Guia Docent

11/12

Facultat de Matemàtiques i Estadística

Curs R. A. Fisher

1890-1962

Master of Science in Advanced Mathematics and Mathematical Engineering

Facultat de Matemàtiques i Estadística
UNIVERSITAT POLITÈCNICA DE CATALUNYA

Program

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

Structure

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

Specific requirements

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

Career prospects

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

Additional information

Interested? Please check http://mamme.masters.upc.edu for more details.

Last update: 03/10/2011

34963 - ACPDE - Advanced Course in Partial Differential Equations

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

Teaching staff

Coordinator: XAVIER CABRE VILAGUT

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

Prior skills

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

Requirements

Undergraduate courses in Partial Differential Equations and in Mathematical Analysis.

Degree competences to which the subject contributes

Specific:

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

Generical:

5. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
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: 03/10/2011

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			
	Self study:	127h 30m	68.00%
	Theory classes:	60h	32.00%

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.

34963 - ACPDE - Advanced Course in Partial Differential Equations

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

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

Bibliography

Basic:

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.* Milan: Springer, 2008. 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.* 2nd rev. and substantially expanded ed. Berlin: Springer, 1996. 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.* Paris: North-Holland, 1988.

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

Last update: 03/10/2011

34952 - AG - Algebraic Geometry

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

Teaching staff

Coordinator: PEDRO PASCUAL GAINZA

Others:
PEDRO PASCUAL GAINZA - A

Requirements

Basic abstract algebra, Topology and Differential Geometry
Commutative Algebra

Degree competences to which the subject contributes

Specific:

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

Generical:

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

Learning objectives of the subject

The main objective of the course is to introduce the student to the Algebraic Geometry of affine and projective varieties over a field. The course will be based on many examples, as in Harris book in the references, stressing the geometric interest of the subject, using the commutattive algebra only as a resource. At the end,depending on the audience, there will be some lectures on schemes theory and their role in algebraic geometry.

Study load

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

Content

Chapter 1: Algebraic sets

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

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

Chapter 2: Algebraic varieties

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

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

Chapter 3: Projective varieties

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

Description:
Projective and quasi-projective varieties. Zariski topology on projective varieties. Regular functions. Examples: hypersurfaces, grassmanians. Completeness of projective varieties.

Chapter 4: Finite maps	Learning time: 28h Theory classes: 9h Self study : 19h
Description: Basic properties. Noether normalization theorem. Zariski's main theorem. Proper maps. Normalization.	

Chapter 5: Local theory	Learning time: 28h Theory classes: 9h Self study : 19h
Description: Local ring. Tangent spaces. Nonsingular points. Nonsingularity and regularity. Smooth maps. Etale neighbourhoods.	

Chapter 6: Dimension theory	Learning time: 28h Theory classes: 9h Self study : 19h
Description: Dimension of affine varieties and of projective varieties. Dimension of the fibers of a morphism.	

Chapter 7: Divisors, differentials and intersection theory	Learning time: 28h Theory classes: 9h Self study : 19h
Description: Divisors, intersectino theory of divisors. Bézout theorem. Differentials, the canonical divisor.	

Qualification system

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

34952 - AG - Algebraic Geometry

Bibliography

Basic:

Harris, Joe. *Algebraic geometry: a first course*. New York: Springer Verlag, 1992. ISBN 0387977163.

Hartshorne, Robin. *Algebraic geometry*. New York: Springer Verlag, 1977. ISBN 0387902449.

Kempf, George. *Algebraic varieties*. Cambridge: Cambridge University Press, 1993. ISBN 0521426138.

Mumford, David. *Algebraic geometry I complex projective varieties*. Corrected 2nd. print. Berlin: Springer Verlag, 1995. ISBN 3540586571.

Shafarevich, Igor. *Basic algebraic geometry*. 2nd. rev. and expanded ed. Berlin: Springer Verlag, 1994. ISBN 3540548122.

Last update: 03/10/2011

34954 - CC - Codes and Cryptography

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

Teaching unit: 726 - MA II - Department of Applied Mathematics II
743 - MA IV - Department of Applied Mathematics IV

Academic year: 2011

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

ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: M. PAZ MORILLO BOSCH

Others:

SIMEON MICHAEL BALL - A
JAVIER HERRANZ SOTOCA - A
M. PAZ MORILLO BOSCH - A
JORGE LUIS VILLAR SANTOS - A

Prior skills

Basic probability, basic number theory and linear algebra

Requirements

Undergraduate mathematics

Degree competences to which the subject contributes

Specific:

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

Generical:

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.

