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

Last modified: 11/06/2023

Unit in charge: School of Mathematics and Statistics
Teaching unit: 749 - MAT - Department of Mathematics.
751 - DECA - Department of Civil and Environmental Engineering.

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

Academic year: 2023 **ECTS Credits:** 7.5 **Languages:** English

LECTURER

Coordinating lecturer: MATTEO GIACOMINI

Others: Primer quadrimestre:
JEZABEL CURBELO HERNANDEZ - A
MATTEO GIACOMINI - A
JOSE JAVIER MUÑOZ ROMERO - A

PRIOR SKILLS

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

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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

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

TEACHING METHODOLOGY

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

LEARNING OBJECTIVES OF THE SUBJECT

The module provides a general overview on the use of partial differential equations (PDEs) to construct mathematical models of physical phenomena and engineering systems. By the end of the module, students are expected to be able to:
- describe basic physical phenomena using PDEs;
- provide intuitive interpretation of the operators appearing in a PDE;
- predict the physical behaviour of an engineering system in view of its mathematical description using PDEs.

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. Diffusion phenomena and heat transfer

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

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

2. Potentials in physics and technology

Description:
Potential theory. Classic gravitation. Electrostatics.

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

3. Modelling in continuum mechanics

Description:
Convection-diffusion-reaction problems. Conservation laws: pure convection, Burger's equation, elasticity, viscoelasticity, wave equation.

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

4. Modelling in fluid dynamics

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

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

GRADING SYSTEM

50% written exam and 50% continuous assessment (assignments and exercises).

EXAMINATION RULES.

The assignments must be submitted via ATENeA by the announced deadline. Late submissions or assignments submitted using other means will not be accepted and will be graded 0. The assignments must be performed individually: students are encouraged to discuss about the assignments but the submitted work must be the result of one own efforts. Plagiarism in the assignments will be punished with a 0 in the classwork grade.

The written exam must be performed individually and will be closed-book. Plagiarism will be punished with a 0 in the module grade.

BIBLIOGRAPHY

Basic:
- Ockendon, J.R. [et al.]. Applied partial differential equations. Revised ed. Oxford: Oxford University Press, 2003. ISBN 0198527713.
- Salsa, Sandro. Partial differential equations in action : from modelling to theory [on line]. Milan [etc.]: Springer, cop. 2008 [Consultation: 07/07/2023]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=3062992. ISBN 9788847007512.
- Witelsky, T.; Bowen, M. Methods of mathematical modelling. Cham (Switzerland): Springer, 2015. ISBN 9783319230412.
- Chorin, A. J.; Marsden, J.E. A Mathematical introduction to fluid mechanics. 3rd ed. Springer, ISBN 978-0387979182.
- Howison, Sam. Practical applied mathematics : modelling, analysis, approximation. New York: Cambridge University Press, 2005. ISBN 0521603692.

Complementary:
- Friedman, A.; Litman, W. Industrial mathematics : a course in solving real-world problems. Philadelphia: SIAM, 1994. ISBN 0898713242.
- Fowler, A.C. Mathematical models in the applied sciences. Cambridge: Cambridge University Press, 1997. ISBN 0521467039.
- LeVeque, Randall J. Finite difference methods for ordinary and partial differential equations : steady state and time-dependent problems [on line]. SIAM, 2007 [Consultation: 07/07/2023]. Available on: https://faculty.washington.edu/rjl/fdmbook/. ISBN 9780898716290.
- Dacorogna, Bernard. Introduction to the calculus of variations [on line]. 2015 [Consultation: 07/07/2023]. Available on: https://www-worldscientific-com.recursos.biblioteca.upc.edu/worldscibooks/10.1142/p967#t=toc. ISBN 9781783265534.