UNIVERSIDAD DE CASTILLA - LA MANCHA

GUÍA DOCENTE

1. General information

Course: DIFFERENTIAL EQUATIONS
Type: BASIC
Degree: 345 - UNDERGRADUATE DEGREE PROGRAMME IN CIVIL ENGINEERING
Center: 603 - E.T.S. CIVIL ENGINEERS OF CR
Year: 2
Main language: Spanish
Use of additional languages:
Web site:

Code: 38310
ECTS credits: 6
Academic year: 2022-23
Group(s): 20
Duration: First semester
Second language: English
English Friendly: Y
Bilingual: N

Lecturer: **GABRIEL FERNANDEZ CALVO** - Group(s): **20**

Building/Office	Department	Phone number	Email	Office hours
Politecnico 2-D31	MATEMÁTICAS	6218	gabriel.fernandez@uclm.es	Will be provided at the beginning of the Course

Lecturer: **ROSA EVA PRUNEDA GONZALEZ** - Group(s): **20**

Building/Office	Department	Phone number	Email	Office hours
Politecnico 2-D33	MATEMÁTICAS	3292	rosa.pruneda@uclm.es	Will be provided at the beginning of the Course

2. Pre-Requisites

Solving problems modeled by Ordinary and Partial Differential Equations is based on the concepts acquired in "Instrumentos Matemáticos I", "Instrumentos Matemáticos I" and "Herramientas Matemático-Informáticas para la Ingeniería".

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

This course provides the necessary skills for solving engineering problems involvingdifferential equations. The different techniques and concepts studied have direct application in many areas of Civil Engineering and they will be useful in subjects as Technology of

4. Degree competences achieved in this course

Course competences

Code	Description
CE01	Students can apply their knowledge in the practical solution of civil engineering problems, with capacity for the analysis and definition of the problem, the proposal of alternatives and their critical evaluation, choosing the optimal solution with technical arguments and with capacity of defense against third parties.
CE02	Students have the ability to broaden their knowledge and solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their area of study. Self-study ability, to undertake further studies with a high degree of autonomy
CE04	Students have the ability to solve mathematical problems that may arise in engineering. Ability to apply knowledge of: linear algebra; geometry; differential geometry; differential and integral calculus; differential and partial derivative equations; numerical methods; numerical algorithms; statistics and optimization.
CE06	Students have a basic knowledge of the use and programming of computers, operating systems, databases and software with engineering application.
CG01	Students achieve general knowledge of Information and Communication Technologies (ICT).

5. Objectives or Learning Outcomes

Course learning outcomes

Description

Students know how functions and data are approximated by means of power and Fourier series expansions and their applications.

Students are able to express correctly both orally and in writing and, in particular, they can use the language of mathematics as a way of expressing accurately the quantities and operations in civil engineering. Students get used to teamwork and behave respectfully.

Students use mathematical and computer tools to pose and solve civil engineering problems.

Students can describe processes related to civil engineering subjects by means of ordinary and partial differential and equations, solve them and interpret their results.

Students learn the most important approximations for numerical method resolution, use some statistical, data processing, mathematical calculation and visualization software packages at user level, develop algorithms and program using a high-level programming language, visualize functions, geometric shapes and data, design experiments, analyze data, and interpret results.

6. Units / Contents

Unit 1: INTRODUCTION TO ORDINARY DIFFERENTIAL EQUATIONS: Ordinary differential equations. Order and Degree. Linear differential equations. Notation. Definition of solution. Particular and general solutions. Initial value problems. Limit value problems. Classification of ordinary differential equations of the first order. Ordinary and differential form. Classification of first order ordinary differential equations.

Unit 2: SEPARABLE DIFFERENTIAL EQUATIONS: General solution. Initial value problems. Homogeneous differential equations.

Unit 3: EXACT DIFFERENTIAL EQUATIONS: Definition. Resolution. Integration factors.

Unit 4: FIRST ORDER LINEAR DIFFERENTIAL EQUATIONS: Resolution. Applications.

Unit 5: HIGHER ORDER LINEAR DIFFERENTIAL EQUATIONS WITH CONSTANT COEFFICIENTS: Characteristic equation. Homogeneous equation resolution. Particular solution. Undetermined coefficients method. Variation of parameters.

Unit 6: LINEAR DIFFERENTIAL EQUATIONS WITH VARIABLE COEFFICIENTS: Introduction. Analytical functions. Ordinary points and singular points. Solutions by series of powers around an ordinary point. Method for homogeneous equations. Method for non-homogeneous equations.

Unit 7: LINEAR SYSTEMS WITH CONSTANT COEFFICIENTS: Introduction. Resolution of the initial value problem. Comparison of the solution methods. Reduction of a system of linear differential equations to a first-order system.

Unit 8: NUMERICAL METHODS FOR ODE: Introduction and motivation. Discretization of initial value ODE. Euler method. Heun method. Order of a numerical method. Runge-Kutta methods. Numerical resolution of EDO systems. Problems of the contour values: shooting method. Use of MATLAB to solving ODEs numerically.

