

## Course guides

# 34958 - MMPDE - Mathematical Modelling with Partial Differential Equations

Last modified: 28/05/2021

<b>Unit in charge:</b>	School of Mathematics and Statistics	
<b>Teaching unit:</b>	749 - MAT - Department of Mathematics. 751 - DECA - Department of Civil and Environmental Engineering.	
<b>Degree:</b>	MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010). (Optional subject).	
<b>Academic year:</b> 2021	<b>ECTS Credits:</b> 7.5	<b>Languages:</b> English

### LECTURER

---

<b>Coordinating lecturer:</b>	SONIA FERNANDEZ MENDEZ
<b>Others:</b>	Primer quadrimestre: JEZABEL CURBELO HERNANDEZ - A SONIA FERNANDEZ MENDEZ - A JAIME HARO CASES - 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. Reaction-diffusion. Conservation laws: elasticity, viscoelasticity, wave equation, electromagnetics, Burger's equation.

**Full-or-part-time:** 10h

Theory classes: 10h

### 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:** 15h

Theory classes: 15h



## 5 Cosmological Models in Mathematical Physics

### Description:

Big Bang Cosmology. Inflation. The current cosmic acceleration.

**Full-or-part-time:** 15h

Self study : 15h

## 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.
- Ryden, Barbara. Introduction to cosmology. 2nd ed. San Francisco [etc.]: Addison Wesley, 2017. ISBN 0805389121.
- 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:

- 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 [Consultation: 19/05/2020]. Available on: <https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=3062992>. ISBN 9788847007512.
- 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.
- LeVeque, Randall J. Finite Difference Methods for Ordinary and Partial Differential Equations: Steady State and Time Dependent Problems [on line]. SIAM, 2007 Available on: <https://faculty.washington.edu/rjl/fdmbook/>. ISBN 978-0-898716-29-0.