

Course guides

34958 - MMPDE - Mathematical Modelling with Partial Differential Equations

Last modified: 16/06/2020

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

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

Academic year: 2020 **ECTS Credits:** 7.5 **Languages:** English

LECTURER

Coordinating lecturer: JUAN DE LA CRUZ DE SOLÀ-MORALES RUBIÓ

Others: Primer quadrimestre:
XAVIER CABRE VILAGUT - A
JEZABEL CURBELO HERNANDEZ - A
JAIME HARO CASES - A
JUAN DE LA CRUZ DE SOLÀ-MORALES RUBIÓ - A

PRIOR SKILLS

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

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:

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

Transversal:

5. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.
6. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.
7. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
8. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
9. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.



TEACHING METHODOLOGY

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

LEARNING OBJECTIVES OF THE SUBJECT

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

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

- * a knowledge of the problems that can be modelled with PDE's.
- * intuitive and physical interpretations of the terms that appear on PDE's.

STUDY LOAD

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

Total learning time: 187.5 h

CONTENTS

1 Heat conduction and diffusion

Description:

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

Full-or-part-time: 56h 15m

Theory classes: 18h

Self study : 38h 15m

2 Potentials in physics and technology

Description:

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

Full-or-part-time: 56h 15m

Theory classes: 18h

Self study : 38h 15m



3 Transients in continuous media

Description:

Acoustics, surface gravity waves, inertial waves.
Electromagnetic and elastic waves.
Dispersion, Stationary waves and high-frequency waves.

Full-or-part-time: 31h 15m

Theory classes: 10h

Self study : 21h 15m

4 Cosmological Models in Mathematical Physics

Description:

Big Bang Cosmology
Inflation
The current cosmic acceleration

Full-or-part-time: 32h 09m

Theory classes: 10h

Self study : 22h 09m

5 Introduction to Calculus of Variations

Description:

Introduction to Calculus of Variations

Full-or-part-time: 12h 52m

Theory classes: 4h

Self study : 8h 52m

GRADING SYSTEM

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

BIBLIOGRAPHY

Basic:

- Dacorogna, Bernard. Introduction to the calculus of variations. London: Imperial College, cop. 2004. ISBN 1860945082.
- Howison, Sam. Practical applied mathematics : modelling, analysis, approximation. New York: Cambridge University Press, 2005. ISBN 0521603692.
- Ockendon, J.R. [et al.]. Applied partial differential equations. Revised ed. Oxford: Oxford University Press, 2003. ISBN 0198527713.
- Witelsky, T.; Bowen, M. Methods of mathematical modelling. Cham (Switzerland): Springer, 2015. ISBN 978-3-319-23041-2.
- Ryden, Barbara. Introduction to cosmology. San Francisco [etc.]: Addison Wesley, 2003. ISBN 0805389121.

Complementary:

- Liddle, A.; Lyth, D.H.. Cosmological inflation and large-scale structure. Cambridge: Cambridge University Press, 2000. ISBN 0521575982.
- Friedman, A.; Litman, W. Industrial mathematics : a course in solving real-world problems. Philadelphia: SIAM, 1994. ISBN 0898713242.
- Fowler, A.C. Mathematical models in the applied sciences. Cambridge: Cambridge University Press, 1997. ISBN 0521467039.
- Salsa, Sandro. Partial differential equations in action : from modelling to theory [on line]. Milan [etc.]: Springer, cop. 2008



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