Unit 9: STURM-LIOUVILLE PROBLEMS: Definition. Resolution. Fourier series.

Unit 10: PHYSICAL SYSTEMS AND PARTIAL DIFFERENTIAL EQUATIONS: Model. Resolution. Classification of partial differential equations. Second order problems. Reduction to canonical forms.

Unit 11: PARABOLIC PROBLEMS. DIFUSSION EQUATION: Diffusion problems: heat equation. Boundary conditions. Separation of variables. Resolution.

Unit 12: HYPERBOLIC PROBLEMS. WAVE EQUATION: The wave equation in one dimension. D'Alembert Solution. Boundary conditions associated with the wave equation. Finite string vibrating. Separation of variables.

Unit 13: ELLIPTIC PROBLEMS. LAPLACE EQUATION: Laplacian. Nature of problems with boundary conditions. Dirichlet problems.

Unit 14: NUMERICAL METHODS FOR PDE: Finite difference method applied to heat, wave and Laplace equations. Use of MATLAB to solve PDE numerically.

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	CE01 CE02 CE04 CE06 CG01	0.8	20	N	-	Magistral lessons will be complemented with the resolution of exercises and the participation of the students in class.
Group tutoring sessions [ON-SITE]	Problem solving and exercises	CE01 CE02 CG01	0.2	5	N	-	Theoretical and practical student doubts will be solved in tutorials.
Progress test [ON-SITE]	Problem solving and exercises	CE01 CE02 CG01	0.2	5	Y	N	Recoverable
Study and Exam Preparation [OFF-SITE]	Combination of methods	CE01 CE02 CE04 CE06 CG01	3.6	90	N	-	
Class Attendance (practical) [ON-SITE]	Project/Problem Based Learning (PBL)	CE01 CE02 CE04 CE06 CG01	0.6	15	N	-	
Computer room practice [ON-SITE]	Project/Problem Based Learning (PBL)	CE01 CE02 CE04 CE06 CG01	0.4	10	Y	Y	Indispensable to pass the subject. Details on content, extension and requirements of the works or practices that have to be delivered in writing will be indicated in Campus Virtual at the beginning of the semester. The minimum score for those computer practices belonging to the part dedicated to Numerical Methods is 4.0 points out of 10.
Final test [ON-SITE]	Assessment tests	CE01 CE02 CG01	0.2	5	Y	Y	Recoverable.
		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
Progress Tests	40.00%	0.00%	
Final test	60.00%	100.00%	
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:

Topics 1 to 7 (partial 1) and 9 to 13 (partial 2) from the Analytical Methods part are evaluated by the average of 2 partial exams (minimum score 4 out of 10) (60%) and progress tests (40%). In the exams, a minimum grade of 4 out of 10 points is required. If a partial exam and/or progress test is passed with minimum score of 4 out of 10, the contents of that partial or progress tests are released for the Ordinary and the Extraordinary call. Progress tests can be retrieved in the Ordinary call by assigning the punctuation obtained in the exam.

Topics 8 and 14 (Numerical Methods) are evaluated exclusively through a MANDATORY practice each (60%) and a final test (40%), which will take place on the dates of the ordinary/extraordinary exams.

The final grade of the Course consists of the marks from both the Analytical Methods (80%) and the Numerical Methods (20%). Indispensable to pass the subject. The minimum score for those computer practices belonging to the part dedicated to Numerical Methods is 4.0 points out of 10. The marks of the computer practices done by the student during the previous academic year will be kept for the next academic year as long as those marks were at least 4.0 points out of 10.

Non-continuous evaluation:

The student will have to do a global exam that will include all the course and competences content. To pass the course, the student must obtain at least a 5 out of 10, which will constitute 100% of his/her grade.

Unless stated otherwise, continuous evaluation criteria will be applied to all students.

Anyone choosing non-continuous assessment must notify it to the lecturer within the class period of the subject. The option is only available if the student's participation in evaluation activities (from the continuous assessment) has not reached 50% of the total Course evaluation.

For the retake exam, the assessment type used for the final exam will remain valid.

Specifications for the resit/retake exam:

Same criteria that apply in final exam.

Specifications for the second resit / retake exam:

The student will have to do a global exam that will include all the course and competences content. To pass the course, the student must obtain at least a 5 out of 10, which will constitute 100% of his/her grade.

9. Assignments, course calendar and important dates

Not related to the syllabus/contents

Hours	hours
Progress test [PRESENCIAL][Problem solving and exercises]	5
Study and Exam Preparation [AUTÓNOMA][Combination of methods]	8
Final test [PRESENCIAL][Assessment tests]	5

Unit 1 (de 14): INTRODUCTION TO ORDINARY DIFFERENTIAL EQUATIONS: Ordinary differential equations. Order and Degree. Linear differential equations. Notation. Definition of solution. Particular and general solutions. Initial value problems. Limit value problems. Classification of ordinary differential equations of the first order. Ordinary and differential form. Classification of first order ordinary differential equations.

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	1
Study and Exam Preparation [AUTÓNOMA][Combination of methods]	1

Unit 2 (de 14): SEPARABLE DIFFERENTIAL EQUATIONS: General solution. Initial value problems. Homogeneous differential equations.