34954 - CC - Codes and Cryptography

Teaching methodology

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

Learning objectives of the subject

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

Study load

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

Content

Introduction to Coding theory

Learning time: 2h 24m
Theory classes: 1h 36m
Self study : 0h 48m

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

Information and Entropy

Learning time: 8h 55m
Theory classes: 3h 37m
Self study : 5h 18m

Description:
Uncertainty or information. Entropy. Mutual information

Source codes without memory

Learning time: 10h 55m
Theory classes: 3h 37m
Self study : 7h 18m

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

Channel coding	Learning time: 10h 55m Theory classes: 3h 37m Self study : 7h 18m
Description: Discrete channels without memory. Symmetric channels. Shannon's theorem.	

Finite fiels	Learning time: 8h 55m Theory classes: 2h 37m Self study : 6h 18m
Description: Irreductible polynomials over Zp. Construction of finite fields. The multiplicative group of a finite field.	

Block codes	Learning time: 21h 55m Theory classes: 7h 37m Self study : 14h 18m
Description: Hamming's distance. Detection and correction of errors. Bounds. Linear codes. Hamming codes. Reed-Muller codes. Hadamard codes	

Cyclic codes	Learning time: 21h 55m Theory classes: 7h 37m Self study : 14h 18m
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 cryptography	Learning time: 4h 55m Theory classes: 2h 37m Self study : 2h 18m
Description: Symmetric key cryptography. Exemple AES.	

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

Description:
Encryption. Digital signature. Examples: RSA and ElGamal. Public key infrastructure.

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

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

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

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

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

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

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

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

34954 - CC - Codes and Cryptography

Directed project	Learning time: 14h 06m Self study (distance learning): 14h 06m
Description: CODING: Weight enumeration polynomial, perfect codes, error bursts, Reed-Muller codes (alternative version) and Kerdock codes. Symmetric codes over F3. CRYPTOGRAPHY: Electronic voting, electronic commerce, management of private data, quantum cryptography.	

Qualification system

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

Regulations for carrying out activities

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

Bibliography

Basic:

Huffman, W. Cary; Pless, Vera. *Fundamentals of error-correcting codes.* Cambridge: Cambridge University Press, 2003. ISBN 0521782805.

Guruswami, Venkatesan. *List decoding of error-correcting codes : winning thesis of the 2002 ACM doctoral dissertation competition.* Berlin: Springer, 2004. ISBN 9783540240518.

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

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.* 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:

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: 03/10/2011

34955 - COMB - Combinatorics

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

Teaching unit: 726 - MA II - Department of Applied Mathematics II
743 - MA IV - Department of Applied Mathematics IV

Academic year: 2011

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

ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: ORIOL SERRA ALBO

Others:

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

Prior skills

Basic calculus and linear algebra. Notions of probability.

Degree competences to which the subject contributes

Specific:

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

Generical:

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.

Last update: 03/10/2011

34955 - COMB - Combinatorics

Learning objectives of the subject

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

Study load

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

Content

Partially ordered sets

Learning time: 24h 40m

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

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

Extremal set theory

Learning time: 24h 40m

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

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

Linear algebra methods in combinatorics

Learning time: 18h 30m

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

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

Finite geometries	Learning time: 18h 30m Theory classes: 3h Practical 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 Practical 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 Practical 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 Practical 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 Practical classes: 5h Self study : 22h 30m
Description: Symbolic and analytic methods. Symmetries and Pólya theory.	

34955 - COMB - Combinatorics

Qualification system

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

Bibliography

Basic:

Alon, Noga; Spencer, Joel H.; Erdös, Paul. *The probabilistic method.* New York: Wiley, 1992. 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.* Cambridge: Cambridge University Press, 2009. 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.* Oxford: Oxford University Press, 1992. ISBN 0198535635.

Last update: 03/10/2011

34950 - CALG - Commutative Algebra

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

Teaching unit: 725 - MA I - Department of Applied Mathematics I

Academic year: 2011

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

ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: FRANCESC D'ASSIS PLANAS VILANOVA

Others:

FRANCESC D'ASSIS PLANAS VILANOVA - A

Prior skills

Linear algebra, calculus, topology, analysis.

Requirements

The two first years of a degree in mathematics.

Degree competences to which the subject contributes

Specific:

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

Generical:

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

34950 - CALG - Commutative Algebra

Learning objectives of the subject

Basic course in Commutative Algebra.
An introduction to rings, ideal, primary decomposition, noetherian rings, integral extensions, completions and dimension theory.

Study load

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

Content

Rings and ideals	Learning time: 12h 45m Theory classes: 3h Self study : 9h 45m
Description: It covers rings, ideals, radicals, extensions, and contractions.	

