Mathematics, UB

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

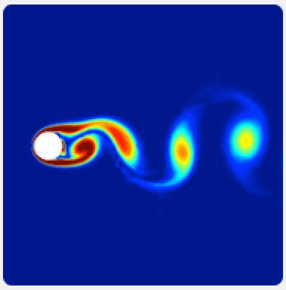
Other appropriate courses (depending on the student interests) with connections to PDEs are:
Quantitative and Qualitative Methods in Dynamical Systems (Q1 MAMME), Hamiltonian Systems (Q2 MAMME), and courses within the Barcelona universities masters offer in Mathematical Finance, Mathematical Biology,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

Focus on Mathematical and Computational Modelling with PDEs

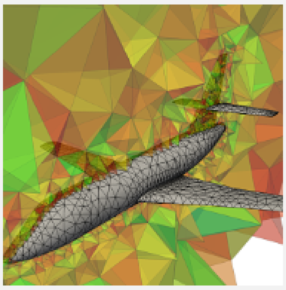
Mathematical and computational modelling with Partial Differential Equations (PDEs) is nowadays an essential tool for analysing, understanding and predicting phenomena in physics, biology, engineering, economics, social sciences and related fields. The applications cover a wide spectrum ranging from 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:

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
Astrodynamics	5 ECTS	English	Master's degree in Aerospace Science and Technology (UPC)
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

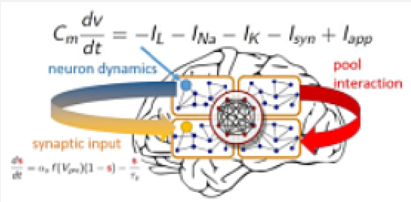
A minimum of 3 MAMME courses (22.5 ECTS) is mandatory.

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

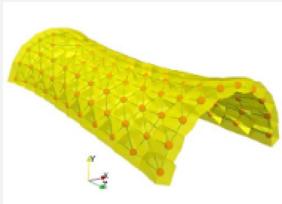
(**) This course is not recommended to students who have followed the course "Geometría Algebraica" of *Grau en Matemàtiques* at FME.

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

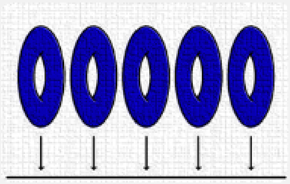
We remind that a minimum of 3 MAMME courses (22.5 ECTS) is mandatory.

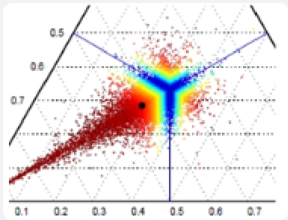
(*) “Numerical Modeling” is recommended to students that do not have a solid background in numerical methods and programming. Registration to this course requires the approval of the director of the corresponding master.

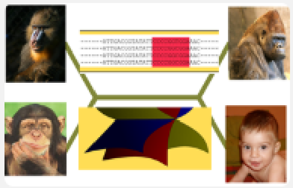
(**) These courses are proposed to students willing to get a deeper focus neuroscience. Registration to these courses requires the approval of the director of the corresponding master.

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	MAMME
Differentiable Manifolds	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
Local Algebra	Master in Advanced Mathematics, UB

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

Last update: 14-06-2019

34950 - CALG - Commutative Algebra

Coordinating unit: 200 - FME - School of Mathematics and Statistics
Teaching unit: 749 - MAT - Department of Mathematics
Academic year: 2019
Degree: MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Teaching unit Optional)
ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: FRANCESC D'ASSIS PLANAS VILANOVA

Others: Primer quadrimestre:
FRANCESC D'ASSIS PLANAS VILANOVA - 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 INFORMATI0N 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

34950 - CALG - Commutative Algebra

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

Study load

Total learning time: 187h 30m	Hours large group:	60h	32.00%
	Self study:	127h 30m	68.00%

Content

Rings and ideals	Learning time: 28h 20m Theory classes: 15h Self study : 13h 20m

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

Modules	Learning time: 24h Theory classes: 12h Self study : 12h

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

Algebraic varieties	Learning time: 24h Theory classes: 12h Self study : 12h

Description:
The spectrum of a ring. Zariski topology.

Introduction to homological algebra	Learning time: 24h Theory classes: 12h Self study : 12h

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

Local algebra	Learning time: 18h 40m Theory classes: 9h Self study : 9h 40m

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

34950 - CALG - Commutative Algebra

Qualification system

The qualification will be based on:
Active participation of the student during the course,
Resolution of assigned exercises
Exposition of a directed work in which the student develops some material related to the course.

If necessary, a final exam

Bibliography

Basic:

- 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.
- Rotman, J.J. An introduction to homological algebra. Academic Press, 1979.
- Bruns, Winfried; Herzog, Jürguen. Cohen-Macaulay rings. Cambridge University Press, 1993.

Last update: 14-06-2019

34951 - NCA - Non-Commutative Algebra

Coordinating unit: 200 - FME - School of Mathematics and Statistics
Teaching unit: 749 - MAT - Department of Mathematics
Academic year: 2019
Degree: MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Teaching unit Optional)
ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: ENRIC VENTURA CAPELL

Others: Primer quadrimestre:
JOSE BURILLO PUIG - 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 INFORMATI0N 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.

Last update: 14-06-2019

34951 - NCA - Non-Commutative Algebra

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

Total learning time: 187h 30m	Hours large group:	60h	32.00%
	Self study:	127h 30m	68.00%

34951 - NCA - Non-Commutative Algebra

Content

Generalities about infinite groups	Learning time: 45h Theory classes: 15h Self study : 30h

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

Cayley graphs and growth of groups	Learning time: 45h Theory classes: 15h Self study : 30h

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

Hyperbolic groups	Learning time: 45h Theory classes: 15h Self study : 30h

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

Algorithmic problems in groups	Learning time: 45h Theory classes: 15h Self study : 30h

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.

34951 - NCA - Non-Commutative Algebra

Qualification 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.

Lyndon, Roger C.; Schupp, Paul E. Combinatorial group theory. 2nd ed. Berlin: Springer, 2001. ISBN 978-3540411581.

Bogopolskij, Oleg Vladimirovic. Introduction to group theory. Zürich: European Mathematical Society, 2008. ISBN 9783037190418.

