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

Last modified: 20/05/2022

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

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

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

LECTURER

Coordinating lecturer: SONIA FERNANDEZ MENDEZ

Others: Primer quadrimestre:
JEZABEL CURBELO HERNANDEZ - A
SONIA FERNANDEZ MENDEZ - A
JOSE JAVIER MUÑOZ ROMERO - A

PRIOR SKILLS

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

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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

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

TEACHING METHODOLOGY

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

LEARNING OBJECTIVES OF THE SUBJECT

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

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

STUDY LOAD

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

Total learning time: 187.5 h

CONTENTS

1 Heat conduction and diffusion

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

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

2 Potentials in physics and technology

Description:
Classical gravitation. Electrostatics.

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

3 Transients in continuous media

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

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

4. Fluid Mechanics

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

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

GRADING SYSTEM

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

BIBLIOGRAPHY

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

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