Modules	Learning time: 12h 45m Theory classes: 3h Self study : 9h 45m
Description: General properties of modules. Tensor product.	

Rings and modules of fractions	Learning time: 18h Theory classes: 6h Self study : 12h
Description: Introduction to rings and modules of fractions	

Primary decompostion	Learning time: 18h Theory classes: 6h Self study : 12h
Description: Classical primary theory. First theorems.	

Integral dependence	Learning time: 18h Theory classes: 6h Self study : 12h
Description: Definition of integral dependence. Theorems of going-up and going-down.	

Chain conditions	Learning time: 18h Theory classes: 6h Self study : 12h
Description: Chain conditions on sets, modules, rings.	

Noetherian rings	Learning time: 18h Theory classes: 6h Self study : 12h
Description: They play a central role in Commutative Algebra and Algebraic Geometry.	

Artin rings	Learning time: 18h Theory classes: 6h Self study : 12h
Description: A good examples of noetherian rings. In some sense the simpliest.	

Discrete valuation rings	Learning time: 18h Theory classes: 6h Self study : 12h
Description: The next case. Noetherian rings of dimension one.	

Completions	Learning time: 18h Theory classes: 6h Self study : 12h
Description: To deal with topologies, completions, filtrations and graded rings.	

Dinmension theory	Learning time: 18h Theory classes: 6h Self study : 12h
Description: A biref introduction to Hilbert functions and dimension theory.	

Qualification system

Continuous assessment, a final exam (if necessary)

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.

Last update: 03/10/2011

34959 - CM - Computational Mechanics

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

Teaching staff

Coordinator: YONGXING SHEN

Others:

YONGXING SHEN - A

Prior skills

Basic knowledge of numerical methods
Basic knowledge of partial differential equations

Degree competences to which the subject contributes

Specific:

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

Generical:

5. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
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

Three elements will be combined: theory classes, where the main concepts will be presented; practical classes in the computer room, with emphasis on the computational aspects; lists of problems. Students will work on these problems individually or in pairs.

Last update: 03/10/2011

34959 - CM - Computational Mechanics

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. 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	Self study:	127h 30m	68.00%
	Theory classes:	60h	32.00%

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. Computational aspects. Applications.

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

Description:
Basic concepts and motivation. One-dimensional plasticity: elastic and plastic strains; elastoplastic constitutive equation; hardening. Multi-dimensional plasticity: stress and strain invariants; yield surface; plastic flow. Numerical time-integration of the constitutive equation: elastic prediction and plastic correction; iterative methods for the plastic correction. Applications.

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

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.

Last update: 03/10/2011

34959 - CM - Computational Mechanics

Qualification system

Exam and assigned problems.

Bibliography

Basic:

Chorin, A. J.; Marsden, J. E. *A mathematical introduction to fluid mechanics.* 2nd ed. New York: Springer-Verlag, 1990. ISBN 0387973001.

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.* New York: Springer-Verlag, 1998. ISBN 0387983198.

Mase, G. Thomas; Mase, George E. *Continuum mechanics for engineers.* 2nd ed. Boca Raton: CRC, 1999. ISBN 0849318556.

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.

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.* New York: Springer-Verlag, 1998. ISBN 0387975209.

Zienkiewicz O. C.;Taylor, R. L. *The finite element method.* 5th ed. Oxford: Butterworth Heinemann, 2000.

Last update: 03/10/2011

34966 - VD - Differentiable Manifolds

Coordinating unit: 200 - FME - Faculty of Mathematics and Statistics
Teaching unit: 743 - MA IV - Department of Applied Mathematics IV
Academic year: 2011
Degree: MASTER IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Teaching unit Optative)
ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: FRANCESC XAVIER GRACIA SABATE

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

Prior skills

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

Degree competences to which the subject contributes

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

Generical:
5. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
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.

34966 - VD - Differentiable Manifolds

Teaching methodology

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

Learning objectives of the subject

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

Study load

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

Content

Vector bundles and de Rham cohomology	Learning time: 37h 30m Theory classes: 10h Practical classes: 2h Self study : 25h 30m

Tangent distributions and Fröbenius theorem	Learning time: 37h 30m Theory classes: 10h Practical classes: 2h Self study : 25h 30m

Lie groups and algebras	Learning time: 37h 30m Theory classes: 10h Practical classes: 2h Self study : 25h 30m

Actions of Lie groups on manifolds	Learning time: 37h 30m Theory classes: 10h Practical classes: 2h Self study : 25h 30m

Symmetries of differential equations	Learning time: 37h 30m Theory classes: 10h Practical classes: 2h Self study : 25h 30m

Qualification system

In general, it will include an exam as well as class presentations. In the case of a small group, the exam may be replaced by personal work. In particular, presentations of parts of the different subjects or solved problems as well as scientific research are considered as possible alternatives to the exam.