Loh, Clara. Geometric group theory : an introduction. Universitext. Springer, 2017. 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.

Others resources:

Several interesting papers and notes by Chuck Miller:

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

Last update: 14-06-2019

34953 - NT - Number Theory

Coordinating unit: 200 - FME - School of Mathematics and Statistics

Teaching unit: 749 - MAT - Department of Mathematics

Academic year: 2019

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

ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: ANA RIO DOVAL

Others: Primer quadrimestre:
JORDI GUARDIA RUBIES - A
JOAN CARLES LARIO LOYO - A
ANA RIO DOVAL - A

Opening hours

Timetable: Day and time to agree, presentially, via email or using Athenea resources.

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. Although it is not strictly necessary, any background on algebraic curves, elliptic curves and basic number theory. But the course will be completely self-contained.

Degree competences to which the subject contributes

Specific:

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

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 INFORMATI0N 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, explaining carefully the contents of the course and providing as much explicit examples, exercises and applications as possible. The students will be encouraged to consult suitable references and to discuss between them and with the professor in order to achieve a good understanding of the material.

Learning objectives of the subject

1) Algebraic number theory.
2) Arithmetic of elliptic and hyperelliptic curves
3) Applications

The material covered in this course interplays with topics of applied arithmetic and number theory (primality testing) and algebraic geometry (curves of low genus)

Study load

Total learning time: 187h 30m	Hours large group:	60h	32.00%
	Self study:	127h 30m	68.00%

Content

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

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

Qualification system

There will be a final exam. Optionally the qualification might be obtained based on:
1) Active participation of the student during the course,
2) Resolution of exercises suggested in class and,
3) Ellaboration of a document in which the student develops in more detail and depth some of the material of the course.

34953 - NT - Number Theory

Regulations for carrying out activities

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

Bibliography

Basic:

Neukirch, Jürgen. Algebraic number theory. Berlin: Springer-Verlag, 1999. ISBN 3540653996.

Silverman, Joseph H. The arithmetic of elliptic curves. 2nd ed. New York: Springer-Verlag, 2009. ISBN 9780387094939.

Silverman, Joseph H. Advanced topics in the arithmetic of elliptic curves. New York: Springer, 1994. ISBN 0387943250.

Cohen, Henri. A Course in computational algebraic number theory. Berlin [etc.]: Springer-Verlag, cop. 1993. ISBN 3540556400.

Cox, David A. Primes of the form x2 + ny2 : Fermat, class field theory, and complex multiplication. New York [etc.]: John Wiley, cop. 1989. ISBN 9780471190790.

Washington, Lawrence C. Elliptic curves : number theory and cryptography. 2nd ed. Boca Raton [etc.]: CRC Press, cop. 2008. ISBN 9781420071467.

Crandall, Richard; Pomerance, Carl. Prime Numbers [Recurs electrònic] : A Computational Perspective [on line]. Second Edition. New York, NY: Springer Science+Business Media, Inc, 2005Available on: <http://dx.doi.org/10.1007/0-387-28979-8>. ISBN 978-0-387-28979-3.

Others resources:

Computer material

SAGE

Mathematical Software

Matlab

Mathematical software

Last update: 14-06-2019

34954 - CC - Codes and Cryptography

Coordinating unit: 200 - FME - School of Mathematics and Statistics
Teaching unit: 749 - MAT - Department of Mathematics
Academic year: 2019
Degree: MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Teaching unit Optional)
ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: SIMEON MICHAEL BALL

Others: Segon quadrimestre:
SIMEON MICHAEL BALL - 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. 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 INFORMATI0N 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.

34954 - CC - Codes and Cryptography

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

Total learning time: 187h 30m	Hours large group:	60h	32.00%
	Self study:	127h 30m	68.00%

Last update: 14-06-2019

34954 - CC - Codes and Cryptography

Content

Introduction	Learning time: 6h 15m Theory classes: 2h Self study : 4h 15m
Description: The problem of communication. Information theory, Coding theory and Cryptographic theory	

Information and Entropy	Learning time: 18h 45m Theory classes: 6h Self study : 12h 45m
Description: Uncertainty or information. Entropy. Mutual information	

Source codes without memory	Learning time: 12h 30m Theory classes: 4h Self study : 8h 30m
Description: Codes. Average length. Huffman codes. Extensions of a source. Theory of an noiseless communication. Notes of compression.	

Channel coding	Learning time: 18h 45m Theory classes: 6h Self study : 12h 45m
Description: Discrete channels without memory. Symmetric channels. Shannon's theorem.	

Block codes	Learning time: 18h 45m Theory classes: 6h Self study : 12h 45m
Description: Hamming's distance. Detection and correction of errors. Bounds. Linear codes.	

Cyclic codes	Learning time: 18h 45m Theory classes: 6h Self study : 12h 45m

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.

Introduction to modern cryptography	Learning time: 15h 37m Theory classes: 5h Self study : 10h 37m

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

Symmetric key cryptography	Learning time: 15h 38m Theory classes: 5h Self study : 10h 38m

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

Public key encryption	Learning time: 15h 37m Theory classes: 5h Self study : 10h 37m

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

Digital signatures	Learning time: 15h 38m Theory classes: 5h Self study : 10h 38m

Description:
Security definitions. RSA and Schnorr signatures.

Proofs of knowledge and other cryptographic protocols	Learning time: 15h 37m Theory classes: 5h Self study : 10h 37m
Description: Ring signatures. Distributed signatures. Identity and attribute based protocols.	

Multiparty computation	Learning time: 15h 38m Theory classes: 5h Self study : 10h 38m
Description: Secret sharing schemes. Unconditionally and computationally secure multiparty computation.	

Qualification 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.

Regulations for carrying out activities

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

34954 - CC - Codes and Cryptography

Bibliography

Basic:

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.

Xambó Descamps, Sebastián. Block error-correcting codes : a computational primer. Berlin: Springer, 2003. ISBN 3540003959.

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.

Complementary:

Johnson, Sarah J. Iterative error correction : turbo, low-density parity-check and repeat-accumulate codes. Cambridge: Cambridge University Press, 2010. ISBN 9780521871488.

Welsh, Dominic. Codes and cryptography. Oxford: Oxford university Press, 1988. ISBN 0198532881.

