UNIVERSIDAD DE CASTILLA - LA MANCHA

GUÍA DOCENTE

1. General information

Course:	NUMERICAL ANALYSIS OF PDE AND APPROXIMATION	**Code:**	310934
Type:	ELECTIVE	**ECTS credits:**	6
Degree:	2351 - MASTER DEGREE PROGRAMME IN PHYSICS AND MATHEMATICS-FISYMAT	**Academic year:**	2020-21
Center:	602 - E.T.S. INDUSTRIAL ENGINEERING OF C. REAL	**Group(s):**	20
Year:	1	**Duration:**	First semester
Main language:	Spanish	**Second language:**	English
Use of additional languages:		**English Friendly:**	Y
Web site:		**Bilingual:**	N

Lecturer: **DAMIAN CASTAÑO TORRIJOS** - Group(s): **20**

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Lecturer: **MARIA CRUZ NAVARRO LERIDA** - Group(s): **20**

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Lecturer: **FRANCISCO PLA MARTOS** - Group(s): **20**

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2. Pre-Requisites

Calculus, algebra, differential equations and functional analysis.

3. Justification in the curriculum, relation to other subjects and to the profession

Partial differential equations are the main tool for modeling in science and technology. Only a few of these equations have an analytical solution. For this reason, numerical resolution is essential for scientific progress. To acquire knowledge on numerical analysis is relevant in an Applied Mathematics Master of Science.

4. Degree competences achieved in this course

Course competences

Code	Description
CB06	Possess and understand knowledge that provides a basis or opportunity to be original in the development and / or application of ideas, often in a research context.
CB07	Apply the achieved knowledge and ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to the area of study
CB08	Be able to integrate knowledge and face the complexity of making judgments based on information that, being incomplete or limited, includes reflections on social and ethical responsibilities linked to the application of knowledge and judgments
CB09	Know how to communicate the conclusions and their supported knowledge and ultimate reasons to specialized and non-specialized audiences in a clear and unambiguous way
CB10	Have the learning skills which allow to continue studying in a self-directed or autonomous way
CE01	Solve physical and mathematical problems, planning their solutions based on the available tools and time and resource constraints
CE02	Develop the ability to decide the appropriate techniques to solve a specific problem with special emphasis on those problems associated with the Modeling in Science and Engineering, Astrophysics, Physics, and Mathematics
CE05	Know how to obtain and interpret physical and/or mathematical data that can be applied in other branches of knowledge
CE07	Ability to understand and apply advanced knowledge of mathematics and numerical or computational methods to problems of biology, physics and astrophysics, as well as to build and develop mathematical models in science, biology and engineering
CE08	Ability to model, interpret and predict from experimental observations and numerical data
CG03	Present publicly the research results or technical reports, to communicate the conclusions to a specialized court, interested persons or organizations, and discuss with their members any aspect related to them
CG04	Know how to communicate with the academic and scientific community as a whole, with the company and with society in general about Physics and/or Mathematics and its academic, productive or social implications
CT03	Develop critical reasoning and the ability to criticize and self-criticize
CT05	Autonomous learning and responsibility (analysis, synthesis, initiative and teamwork)

5. Objectives or Learning Outcomes

Course learning outcomes

Description

Interpretation of the obtained numerical solution and critical judgment of its quality. Relation with the applied science referred to

Gain the ability to solve a specific problem as a team: from the choice of an appropriate method to the oral and written presentation of the results obtained after

its implementation
Learn to use some tools of Basic Analysis and Functional Analysis to carry out the numerical analysis of a method

Know some software tools that allow to completely solve a problem in the computer, which entails know how to program, generate a computational mesh, apply the appropriate calculus module and visualize the numerical solution. Practical problem solving.
Understand the theoretic design of finite element, finite difference, finite and spectral volume methods, from known analytic techniques (variational formulations, Taylor developments, integration formulas by parts).
Understand the specific characteristics of the elliptic, parabolic and hyperbolic equations which be solved by numerical methods
Know and understand the basic concepts of consistency, stability and convergence of a numerical scheme in this context, as well as their interrelation

6. Units / Contents

Unit 1: Finite Differences
- **Unit 1.1** Boundary value problems
- **Unit 1.2** Parabolic evolution problems
- **Unit 1.3** Error analysis
- **Unit 1.4** Practice exercises

Unit 2: Spectral Methods
- **Unit 2.1** Fourier approximation
- **Unit 2.2** Orthogonal polynomial approximation
- **Unit 2.3** Practice exercises

Unit 3: Finite Elements
- **Unit 3.1** Formulation and error analysis
- **Unit 3.2** Effective implementation
- **Unit 3.3** Practice exercises

Unit 4: Finte Volumes and Finite Differences
- **Unit 4.1** Finite Differences for hyperbolic evolution problems
- **Unit 4.2** Formulation and error analysis
- **Unit 4.3** Effective implementation
- **Unit 4.4** Practice exercises

Unit 5: Courses and seminars

7. Activities, Units/Modules and Methodology

Training Activity	Methodology	Related Competences (only degrees before RD 822/2021)	ECTS	Hours	As	Com	Description
Class Attendance (theory) [ON-SITE]	Lectures		1.5	37.5	Y	N	
Computer room practice [ON-SITE]	Problem solving and exercises		0.7	17.5	Y	Y	
Individual tutoring sessions [ON-SITE]			0.2	5	Y	N	
Writing of reports or projects [OFF-SITE]	Self-study		3.6	90	Y	Y	
		Total:	**6**	**150**			
		Total credits of in-class work: 2.4					**Total class time hours: 60**
		Total credits of out of class work: 3.6					**Total hours of out of class work: 90**

As: Assessable training activity
Com: Training activity of compulsory overcoming (It will be essential to overcome both continuous and non-continuous assessment).