Bibliography

Basic:

Abraham, Ralph; Marsden, Jerrold E.. *Foundations of mechanics*. 2nd ed.. Reading, MA: The Benjamin/Cummings, 1978. ISBN 080530102X.

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

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

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

Greub, W. H.; Halperin, S.; Vanstone, R.. *Connections, curvature and cohomology (vol I)*. New York: Academic Press, 1972-1976.

Greub, W. H.; Halperin, S.; Vanstone, R.. *Connections, curvature and cohomology (vol II)*. New York: Academic Press, 1972-1976.

Last update: 03/10/2011

34956 - DG - Discrete and Algorithmic Geometry

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

Teaching staff

Coordinator: VERA SACRISTAN ADINOLFI

Others:
JULIAN PFEIFLE - A
VERA SACRISTAN ADINOLFI - A

Prior skills

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

Degree competences to which the subject contributes

Specific:

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

Generical:

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			
	Self study:	127h 30m	68.00%
	Theory classes:	60h	32.00%

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 Practical classes: 2h Self study : 13h
Description: Convex hull computation. Linear programming in low dimensions.	

Decompositions and arrangements	Learning time: 31h Theory classes: 7h Practical 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 Practical classes: 3h Self study : 21h
Description: Proximity problems. Voronoi diagram, Delaunay triangulation. Shape reconstruction.	

Discrete geometry in arbitrary dimension	Learning time: 37h Theory classes: 8h Practical classes: 4h Self study : 25h
Description: Geometry of three-dimensional manifolds. Phenomena in higher dimensions. Johnson-Lindenstrauss lemma and Compressed Sensing. Triangulations of products of polytopes. Lattices, tessellations and packings. Aperiodic tessellations and the method of sections.	

Nonlinear discrete geometry	Learning time: 37h Theory classes: 8h Practical classes: 4h Self study : 25h
Description: Positive semidefinite quadratic forms and sphere packings; Voronoi reductions; Delaunay subdivisions. Splines regarded as toric varieties; splines with linear precision in reconstructing functions.	

Applications	Learning time: 11h Theory classes: 4h Self study : 7h
Description: GPS, GIS, structural rigidity and tensegrities; computational astrophysics, algorithmic chemistry; other applications.	

Software	Learning time: 9h Laboratory classes: 2h Self study : 7h
Description: STL, CGAL, polymake, ANN, curved spaces, etc.	

Qualification system

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

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

34956 - DG - Discrete and Algorithmic Geometry

Bibliography

Basic:

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, 1998. ISBN 0521565294.

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

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

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.

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.

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

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

Last update: 03/10/2011

34957 - GT - Graph Theory

Coordinating unit:	200 - FME - Faculty of Mathematics and Statistics
Teaching unit:	743 - MA IV - Department of Applied Mathematics IV 726 - MA II - Department of Applied Mathematics II
Academic year:	2011
Degree:	MASTER IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Teaching unit Optative)
ECTS credits:	7,5
Teaching languages:	English

Teaching staff

Coordinator: ORIOL SERRA ALBO

Others:

MIGUEL ANGEL FIOL MORA - A
ANNA LLADO SANCHEZ - A
MARCOS NOY SERRANO - A
ORIOL SERRA ALBO - A

Prior skills

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

Degree competences to which the subject contributes

Specific:

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

Generical:

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.

Last update: 03/10/2011

34957 - GT - Graph Theory

Learning objectives of the subject

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 surafaces.
Minors.

Study load

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

Content

Spectral techniques in Graph Theory

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.

Symmetries in graphs

Minors and treewidth

Graphs on surfaces

Graph homomorphisms

Random graphs

34957 - GT - Graph Theory

Extremal Graph Theory	Learning time: 75h Theory classes: 24h 10m Practical classes: 24h 10m Assessment sessions: 3h Self study (distance learning): 23h 40m

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 forthe evaluation of the final exam.

Bibliography

Basic:

Biggs, Norman L. *Algebraic graph theory*. 2nd ed. New York: Cambridge University Press, 1993. ISBN 0521458978.

Kolchin, V. F. *Random graphs*. Cambridge: Cambridge University Press, 1999. ISBN 0521440815.

Chung, Fan R. K. *Spectral Graph Theory*. Providence: American Mathematical Society, 1997. ISBN 0821803158.

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.