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.

Last update: 14-06-2019

34955 - COMB - Combinatorics

Coordinating unit: 200 - FME - School of Mathematics and Statistics
Teaching unit: 749 - MAT - Department of Mathematics
Academic year: 2019
Degree: MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Teaching unit Optional)
ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: ORIOL SERRA ALBO

Others: Segon quadrimestre:
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 INFORMATI0N 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.

Study load

Total learning time: 187h 30m	Hours large group:	60h	32.00%
	Self study:	127h 30m	68.00%

34955 - COMB - Combinatorics

Content

Partially ordered sets	Learning time: 24h 40m Practical classes: 4h Laboratory classes: 4h Self study : 16h 40m
Description: Sperner's theorem. LYM inequalities. Bollobás's theorem. Dilworth's theorem	

Extremal set theory	Learning time: 24h 40m Theory classes: 4h Laboratory classes: 4h Self study : 16h 40m
Description: Theorems of Baranyai, Erdos-de Bruijn and Erdos-Ko-Rado	

Linear algebra methods in combinatorics	Learning time: 18h 30m Theory classes: 3h Laboratory classes: 3h Self study : 12h 30m
Description: The polynomial method and applications. Fisher's theorem. Equiangular lines, sets with few differences	

Finite geometries	Learning time: 18h 30m Theory classes: 3h Laboratory classes: 3h Self study : 12h 30m
Description: q-anologs of extremal problems. Segre's theorem. Blocking sets, ovals and hyperovals.	

Matroids	Learning time: 18h 30m Theory classes: 3h Laboratory classes: 3h Self study : 12h 30m
Description: Axioms. Transversal matroids. Greedy algorithms. The Tutte polynomial	

Probabilistic methods in combinatorics	Learning time: 18h 30m Theory classes: 3h Laboratory classes: 3h Self study : 12h 30m
Description: Permanents, transversals, hypergraph coloring. Monotone properties and threshold functions	

Ramsey theory	Learning time: 31h 40m Theory classes: 5h Laboratory classes: 5h Self study : 21h 40m
Description: Theorems of Ramsey and Hales-Jewett. Theorems of Schur, Van der Waerden and Rado.	

Enumerative combinatorics	Learning time: 32h 30m Theory classes: 5h Laboratory classes: 5h Self study : 22h 30m
Description: Symbolic and analytic methods. Symmetries and Pólya theory.	

Qualification system

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

34955 - COMB - Combinatorics

Bibliography

Basic:

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.

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

Flajolet P.; Sedgewick R. Analytic combinatorics [on line]. Cambridge: Cambridge University Press, 2009Available on: <http://site.ebrary.com/lib/upcatalunya/docDetail.action?docID=10277515>. ISBN 9780521898065.

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

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. 2nd ed. Oxford: Oxford University Press, 2011. ISBN 9780199603398.

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

Last update: 14-06-2019

34956 - DG - Discrete and Algorithmic Geometry

Coordinating unit: 200 - FME - School of Mathematics and Statistics
Teaching unit: 749 - MAT - Department of Mathematics
Academic year: 2019
Degree: MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Teaching unit Optional)
ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: CLEMENS HUEMER

Others: Primer quadrimestre:
CLEMENS HUEMER - A
JULIAN THORALF PFEIFLE - A

Prior skills

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

Degree competences to which the subject contributes

Specific:

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

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 INFORMATI0N 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.

34956 - DG - Discrete and Algorithmic Geometry

Teaching methodology

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

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

Learning objectives of the subject

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

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

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

Study load

Total learning time: 187h 30m	Hours large group:	60h	32.00%
	Self study:	127h 30m	68.00%

34956 - DG - Discrete and Algorithmic Geometry

Content

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

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

Convexity	Learning time: 19h Theory classes: 4h Laboratory classes: 2h Self study : 13h

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

Decompositions and arrangements	Learning time: 31h Theory classes: 7h Laboratory classes: 3h Self study : 21h

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.

Proximity Structures	Learning time: 31h Theory classes: 7h Laboratory classes: 3h Self study : 21h

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

Polytopes and Subdivisions of Point Sets	Learning time: 38h Theory classes: 10h Laboratory classes: 3h Self study : 25h
Description: Homogeneous coordinates. Polytopes: faces and boundary structure; examples; operations on polytopes (polarity, products, etc.). Point sets: subdivisions and triangulations (including Delaunay and Voronoi).	

Lattice Geometry	Learning time: 24h Theory classes: 6h Laboratory classes: 2h Self study : 16h
Description: Examples of lattices. Ehrhart's Theorem on integer points in polytopes. Brion's Theorem.	

Symmetry	Learning time: 23h Theory classes: 6h Practical classes: 1h Self study : 16h
Description: Orbifolds and the Magic Theorem on symmetry groups in the plane. Exploitation of symmetry in linear optimization.	

Software	Learning time: 9h Laboratory classes: 2h Self study : 7h
Description: Polymake, Curved Spaces, etc.	

Qualification 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 on the blackboard (15 %), and there will be an exam (35 %).

34956 - DG - Discrete and Algorithmic Geometry

Bibliography

Basic:

Berg, Mark de; Cheong, Otfried; Kreveld, Marc van; Overmars, Mark. Computational geometry: algorithms and applications. 3rd ed. revised. Berlin: Springer, 2008. ISBN 9783540779735.

Boissonnat, J. D.; Yvinec, M. Algorithmic geometry. Cambridge: Cambridge University Press, 1997. ISBN 0521565294.

Conway, John Horton; Sloane, N. J. A. Sphere packings, lattices and groups. 3rd ed. Berlin: Springer, 1999. ISBN 0387985859.

Edelsbrunner, Herbert. Algorithms in combinatorial geometry. Berlín: Springer, 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, 1995. ISBN 0471588903.

Ziegler, Günter M. Lectures on polytopes. New York: Springer-Verlag, 1995. ISBN 038794365X.

Beck, Matthias ; Robins, Sinai. Computing the continuous discretely : integer-point enumeration in polyhedra. New York: Springer, 2007. ISBN 9780387291390.

Complementary:

Bokowski, Jürgen. Computational oriented matroids : equivalence classes of matrices within a natural framework. Cambridge: Cambridge University Press, 2006. ISBN 9780521849302.