8. Evaluation criteria and Grading System

Evaluation System	Continuous assessment	Non-continuous evaluation*	Description
Assessment of active participation	20.00%	10.00%	Active participation in solving problems
Assessment of activities done in the computer labs	30.00%	20.00%	Resolution of practice exercises in the computer lab
Practicum and practical activities reports assessment	50.00%	70.00%	Delivery of proposed works
Total:	**100.00%**	**100.00%**	

According to art. 4 of the UCLM Student Evaluation Regulations, it must be provided to students who cannot regularly attend face-to-face training activities the passing of the subject, having the right (art. 12.2) to be globally graded, in 2 annual calls per subject , an ordinary and an extraordinary one (evaluating 100% of the competences).

Evaluation criteria for the final exam:

Continuous assessment:
Assessment of active participation, work in the computer lab, and autonomous work

Non-continuous evaluation:
Evaluation criteria not defined

9. Assignments, course calendar and important dates

Not related to the syllabus/contents	
Hours	**hours**
Unit 1 (de 5): Finite Differences	

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	8
Computer room practice [PRESENCIAL][Problem solving and exercises]	4
Individual tutoring sessions [PRESENCIAL][]	1
Writing of reports or projects [AUTÓNOMA][Self-study]	20
Unit 2 (de 5): Spectral Methods	
Activities	**Hours**
Class Attendance (theory) [PRESENCIAL][Lectures]	8
Computer room practice [PRESENCIAL][Problem solving and exercises]	4
Individual tutoring sessions [PRESENCIAL][]	1
Writing of reports or projects [AUTÓNOMA][Self-study]	20
Unit 3 (de 5): Finite Elements	
Activities	**Hours**
Class Attendance (theory) [PRESENCIAL][Lectures]	8
Computer room practice [PRESENCIAL][Problem solving and exercises]	4
Individual tutoring sessions [PRESENCIAL][]	1
Writing of reports or projects [AUTÓNOMA][Self-study]	20
Unit 4 (de 5): Finte Volumes and Finite Differences	
Activities	**Hours**
Class Attendance (theory) [PRESENCIAL][Lectures]	8
Computer room practice [PRESENCIAL][Problem solving and exercises]	4
Individual tutoring sessions [PRESENCIAL][]	1
Writing of reports or projects [AUTÓNOMA][Self-study]	20
Unit 5 (de 5): Courses and seminars	
Activities	**Hours**
Class Attendance (theory) [PRESENCIAL][Lectures]	5.5
Computer room practice [PRESENCIAL][Problem solving and exercises]	1.5
Individual tutoring sessions [PRESENCIAL][]	1
Writing of reports or projects [AUTÓNOMA][Self-study]	10
Global activity	
Activities	**hours**
Computer room practice [PRESENCIAL][Problem solving and exercises]	17.5
Individual tutoring sessions [PRESENCIAL][]	5
Writing of reports or projects [AUTÓNOMA][Self-study]	90
Class Attendance (theory) [PRESENCIAL][Lectures]	37.5
Total horas:	150

10. Bibliography and Sources

Author(s)	Title/Link	Publishing house	Citv	ISBN	Year	Description
20. A.Quarterioni, R.Sacco, F.Saleri	Numerical Mathematics	Springer-Verlag			2000	
C. Bernardi and Y. Maday	Approximations spectrales de problemes aux limites elliptiques	Springer			1992	
C. Canuto, M.Y. Hussaini, A. Quarteroni and T.A. Zang	Spectral Methods for Fluid Dynamics	Springer			1988	
C. Johnson	Numerical solution of P.D.E. by the Finite Element Method	Cambridge University Press			1987	
D. Gotlieb and S. Orszag	Numerical Analysis of Spectral Methods ¿Theory and Applications	SIAM			1977	
D.F.Griffiths, A.R.Mitchell	The finite difference method in partial differential equation	John Wiley			1980	
E. Godlewski, P.A. Raviart	Hyperbolic systems of conservation laws	Ellipses			1991	
E.Godlewski, P.A. Raviart	Numerical Approximation of Hyperbolic Systems of Conservation Laws	Springer-Verlag			1996	
G.D. Smith	Numerical Solution of Partial Differential Equations: Finite Difference Methods	Oxford University Press			1985	
G.F.Forsythe, W.R.Wasow	Finite difference methods for partial differential equations	John Wiley			1960	
J. C. Strikwerda	Finite difference Schemes and Partial Differential	Pacific Grove, CA: Wadsworth and Brooks			1989	
J.H.Mathews, K.D. Fink	Métodos Numéricos con MATLAB	Prentice-Hall			2000	
J.M. Sanz-Serna	Fourier techniques in numerical methods for evolutionary problems. 3RD Granada Seminar on Computational Physics	Springer			1995	
L.N. Trefethen	Spectral methods in Matlab	SIAM			2000	
O.C. Zienkiewicz	The Finite Element Method in Engineering Science	McGraw-Hill			1971	

P.G.Ciarlet	The finite element method for elliptic problems	North Holland	1978
R. LeVeque	Finite Volume Methods for Hyperbolic Problems	Cambridge Univesity Press	2002
R.B. Richtmyer, K.W. Morton	Difference methods for initial-value problems	John Wiley & Sons	1967
R.G. Voigt, D. Gotlieb and M.Y. Hussaini	Spectral Methods for Partial Differential Equations	SIAM	1984
S. Nakamura	Análisis Numérico y visualización gráfica con MATLAB	Pearson Educación/Prentice-Hall Hispanoamerica	1997