Last update: 03/10/2011

34962 - HS - Hamiltonian Systems

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

Teaching staff

Coordinator: AMADEU DELSHAMS I VALDES

Others:

AMADEU DELSHAMS I VALDES - A

Prior skills

Knowledge of calculus, algebra and ordinary differential equations.

Degree competences to which the subject contributes

Specific:

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

Generical:

5. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
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: 03/10/2011

34962 - HS - Hamiltonian Systems

Teaching methodology

Standard exposition in front of the blackboard, resolution of exercices, completion of a project and/or attendance to the winter school RTNS
http://www.dance-net.org/index.php?contingut=rtns.php

Learning objectives of the subject

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

Study load

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

Content

Hamiltonian formalism

Learning time: 26h

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

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

Hamiltonian and Lagrangian systems

Learning time: 13h

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

Description:
Lagrangian systems. Configuration manifold, tangent and cotangent bundles. Systems with symmetries, Noether theorem. Principle of minimal action.

Integrable and quasi-integrable Hamiltonian systems	Learning time: 13h Theory classes: 2h Practical classes: 2h Self study : 9h
Description: Complete integrability and Liouville-Arnold theorem. Quasi-periodic flows on a torus, resonances. Examples of quasi-integrable systems. Twist maps and billiards. Analytic non-integrability.	

Invariant objects of dynamical systems	Learning time: 13h Theory classes: 2h Practical classes: 2h Self study : 9h
Description: Continuous and discrete dynamical systems, Poincaré map. Local structure of hyperbolic invariant objects: invariant manifolds. Center manifold. Local bifurcations.	

Perturbation theory in dynamical systems	Learning time: 13h Theory classes: 2h Practical classes: 2h Self study : 9h
Description: Classical perturbation theory. Perturbations of homoclinic orbits in the plane: Melnikov method.	

Homoclinic points and chaotic dynamics	Learning time: 13h Theory classes: 2h Practical classes: 2h Self study : 9h
Description: Homoclinic points and bifurcations. Hyperbolic sets and transverse homoclinic points: systems with chaotic dynamics. Newhouse phenomenon.	

Normal forms	Learning time: 13h Theory classes: 2h Practical classes: 2h Self study : 9h

Description:
Poincaré-Dulac normal forms. Convergence: Poincaré and Siegel domains. Hamiltonian normal forms. Bifurcstions. Lie series. Construction of algebraic manipulators.

Stability of dynamical systems and Hamiltonian systems	Learning time: 13h Theory classes: 2h Practical classes: 2h Self study : 9h

Description:
KAM theory (Kolmogorov-Arnold-Moser), twist theorem. Small divisors and Diophantine inequalities. Effective stability and Nekhoroshev theorem. Splitting of separatrices, Melnikov potential. Arnold diffusion.

Discrete dynamical systems	Learning time: 13h Theory classes: 2h Practical classes: 2h Self study : 9h

Description:
Discrete systems. Denjoy theorem. Generic properties. Sarkovskii theorem.

Recent Trends in Nonlinear Science	Learning time: 57h 30m Theory classes: 20h Self study : 37h 30m

Description:
Smooth Ergodic Theory: Lyapunov exponents, Oseledets' Theorem, nonuniform hyperbolicity.

Delay equations with applications to engineering: delay equations, stability, bifurcations.

Multi-frequency Oscillations in Dynamical Systems.

Planning of activities

RECENT TRENDS IN NONLINEAR SCIENCE

Description:

Attendance to the winter school RTNS http://www.dance-net.org/index.php?contingut=rtns.php

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 research work. Moreover, they will attend the RTNS and produce a document about them.

Bibliography

Basic:

Arnol'd, V. I.; Kozlov, Valerii V.; Neishtadt, Anatoly I. *Mathematical aspects of classical and celestial mechanics*. 3th ed. Berlin: Springer-Verlag, 2006. ISBN 3540282467.

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.

Barreira, Luis; Pesin, Yakov B. *Nonuniform hyperbolicity : dynamics of systems with nonzero Lyapunov exponents.* Cambridge: Cambridge University Press, 2007. ISBN 978-0-521-83258-8.

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

Others resources:

Hyperlink

Grup de sistemes dinàmics

https://recerca.upc.edu/sd

pàgina web del Grup de Sistemes Dinàmics de la UPC on es descriuen diversos projectes i els investigadors que hi treballen així com diverses activitats relacionades

Last update: 03/10/2011

34958 - MMPDE - Mathematical Modelling with Partial Differential Equations

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

Teaching staff

Coordinator: JUAN DE LA CRUZ DE SOLÀ-MORALES RUBIÓ

Others:
TIMOTHY MYERS - 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.