Schurmann, Achill. Computational geometry of positive definite quadratic forms : polyhedral reduction theories, algorithms, and applications. Providence: AMS ULECT-48, 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. Berlin: Springer, 2011. ISBN 9783642172854.

Others resources:

Audiovisual material

Mathfilm festival 2008 [Enregistrament vídeo]: a collection of mathematical videos. Berlin : Springer, 2008

Videomath Festival at International Congress of Mathematicians, Berlin, Germany 1998 [Enregistrament vídeo] / edited and produced Hans Christian Hege, Konrad Polthier. [Berlin] : Springer, 1998

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

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

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BARCELONATECH

Last update: 14-06-2019

34957 - GT - Graph Theory

Coordinating unit: 200 - FME - School of Mathematics and Statistics
Teaching unit: 749 - MAT - Department of Mathematics
Academic year: 2019
Degree: MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Teaching unit Optional)
ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: ORIOL SERRA ALBO

Others: Primer quadrimestre:
ANNA LLADO SANCHEZ - A
MARCOS NOY SERRANO - A
ORIOL SERRA ALBO - A

Prior skills

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

Degree competences to which the subject contributes

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

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 INFORMATI0N 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

Sessions of presentation of material alternate with sessions with student presentations of problems and specific topics. The active participation of students is a requirement for the evaluation of the course.

Learning objectives of the subject

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

Study load

Total learning time: 187h 30m	Hours large group:	60h	32.00%
	Self study:	127h 30m	68.00%

Content

Spectral techniques in Graph Theory	Learning time: 12h Theory classes: 12h

Description:
Adjacency and Laplacian matrix. Spectral properties. Cospectral graphs. Graph invariants and spectral properties: chromatic number, Cheeger constant, expansion properties, maxcut, bisection width. The matrix tree theorem. Random walks in graphs. Shannon capacity.

Specific objectives:
Computation of spectra. Circulant graphs. Spectra and graph operations. Obtention of spectral bounds for graph invariants.

Symmetries in graphs	Learning time: 1h Theory classes: 1h

Description:
Vertex symmetric and Edge symmetric graphs. Cayley graphs. Highly symmetric graphs

Specific objectives:
Circulant graphs. Hypercubes. Toroidal graphs.

Minors and treewidth	Learning time: 11h Theory classes: 11h

Description:
Minors. Minor closed classes. Well quasi-ordering. Graph minor theorem for trees. Tree decomposition. Tree width.

Specific objectives:
Classes defined by forbidden minors. Serie-Parallel graphs. k-trees and tree width.

Graphs on surfaces	Learning time: 4h Theory classes: 4h

Description:
Planar graphs. Kuratowski theorem. Triangulations. Graphs on surfaces. Genus.

Specific objectives:
Euler formula. Planar separator theorem

Graph homomorphisms	Learning time: 6h Theory classes: 6h
Description: Graph homomorphisms. Retracts and Cores. The homomorphism order. Antichains. Specific objectives: Homomorphisms and colorings. Fractional and circular chromatic numbers.	

Random graphs	Learning time: 12h Theory classes: 12h
Description: Erdos-Rényi model of random graphs. Probabilistic method. Properties of almost all graphs. Threshold functions. Evolution of random graphs. Specific objectives: Graphs with large girth and large chromatic number. Expansion properties of random graphs. Threshold for connectivity. The Poisson paradigm.	

Extremal Graph Theory	Learning time: 12h Theory classes: 12h
Description: Extremal problems in graph theory. Turán theorem. The Erdos-Stone-Simonovits theorem. Stability of extremal graphs. Szemerédi regularity lemma. Specific objectives: Counting Lemma and Removal Lemma.Applications of Szemerédi regularity Lemma.	

Qualification system

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

Regulations for carrying out activities

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

34957 - GT - Graph Theory

Bibliography

Basic:

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. Cambridge, [etc.]: Cambridge University Press, cop. 2016. ISBN 978-1107118508.

Brouwer, A. E; Haemers, W. H. Spectra of Graphs. New York [etc.]: Springer, cop. 2012. ISBN 978-1-4614-1938-9.

Alon, Noga; Spencer Joel. The Probabilistic Method. 2016. Wiley,

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.

Last update: 14-06-2019

34958 - MMPDE - Mathematical Modelling with Partial Differential Equations

Coordinating unit: 200 - FME - School of Mathematics and Statistics

Teaching unit: 749 - MAT - Department of Mathematics
981 - CRM - Mathematical Research Centre

Academic year: 2019

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

ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: JUAN DE LA CRUZ DE SOLÀ-MORALES RUBIÓ

Others: Primer quadrimestre:
XAVIER CABRE VILAGUT - A
GYULA CSATO - A
JUAN DE LA CRUZ DE SOLÀ-MORALES RUBIÓ - A

Prior skills

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

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 INFORMATI0N 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 will contain the main contents of the course, but the students will also be asked to make presentations of additional material in seminar sessions. Problem solution will also be asked.

Learning objectives of the subject

The course will provide a general overview on the use of partial differential equations (PDE) and boundary value problems to construct mathematical models of real phenomena.
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

Total learning time: 187h 30m	Hours large group:	60h	32.00%
	Self study:	127h 30m	68.00%

34958 - MMPDE - Mathematical Modelling with Partial Differential Equations

Content

1 Heat conduction and diffusion

Learning time: 56h 15m

Theory classes: 18h
Self study : 38h 15m

Description:
Review of Vector Calculus, Fick and Fourier laws, Random walks, self-similar solutions, Einstein calculation.
Boundary conditions, Energy Functionals, separation of variables, Thin domains, Convergence to gaussians, entropy
Steffan Problem, Black-Scholes model, Reaction-diffusion. Fractional diffusion.

2 Potentials in physics and technology

Learning time: 56h 15m

Theory classes: 18h
Self study : 38h 15m

Description:
Classical gravitation, electrostatics, volume and layer potentials
Euler equations of inviscid fluids and potential flows.
Complex analysis methods in plane potential flows. Lift and drag.
Navier-Stokes system and the viscous contribution to drag. Stokes and Boundary layer equations.

3 Transients in continuous media

Learning time: 31h 15m

Theory classes: 10h
Self study : 21h 15m

Description:
Acoustics, surface gravity waves, inertial waves.
Electromagnetic and elastic waves.
Dispersion, Stationary waves and high-frequancy waves.

4 Geometry

Learning time: 23h 26m

Theory classes: 7h 30m
Self study : 15h 56m

Description:
The Laplace-Beltrami operator.
Calculus of variations.
Minimal surfaces.

34958 - MMPDE - Mathematical Modelling with Partial Differential Equations

Qualification system

Attendance to lectures, presentation of additional materials and problem solving will be the basis of a qualification up to a certain level (60%). A higher mark will require a writen exam.

Bibliography

Basic:

Howison, Sam. Practical applied mathematics : modelling, analysis, approximation. New York: Cambridge University Press, 2005. ISBN 0521603692.

Friedman, A.; Litman, W. Industrial mathematics : a course in solving real-world problems. Philadelphia: SIAM, 1994. ISBN 0898713242.

Ockendon, J.R. [et al.]. Applied partial differential equations. Revised ed. Oxford: Oxford University Press, 2003. ISBN 0198527713.

Fowler, A.C. Mathematical models in the applied sciences. Cambridge: Cambridge University Press, 1997. ISBN 0521467039.

Complementary:

Tijonov, A.; Samarsky, A. Ecuaciones de la física matemática. 3ª ed. Moscú: Mir, 1983.

Salsa, Sandro. Partial differential equations in action : from modelling to theory [on line]. Milan [etc.]: Springer, cop. 2008Available on: < http://site.ebrary.com/lib/upcatalunya/docDetail.action?docID=10231792&p00>. ISBN 9788847007512.

Last update: 14-06-2019

34959 - CM - Computational Mechanics

Coordinating unit: 200 - FME - School of Mathematics and Statistics
Teaching unit: 749 - MAT - Department of Mathematics
751 - DECA - Department of Civil and Environmental Engineering
Academic year: 2019
Degree: MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Teaching unit Optional)
ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: JOSE JAVIER MUÑOZ ROMERO

Others: Segon quadrimestre:
SONIA FERNANDEZ MENDEZ - A
JOSE JAVIER MUÑOZ ROMERO - 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 INFORMATI0N 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.

34959 - CM - Computational Mechanics

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 (mainly tensors) used in computational mechanics
- Be aware of the different level of complexity of various problems (e.g. linear vs. nonlinear, static vs. dynamic).

Study load

Total learning time: 187h 30m	Hours large group:	60h	32.00%
	Self study:	127h 30m	68.00%

34959 - CM - Computational Mechanics

Content

CONTINUUM MECHANICS	Learning time: 31h 15m Theory classes: 8h Practical classes: 2h Self study : 21h 15m

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.

COMPUTATIONAL ELASTICITY	Learning time: 31h 15m Theory classes: 8h Practical classes: 2h Self study : 21h 15m

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.

COMPUTATIONAL DYNAMICS	Learning time: 31h 15m Theory classes: 8h Practical classes: 2h Self study : 21h 15m

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.

COMPUTATIONAL PLASTICITY AND VISCOELASTICITY	Learning time: 31h 15m Theory classes: 8h Practical classes: 2h Self study : 21h 15m

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.
Viscoelastic materials. Maxwell and Kelvin-Voigt one-dimensional models. Numerical solution. Extension to multiple dimensions.

COMPUTATIONAL FLUID DYNAMICS	Learning time: 31h 15m Theory classes: 8h Practical classes: 2h Self study : 21h 15m

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. Applications.

COMPUTATIONAL METHODS FOR WAVE PROBLEMS	Learning time: 31h 15m Theory classes: 8h Practical classes: 2h Self study : 21h 15m

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.

Qualification system

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

34959 - CM - Computational Mechanics

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:

Bathe, Klaus-Jürgen. Finite element procedures. New Jersey: Prentice-Hall, 1996. ISBN 0133014584.

Bonet, Javier; Wood, R. D. Nonlinear continuum mechanics for finite element analysis. 2nd ed. Cambridge: Cambridge University Press, 2008. ISBN 9780521838702.

Holzapfel, Gerhard A. Nonlinear solid mechanics : a continuum approach for engineering. Chichester: John Wiley & Sons, cop. 2000. ISBN 978-0-471-82319-3.

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, 1998Available on: <http://link.springer.com/book/10.1007/b98904>.

Taber, Larry A. Nonlinear theory of elasticity. Applications in Biomechanics [on line]. 2008. Singapore: World Scientific Publishing, 2004 [Consultation: 27/05/2015]. Available on: <http://www.worldscientific.com/worldscibooks/10.1142/5452>. ISBN 9812387358.

Zienkiewicz O. C.;Taylor, R. L. The finite element method [on line]. 6th ed. Oxford: Butterworth Heinemann, 2005Available on: <http://www.sciencedirect.com/science/book/9780750664318>.

Last update: 14-06-2019

34960 - MMB - Mathematical Models in Biology

Coordinating unit: 200 - FME - School of Mathematics and Statistics
Teaching unit: 749 - MAT - Department of Mathematics
Academic year: 2019
Degree: MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Teaching unit Optional)
ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: JESUS FERNANDEZ SANCHEZ

Others: Primer quadrimestre:
MARTA CASANELLAS RIUS - A
JESUS FERNANDEZ SANCHEZ - A
ANTONI GUILLAMON GRABOLOSA - A
JOSE TOMAS LAZARO OCHOA - 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 analyize 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 INFORMATI0N 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. The SAGE computing environment will be used, with interfaces to Python, R and C if necessary.

Learning objectives of the subject

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

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

Total learning time: 187h 30m	Hours large group:	60h	32.00%
	Self study:	127h 30m	68.00%

34960 - MMB - Mathematical Models in Biology

Content

Mathematical models in Genomics

Learning time: 75h

Theory classes: 12h
Laboratory classes: 12h
Self study : 51h

Description:

1. Brief introduction to genomics (genome, gen structure, genetic code...). Genome databases online.
2. Phylogenetics: Markov models of molecular evolution (Jukes-Cantor, Kimura, Felsenstein hierarchy...), phylogenetic trees, branch lengths. Phylogenetic tree reconstruction (distance and character based methods).
3. Genomics: Markov chains and Hidden Markov models for gene prediction. Tropical arithmetics and Viterbi algorithm. Forward and Expectation-Maximization algorithms.
4. Multiple sequence alignment: dynamical programming, tropical arithmetics and Pair-HMMs

Mathematical Models in Neurohysiology

Learning time: 56h 15m

Theory classes: 9h
Laboratory classes: 9h
Self study : 38h 15m

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.