Generical:

5. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
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: 03/10/2011

34958 - MMPDE - Mathematical Modelling with Partial Differential Equations

Teaching methodology

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

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

Learning objectives of the subject

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

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

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

Study load

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

Content

1 Modelling with PDEs	Learning time: 93h 45m Theory classes: 30h Self study : 63h 45m

Description:
- Heat conduction and diffusion.
- Potentials in physics and technology.
- Transients in continuous media
- Populations dynamics.
- Equations of distribution of particles.

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34958 - MMPDE - Mathematical Modelling with Partial Differential Equations

2 Phase Transitions	Learning time: 93h 45m Theory classes: 30h Self study : 63h 45m
Description: - Introduction to phase change problems and exact solutions. - Mathematical techniques for phase change and moving boundary problems - Integral methods. - Approximate solutions methods. - Practical applications.	

Qualification system

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

Bibliography

Basic:

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.

Crank, John. *Free and moving boundary problems.* Oxford: Clarendon, 1984. ISBN 0198533705.

Hill, J.M. *One-Dimensional Stefan Problems.* New York: Wiley, 1987. ISBN 0470203889.

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

Complementary:

Crank, John. *The Mathematics of diffusion.* 2nd ed. Oxford: Clarendon Press, 1975. ISBN 0198534116.

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

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

Last update: 03/10/2011

34960 - MMB - Mathematical Models in Biology

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

Teaching unit: 725 - MA I - Department of Applied Mathematics I
726 - MA II - Department of Applied Mathematics II

Academic year: 2011

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

ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: JOAQUIM PUIG SADURNI

Others:

JESUS FERNANDEZ SANCHEZ - A
ANTONI GUILLAMON GRABOLOSA - A
JOAQUIM PUIG SADURNI - A

Prior skills

* Proficiency in undergraduate mathematics: calculus, algebra, probability and statistics.
* Ability to perform basic operations in linear algebra: eigenvalues and eigenvectors, computation of determinants, rank of matrices...
* Ability to 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.
* Courses and all the bibliography will be in English.

Degree competences to which the subject contributes

Specific:

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

Generical:

5. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
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 consist of lectures, problem sessions and practical computer sessions. Lectures will consist of expositions about the contents of this subject following a biological problem.

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

Learning objectives of the subject

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

* Understand and discuss basic models of dynamical systems of biological origin, in terms of the parameters.
* Model simple phenomena, analyze them (numerically and/or analytically) and understand the effect of parameters.
* Understand the diversity of mechanisms and the different levels of modelization of physiological activity.
* Obtain and analyze genomic sequences of real biological species and databases containing them.
* Use computer software for gene prediction, alignment and phylogenetic reconstruction.
* 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	Self study:	127h 30m	68.00%
	Theory classes:	60h	32.00%

Content

34960 - MMB - Mathematical Models in Biology

Models of Population Dynamics	Learning time: 56h 20m Theory classes: 9h Practical classes: 9h Self study : 38h 20m

Description:
1. Differential equations models. Stability and Bifurcations. Applications to population dynamics.
2. One-dimensional discrete models. Chaos in biological systems.
3. Introduction to stochastic models. Branching processes
4. Simulation with SAGE

Mathematical models in Genomics	Learning time: 62h 30m Theory classes: 12h Practical classes: 8h Self study : 42h 30m

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 Physiology	Learning time: 56h 20m Theory classes: 11h Practical classes: 7h Self study : 38h 20m

Description:
1. Enzymatic reactions and Michaelis-Menten theory.
2. Neuronal activity: transmembranic diffusion, Hodgkin-Huxley models and variations.
3. Pancreatic Beta cells and bursting models.
4. Models in systems physiology: hormone physiology, respiration, cardiac activity.

Biological networks	Learning time: 12h 20m Theory classes: 3h Practical classes: 1h Self study : 8h 20m
Description: 1. Complex networks in biology. 2. Networks of neurons: synapse modelling, connectivity and synchronization. 3. Firing rate models and mean field techniques in cell networks.	

Qualification system

The course has three parts and each of these parts will give a part of the qualification, based on practical problems to be delivered. Besides, students will be asked to write a report on a specialized subject (from a list of suggested topics) and deliver it 2 days before presenting it in front of the students and teachers . The contents and the clarity of explanations and exposition.

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

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

- NT=report qualification.

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Last update: 03/10/2011

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.* Berlin: Springer, 2005. ISBN 354025305X.

Murray, J.D. *Mathematical biology*. 3rd ed. Berlin: Springer, 2002. ISBN 978-0-387-95223-9.