Models of Population Dynamics

Learning time: 37h 30m

Theory classes: 6h
Laboratory classes: 6h
Self study : 25h 30m

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.

Biological networks	Learning time: 18h 45m Theory classes: 3h Laboratory classes: 3h Self study : 12h 45m
Description: 1. Complex networks in biology. 2. Networks of neurons.	

Qualification 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.

34960 - MMB - Mathematical Models in Biology

Bibliography

Basic:

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, 2005Available on: <http://dx.doi.org/10.1007/3-540-27877-X>. ISBN 354025305X.

Murray, J.D. Mathematical biology [on line]. 3rd ed. Berlin: Springer, 2002Available 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.

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

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. New York: Springer, 2010. ISBN 978-0-387-87708-2.

Keeling, Matthew James; Rohani, Pejman. Modeling infectious diseases in humans and animals. Princeton: Princeton University Press, cop. 2008. ISBN 9780691116174.

Complementary:

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/>.

Keener, James P.; Sneyd, James. Mathematical physiology. Vol 1. 2nd ed. New York: Springer Verlag, 2009. ISBN 9780387758466.

Durbin, Richard [et al.]. Biological sequence analysis : probabilistic models of proteins and nucleic acids. Cambridge: Cambridge University Press, 1998. 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>.

Felsenstein, J. PHYLIP [on line]. [Consultation: 23/11/2012]. Available on: <http://evolution.genetics.washington.edu/phylip.html>.

European Bioinformatics Institute; Wellcome Trust Sanger Institute. Ensembl project [on line]. [Consultation: 23/11/2012]. Available on: <http://www.ensembl.org>.

Last update: 14-06-2019

34961 - QQMDS - Quantitative and Qualitative Methods in Dynamical Systems

Coordinating unit: 200 - FME - School of Mathematics and Statistics

Teaching unit: 749 - MAT - Department of Mathematics

Academic year: 2019

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

ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: PAU MARTIN DE LA TORRE

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

Opening hours

Timetable: Make an appointment by email

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 INFORMATI0N 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.

Last update: 14-06-2019

34961 - QQMDS - Quantitative and Qualitative Methods in Dynamical Systems

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

Total learning time: 187h 30m	Hours large group:	60h	32.00%
	Self study:	127h 30m	68.00%

34961 - QQMDS - Quantitative and Qualitative Methods in Dynamical Systems

Content

Invariant objects in Dynamical Systems	Learning time: 10h Theory classes: 10h

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

Normal forms	Learning time: 10h Theory classes: 10h

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

Perturbation theory in Dynamical Systems	Learning time: 15h Theory classes: 15h

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

Bifurcations	Learning time: 10h Theory classes: 10h

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

Homoclinic points and chaotic Dynamics	Learning time: 10h Theory classes: 10h
Description: Smale horseshoe. Homoclinic points and bifurcations. Hyperbolic sets and transversal homoclinic points. Dynamical systems with chaotic dynamics. Newhouse phenomenum.	

Non-smooth systems	Learning time: 5h Theory classes: 5h
Description: Introduction to non-smooth diferential equations. Definition and motivating examples. Filipov's convention.	

Qualification 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.

Regulations for carrying out activities

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

Bibliography

Basic:

- 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.
- 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.
- Hirsch, Morris W.; Smale, Stephen; Devaney, Robert L. Differential equations, dynamical systems, and an introduction to chaos. 3rd Edition. Amsterdam: Elsevier/Academic Press, 2013. ISBN 978-0-12-382010-5.

Last update: 14-06-2019

34962 - HS - Hamiltonian Systems

Coordinating unit: 200 - FME - School of Mathematics and Statistics
Teaching unit: 749 - MAT - Department of Mathematics
Academic year: 2019
Degree: MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Teaching unit Optional)
ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: MARCEL GUARDIA MUNARRIZ

Others: Segon quadrimestre:
AMADEU DELSHAMS I VALDES - A
MARCEL GUARDIA MUNARRIZ - 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 INFORMATI0N 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

34962 - HS - Hamiltonian Systems

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

Study load

Total learning time: 187h 30m	Hours large group:	60h	32.00%
	Self study:	127h 30m	68.00%

Content

Hamiltonian formalism

Learning time: 28h

Theory classes: 10h
Self study : 18h

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

Celestial mechanics

Learning time: 34h

Theory classes: 12h
Self study : 22h

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.

Geometric theory and invariant objects of Hamiltonian systems

Learning time: 24h

Theory classes: 8h
Self study : 16h

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

Integrable systems

Learning time: 10h

Theory classes: 4h
Self study : 6h

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

Quasi-integrable Hamiltonian systems	Learning time: 26h Theory classes: 8h Self study : 18h

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.

Lagrangian systems and variational methods	Learning time: 12h Theory classes: 4h Self study : 8h

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

Hamiltonian Partial Differential Equations	Learning time: 4h Theory classes: 2h Self study : 2h

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.

- Interactions between Dynamical Systems and Partial Differential Equations	Learning time: 49h 30m Theory classes: 12h Self study : 37h 30m

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

34962 - HS - Hamiltonian Systems

Planning of 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.

Qualification system

The students have to do some problems and a project. There will be also an exam of the theoretical part of the course. Moreover, they will attend the JISD.

Bibliography

Basic:

Meyer, Kenneth R.; Hall, Glen R.; Offin, Dan. Introduction to Hamiltonian dynamical systems and the n-body problem. 2nd ed. New York: Springer-Verlag, 2009. ISBN 978-0-387-09723-7.

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

Treschev, Dmitry; Zubelevich, Oleg. Introduction to the perturbation theory of Hamiltonian systems. Berlin: Springer Verlag, 2010. ISBN 978-3-642-03027-7.

Celletti, Alessandra. Stability and chaos in celestial mechanics [on line]. Springer-Praxis, 2010Available on: <http://site.ebrary.com/lib/upcatalunya/detail.action?docID=10372372>. ISBN 978-3-540-85145-5.

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

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

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

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.

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

Others 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

Last update: 14-06-2019

34963 - ACPDE - Advanced Course in Partial Differential Equations

Coordinating unit: 200 - FME - School of Mathematics and Statistics
Teaching unit: 749 - MAT - Department of Mathematics
Academic year: 2019
Degree: MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Teaching unit Optional)
ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: ALBERT MAS BLESA

Others: Segon quadrimestre:
XAVIER CABRE VILAGUT - A
GYULA CSATO - A
JUAN CARLOS FELIPE NAVARRO - A
ALBERT MAS BLESA - A

Prior skills

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

Requirements

Undergraduate courses in Partial Differential Equations and in Mathematical Analysis.

Degree competences to which the subject contributes

Specific:

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

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 INFORMATI0N RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.

34963 - ACPDE - Advanced Course in Partial Differential Equations

Teaching methodology

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

Learning objectives of the subject

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

Study load

Total learning time: 187h 30m	Hours large group:	60h	32.00%
	Self study:	127h 30m	68.00%

34963 - ACPDE - Advanced Course in Partial Differential Equations

Content

Classical methods for the Poisson and heat equations

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

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

Sobolev spaces and variational methods

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

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

Evolution equations

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

Description:
Prabolic equations. Galerkin method. Semigroups. Nonlinear conservation laws.

Introduction to nonlinear PDEs

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

Description:
Calculus of Variations. Nonlinear eigenvalue problems. Semi-linear elliptic equations.

Qualification system

The evaluation of the course is based:
- on the weekly resolution of problems proposed in class (15%);
- a midterm exam (35%);
- a final comprehensive exam (50%).
- eventually, there could be the possibility of a final project in order to improve the grade.
- the active participation during the course will be a requirement for the evaluation of the final exam.

34963 - ACPDE - Advanced Course in Partial Differential Equations

Bibliography

Basic:

Evans, Lawrence Craig. 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, 2008Available on: <http://site.ebrary.com/lib/upcatalunya/docDetail.action?docID=10231792&p00>. ISBN 9788847007512.

Brézis, H. Análisis funcional : teoría y aplicaciones. Madrid: Alianza, 1984. ISBN 8420680885.

Complementary:

Struwe, Michael. Variational methods : applications to nonlinear partial differential equations and hamiltonian systems [on line]. 2nd rev. and substantially expanded ed. Berlin: Springer, 1996Available on: <http://dx.doi.org/10.1007/978-3-540-74013-1>. ISBN 3540520228.

Gilbarg, David; Trudinger, Neil S. Elliptic partial differential equations of second order. 2nd ed., rev. third printing. Berlin: Springer-Verlag, 1998. ISBN 354013025X.

Zuily, C. Problems in distributions and partial differential equations [on line]. Paris: North-Holland, 1988Available on: <http://site.ebrary.com/lib/upcatalunya/detail.action?docID=10259031>.

Necas, Jindrich. Introduction to the theory of nonlinear elliptic equations. Chichester: John Wiley & Sons, 1986. ISBN 0471908940.

Last update: 14-06-2019

34964 - NMDS - Numerical Methods for Dynamical Systems

Coordinating unit: 200 - FME - School of Mathematics and Statistics
Teaching unit: 749 - MAT - Department of Mathematics
Academic year: 2019
Degree: MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Teaching unit Optional)
ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: MARIA MERCEDES OLLE TORNER

Others: Primer quadrimestre:
MARIA MERCEDES OLLE TORNER - A

Prior skills

Good knowledge of a programming language.

Requirements

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

Degree competences to which the subject contributes

Specific:

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

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 INFORMATI0N 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.

34964 - NMDS - Numerical Methods for Dynamical Systems

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

Total learning time: 187h 30m	Hours large group:	60h	32.00%
	Self study:	127h 30m	68.00%

Content

Numerical (preliminary) tools for practical purposes: integrators for ODE and graphical interfaces. Examples.	Learning 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.	Learning time: 6h Theory classes: 3h Practical classes: 3h
Computation and stability of fixed points. Vector fields and maps. Implementation and examples.	Learning time: 10h Theory classes: 5h Practical classes: 5h
Computation and stability of periodic orbits. Implementation, continuation of families, bifurcations. Multiple shooting.	Learning time: 10h Theory classes: 5h Practical classes: 5h
Computation of tori: representation, computation and continuation. Implementation and examples.	Learning time: 15h Theory classes: 7h 30m Practical classes: 7h 30m
Analysis of bifurcations. Some examples.	Learning time: 15h Theory classes: 7h 30m Practical classes: 7h 30m

-

Degree competences to which the content contributes:

34964 - NMDS - Numerical Methods for Dynamical Systems

Qualification system

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

Regulations for carrying out activities

No rules, in principle.

Bibliography

Basic:

- Lichtenberg, Allan J; Lieberman, M. A. Regular and chaotic 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.

Last update: 14-06-2019

34965 - NMPDE - Numerical Methods for Partial Differential Equations

Coordinating unit: 200 - FME - School of Mathematics and Statistics

Teaching unit: 749 - MAT - Department of Mathematics
751 - DECA - Department of Civil and Environmental Engineering

Academic year: 2019

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

ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: 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 INFORMATI0N 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.

Last update: 14-06-2019

34965 - NMPDE - Numerical Methods for Partial Differential Equations

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 with application to bounded and unbounded domains.

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

Total learning time: 187h 30m	Hours large group:	60h	32.00%
	Self study:	127h 30m	68.00%

34965 - NMPDE - Numerical Methods for Partial Differential Equations

Content

Fundamentals of Finite Element Methods (FEM)	Learning time: 28h Theory classes: 14h Laboratory classes: 14h

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, time integration for parabolic equations.
Application to the numerical modelling of flow in porous medium, and potential flow.
Introduction to a posteriori error estimation and adaptivity.
Solution of the convection-diffusion equation. Stabilized formulations for convection dominated problems.