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

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

Izhikevich, Eugene M. *Dynamical systems in neuroscience : the geometry of excitability and bursting.* Cambridge: MIT Press, 2007. ISBN 0262090430.

Pikovsky, Arkady; Rosenblum, Michael; Kurths, Jürgen. *Synchronization : a universal concept in nonlinear sciences.* Cambridge: Cambridge University Press, 2001. ISBN 0521592852.

Complementary:

Stein, William A. [et al.]. *Sage mathematics software (Version 4.4.2)* [on line]. 2010 [Consultation: 11/05/2010]. Available on: <http://www.sagemath.org/>.

Durbin, Richard [et al.]. *Biological sequence analysis : probabilistic models of proteins and nucleic acids.* Cambridge: Cambridge University Press, 1998. ISBN 0521629713.

Renart Alfonso; Brunel, Nicolas; JingWang, Xiao. "Mean-field theory of irregularly spiking neuronal populations and working memory in recurrent cortical networks". Feng, Jianfeng. *Computational neuroscience : comprehensive approach* [on line]. Boca Raton: Chapman & Hall/CRC, 2004. p. 432-490Available on: <http://nba.uth.tmc.edu/homepage/cnjclub/2007summer/renart_chapter.pdf>.

Rolls, Edmund T.; Deco, Gustavo. *The noisy brain : stochastic dynamics as a principle of brain function.* Oxford: Oxford University Press, 2010. ISBN 9780199587865.

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

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

Last update: 03/10/2011

34953 - NT - Number Theory

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

Teaching unit: 726 - MA II - Department of Applied Mathematics II
743 - MA IV - Department of Applied Mathematics IV

Academic year: 2011

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

ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: JORDI GUARDIA RUBIES

Others:
JOSEP GONZALEZ ROVIRA - A
JORDI GUARDIA RUBIES - A

Prior skills

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

Requirements

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

Degree competences to which the subject contributes

Specific:

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

Generical:

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.

34953 - NT - Number Theory

Teaching methodology

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

Learning objectives of the subject

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

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

Study load

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

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

Regulations for carrying out activities

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

34953 - NT - Number Theory

Bibliography

Basic:

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

Silverman, Joseph H. *The arithmetic of elliptic curves*. New York: Springer-Verlag, 1986. ISBN 0387962034.

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

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Last update: 03/10/2011

34964 - NMDS - Numerical Methods for Dynamical Systems

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

Teaching unit: 725 - MA I - Department of Applied Mathematics I

Academic year: 2011

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

ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: MERCEDES OLLE TORNER

Others:

MERCEDES OLLE TORNER - A

Prior skills

Good knowledge of a programming language.

Requirements

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

Degree competences to which the subject contributes

Specific:

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

Generical:

5. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
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	Self study:	127h 30m	68.00%
	Theory classes:	60h	32.00%

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

34964 - NMDS - Numerical Methods for Dynamical Systems

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

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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.* Cambridge: Cambridge University Press, 1988.

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: 03/10/2011

34965 - NMPDE - Numerical Methods for Partial Differential Equations

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

Teaching unit: 727 - MA III - Department of Applied Mathematics III
725 - MA I - Department of Applied Mathematics I

Academic year: 2011

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

ECTS credits: 7,5 Teaching languages: English

Teaching staff

Coordinator: MARCO DISCACCIATI

Others:

MARCO DISCACCIATI - A

Prior skills

Basics on numerical methods, differential equations and calculus.

Degree competences to which the subject contributes

Specific:

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

Generical:

5. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
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.
Some exercises and home works will involve use of finite element or finite difference basic programs and some coding.

34965 - NMPDE - Numerical Methods for Partial Differential Equations

Learning objectives of the subject

This module presents the fundamentals of classical numerical techniques for linear partial differential equations (PDEs), with application to a wide variety of problems in science, engineering, and other fields.
Learning outcomes are:
*A knowledge and understanding of
- the fundamentals of classical numerical techniques for linear PDEs,
- the derivation of weak forms and their solution,
- why finite elements approximate and converge to the solution of a PDE,
- the basic structure of a finite element code,
- different methods for prescribing boundary conditions,
- how to solve transient problems,
- stability properties for explicit and implicit time integrators
- basics on stabilization techniques for convection dominated problems

* Ability to
- identify the key issues when solving a boundary value problem,
- employ appropriate order polynomials together with appropriate integration rules,
- solve simple boundary value problems by hand,
- analyze the convergence and stability of a numerical scheme,
- use a simple FE or FD computer code to set up and produce results for computational simulation,
- formulate and implement simple key aspects of a FE code,
- check the reliability and accuracy of a computed solution.