FEM for incompressible flow problems	Learning time: 16h Theory classes: 8h Practical classes: 8h

Description:
Weak form and discretization of the Stokes equations. Stable FEM discretizations for incompressible flow problems: LBB condition.
Application to microfluidics and geophysics.
Introduction to the numerical solution of the incompressible Navier-Stokes equations.
Introduction to eXtended FEM (X-FEM) for two-phase problems.

FEM for wave problems	Learning time: 16h Theory classes: 8h Laboratory classes: 8h

Description:
FEM solution of the 1D wave equation. FEM solution of Helmholtz equation. Non-reflecting boundary conditions.
Application to acoustics.
Introduction to DG for first order conservation laws. Application to acoustics and electromagnetics.

Qualification system

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

34965 - NMPDE - Numerical Methods for Partial Differential Equations

Bibliography

Basic:

Wait, R.; Mitchell, A. R. Finite elements 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, 2005Available on: <http://www.sciencedirect.com/science/book/9780750664318>.

Donea, Jean M; Huerta, A. Finite element methods for flow problems. Chichester: John Wiley & Sons, 2003. ISBN 0471496669.

Ainsworth, M.; Oden, J. T. A posteriori error estimation in finite element analysis. New York: John Wiley & sons, 2000. ISBN 047129411X.

Quarteroni, Alfio. Numerical Models for Differential Problems [on line]. 2009. Springer, Available on: <http://dx.doi.org/10.1007/978-88-470-1071-0>.

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.

Last update: 14-06-2019

34966 - VD - Differentiable Manifolds

Coordinating unit: 200 - FME - School of Mathematics and Statistics
Teaching unit: 749 - MAT - Department of Mathematics
Academic year: 2019
Degree: MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Teaching unit Optional)
ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: EVA MIRANDA GALCERÁN

Others: Segon quadrimestre:
EVA MIRANDA GALCERÁN - A
MIGUEL CARLOS MUÑOZ LECANDA - A
CEDRIC OMS - 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.

34966 - VD - Differentiable Manifolds

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

Total learning time: 187h 30m	Hours large group:	60h	32.00%
	Self study:	127h 30m	68.00%

Content

Complements in Differential Geometry	Learning time: 14h 52m Theory classes: 6h Self study : 8h 52m

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.

Introduction to Differential Topology	Learning time: 14h 40m Theory classes: 8h Self study : 6h 40m

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

Introduction to Lie theory	Learning time: 16h 20m Theory classes: 8h Self study : 8h 20m

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.

Lie group actions on smooth manifolds	Learning time: 9h Theory classes: 4h Self study : 5h

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

Basic notions on De Rham Cohomology	Learning time: 8h Theory classes: 3h Self study : 5h
Description: We define De Rham cohomology and compare it to other cohomologies.	

Introduction to Symplectic and Poisson Geometry	Learning time: 31h 40m Theory classes: 15h Self study : 16h 40m
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.	

Qualification system

There will be a final exam, as well as the possibility to write an optional essay that would contribute to the final grade. Students would choose, together with the lecturers, a topic that complements or advances the material taught during the course, according to their mathematical interests.

Regulations for carrying out activities

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

- Case A: an student that does only the final exam. Then the final grade would be that of the exam.
- Case B: an student that does the final exam AND submits a written essay. Then the final note would be the result of MAX(exam, 35% exam + 40% essay+ 25% exercises)

34966 - VD - Differentiable Manifolds

Bibliography

Basic:

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Cannas da Silva, Anna. Lectures on symplectic geometry. Springer-Verlag, 2008.

Duistermaat, J. J. ; Kolk, Johan A. C. Lie groups. Berlin: Springer-Verlag, 2000. ISBN 3540152938.

Fegan, H.D.. Introduction to compact lie groups. ISBN 9810236867.

Guillemin, V; Sternberg, Shlomo. Symplectic techniques in physics. Repr. with corrections. Cambridge [etc.]: Cambridge University Press, 1990. ISBN 978-0521389907.

Guillemin, Victor; Pollack, Alan. Differential topology. Reprint of the 1974 original. AMS Chelsea Publishing,

Knauf, A.. Mathematical Physics: Classical Mechanics. Springer, 2018. ISBN 978-3-662-55774-7.

Lee, John M. Introduction to smooth manifolds. New York: Springer-Verlag, 2003. ISBN 0387954481.

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.

Tu, Loring W. An Introduction to manifolds. 2nd ed. New York: Springer, cop. 2011. ISBN 9781441973993.

Warner, Frank W. Foundations of differentiable manifolds and Lie groups. New York [etc.]: Springer, cop. 1983. ISBN 9780387908946.

Complementary:

Bott, Raoul; Tu, Loring W. Differential forms in algebraic topology. New York: Springer-Verlag, 1982. ISBN 0387906134.

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.

Nakahara, Mikio. Geometry, topology, and physics. 2nd ed. New York [etc.]: Taylor & Francis, cop. 2003. ISBN 0750306068.

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, 2016Available on: <http://www.cis.upenn.edu/~jean/gbooks/manif.html>.

Others resources:

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH

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)** 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 expedició del títol, 3.267 € (4.900 € per a no residents a la UE).
Més informació sobre preus i pagament de la matrícula
Més informació de beques i ajuts

Idiomes
Anglès

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

Preinscripció
Preinscripció tancada (consulta els nous períodes de preinscripció al calendari acadèmic).
Com es formalitza la preinscripció?

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 és capaç de saber o 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

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		
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
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)** 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 la expedición del título, 3.267 € (4.900 € para no residentes en la UE).
Más información sobre precios y pago de la matrícula
Más información de becas y ayudas

Idiomas
Inglés

Lugar de impartición

Facultad de Matemáticas y Estadística (FME)

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

ACCESO

Requisitos generales
Requisitos académicos de acceso a un máster

Plazas
30

Preinscripción
Preinscripción cerrada (consulta los nuevos periodos de preinscripción en el calendario académico).
¿Cómo se formaliza la preinscripción?

Matrícula

¿Cómo se formaliza la matrícula?

Legalización de documentos

Los documentos expedidos por estados no miembros de la Unión Europea ni firmantes del Acuerdo sobre el espacio económico europeo tienen que estar legalizados por vía diplomática o con correspondiente apostilla.

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

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

PLAN DE ESTUDIOS

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		
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
Sistemas Hamiltonianos	7.5	Optativa
Variedades Diferenciables	7.5	Optativa