Study load

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

Content

Overview of partial differential equations	Learning time: 6h Theory classes: 2h Self study : 4h

Description:
Mathematical and physical classification of PDEs. Problems in engineering and applied sciences modeled by PDEs.

Finite element method for elliptic equations	Learning time: 35h Theory classes: 5h Practical classes: 6h Self study : 24h
Description: Fundamentals of the Finite Element Method (FEM): weighted residuals, finite element discretization, reference element and isoparametric transformation, numerical integration. Structure of a basic FEM code. Overview of linear solvers	

Analysis of the FEM: existence and uniqueness of solution and convergence	Learning time: 15h Theory classes: 3h Practical classes: 2h Self study : 10h
Description: Application of the Lax-Milgram theorem. Cea's Lemma and Galerkin orthogonality. A priori error bounds. Convergence.	

Implementation of boundary conditions	Learning time: 25h Theory classes: 4h Practical classes: 4h Self study : 17h
Description: Techniques for the implementation of Dirichlet boundary conditions: system transformation, Lagrange multipliers, Nitsche's method, etc.	

Parabolic equation	Learning time: 50h 30m Theory classes: 6h Practical classes: 10h Self study : 34h 30m
Description: Space and time integration of the parabolic equation. Classical methods for time integration: Euler, backward Euler and Crank-Nicolson. Stability analysis for 1D problems: amplification matrix analysis and Von Neumann analysis.	

Introduction to stabilization techniques for convection dominated problems	Learning time: 28h Theory classes: 5h Practical classes: 4h Self study : 19h
Description: Analysis of the 1D convection-diffusion equation and Peclèt number. Classical stabilization techniques	

Introduction to accuracy assessment and adaptivity	Learning time: 28h Theory classes: 5h Practical classes: 4h Self study : 19h
Description: Introduction to error estimation and error bounds. Remeshing and adaptivity strategies	

Qualification system

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

Bibliography

Basic:

Hughes, Thomas J. R. *The finite element method : linear static and dynamic finite element analysis.* Englewood Cliffs, NJ: Prentice-Hall International, 1987. ISBN 0133170179.

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.* 5th ed. Oxford: Butterworth Heinemann, 2000.

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.

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: 03/10/2011

34961 - QQMDS - Quantitative and Qualitative Methods in Dynamical Systems

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

Teaching staff

Coordinator: M. TERESA MARTINEZ-SEARA ALONSO

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

Opening hours

Timetable: A convenir

Prior skills

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

Degree competences to which the subject contributes

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

Generical:
5. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
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.

34961 - QQMDS - Quantitative and Qualitative Methods in Dynamical Systems

Teaching methodology

We don't distinguish theoretical and practical classes. Some results about modern theory in Dynamical systems are presented in class. The main idea is to give basic knowledge and useful tools in the study of a dynamical system from both quantitative and qualitative points of view. We will stress the relation between different 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	Self study:	127h 30m	68.00%
	Theory classes:	60h	32.00%

Content

-Invariant objects in Dynamical Systems	Learning time: 20h Theory classes: 5h Practical classes: 5h Other activities: 10h
Description: Continuous and dicrete Dynamical Systems. Poincaré map. Local behaviour of hyperbolic invariant objects. Invariant manifolds. Central manifold. Local bifurcations.	

-Perturbation theory in Dynamical Systems	Learning time: 20h Theory classes: 5h Practical classes: 5h Other activities: 10h
Description: Clasic perturbation theory. Perturbed homoclinic orbits in the plane. Melnikov method.	

Discrete Dynamical Systems	Learning time: 20h Theory classes: 5h Practical classes: 5h Other activities: 10h

Description:
Discrete systems. Denjoy theorem. Generic properties. Sarkovskii theorem.

-Homoclinic points and chaotic Dynamics	Learning time: 20h Theory classes: 5h Practical classes: 5h Other activities: 10h

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

-Normal forms	Learning time: 20h Theory classes: 5h Practical classes: 5h Other activities: 10h

Description:
Poincaré-Dulac normal forms. Convergence: Poincaré and Siegel domains.
Hamiltoniane normal forms. Bifurcations. Lie series. Construction of
algebraic and analytic manipulators.

-Normal forms: its aplication to stability in Dynamical Systems	Learning time: 20h Theory classes: 5h Practical classes: 5h Other activities: 10h

Description:
KAM (Kolmogorov-Arnold-Moser) theory, twist theorem. Small divisors and diophantic inequalities. Efective stability and Nekhoroshev theorem.
Splitting of separatrices, Melnikov potential. Arnold diffusion.

Last update: 03/10/2011

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Qualification system

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

Regulations for carrying out activities

There are no exams.

Bibliography