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	1
Study and Exam Preparation [AUTÓNOMA][Combination of methods]	6

Unit 3 (de 14): EXACT DIFFERENTIAL EQUATIONS: Definition. Resolution. Integration factors.

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	1
Group tutoring sessions [PRESENCIAL][Problem solving and exercises]	.5
Study and Exam Preparation [AUTÓNOMA][Combination of methods]	5
Class Attendance (practical) [PRESENCIAL][Project/Problem Based Learning (PBL)]	1

Unit 4 (de 14): FIRST ORDER LINEAR DIFFERENTIAL EQUATIONS: Resolution. Applications.

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	2
Group tutoring sessions [PRESENCIAL][Problem solving and exercises]	.25
Study and Exam Preparation [AUTÓNOMA][Combination of methods]	6
Class Attendance (practical) [PRESENCIAL][Project/Problem Based Learning (PBL)]	1

Unit 5 (de 14): HIGHER ORDER LINEAR DIFFERENTIAL EQUATIONS WITH CONSTANT COEFFICIENTS: Characteristic equation. Homogeneous equation resolution. Particular solution. Undetermined coefficients method. Variation of parameters.

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	2
Group tutoring sessions [PRESENCIAL][Problem solving and exercises]	.25
Study and Exam Preparation [AUTÓNOMA][Combination of methods]	7
Class Attendance (practical) [PRESENCIAL][Project/Problem Based Learning (PBL)]	3
Computer room practice [PRESENCIAL][Project/Problem Based Learning (PBL)]	2

Unit 6 (de 14): LINEAR DIFFERENTIAL EQUATIONS WITH VARIABLE COEFFICIENTS: Introduction. Analytical functions. Ordinary points and singular points. Solutions by series of powers around an ordinary point. Method for homogeneous equations. Method for non-homogeneous equations.

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	1
Group tutoring sessions [PRESENCIAL][Problem solving and exercises]	.5
Study and Exam Preparation [AUTÓNOMA][Combination of methods]	5
Class Attendance (practical) [PRESENCIAL][Project/Problem Based Learning (PBL)]	1

Unit 7 (de 14): LINEAR SYSTEMS WITH CONSTANT COEFFICIENTS: Introduction. Resolution of the initial value problem. Comparison of the solution methods. Reduction of a system of linear differential equations to a first-order system.

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	2
Group tutoring sessions [PRESENCIAL][Problem solving and exercises]	.5
Study and Exam Preparation [AUTÓNOMA][Combination of methods]	7
Class Attendance (practical) [PRESENCIAL][Project/Problem Based Learning (PBL)]	3
Computer room practice [PRESENCIAL][Project/Problem Based Learning (PBL)]	1

Unit 8 (de 14): NUMERICAL METHODS FOR ODE: Introduction and motivation. Discretization of initial value ODE. Euler method. Heun method. Order of a numerical method. Runge-Kutta methods. Numerical resolution of EDO systems. Problems of the contour values: shooting method. Use of MATLAB to solving ODEs numerically.

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	1
Group tutoring sessions [PRESENCIAL][Problem solving and exercises]	.5
Study and Exam Preparation [AUTÓNOMA][Combination of methods]	6
Class Attendance (practical) [PRESENCIAL][Project/Problem Based Learning (PBL)]	1
Computer room practice [PRESENCIAL][Project/Problem Based Learning (PBL)]	3

Unit 9 (de 14): STURM-LIOUVILLE PROBLEMS: Definition. Resolution. Fourier series.

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	1
Study and Exam Preparation [AUTÓNOMA][Combination of methods]	5
Class Attendance (practical) [PRESENCIAL][Project/Problem Based Learning (PBL)]	1

Unit 10 (de 14): PHYSICAL SYSTEMS AND PARTIAL DIFFERENTIAL EQUATIONS: Model. Resolution. Classification of partial differential equations. Second order problems. Reduction to canonical forms.

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	1
Group tutoring sessions [PRESENCIAL][Problem solving and exercises]	.5
Study and Exam Preparation [AUTÓNOMA][Combination of methods]	1
Class Attendance (practical) [PRESENCIAL][Project/Problem Based Learning (PBL)]	1

Unit 11 (de 14): PARABOLIC PROBLEMS. DIFUSSION EQUATION: Diffusion problems: heat equation. Boundary conditions. Separation of variables. Resolution.

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	2
Group tutoring sessions [PRESENCIAL][Problem solving and exercises]	.5
Study and Exam Preparation [AUTÓNOMA][Combination of methods]	3
Class Attendance (practical) [PRESENCIAL][Project/Problem Based Learning (PBL)]	2

Unit 12 (de 14): HYPERBOLIC PROBLEMS. WAVE EQUATION: The wave equation in one dimension. D'Alembert Solution. Boundary conditions associated with the wave equation. Finite string vibrating. Separation of variables.

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	2
Group tutoring sessions [PRESENCIAL][Problem solving and exercises]	.5
Study and Exam Preparation [AUTÓNOMA][Combination of methods]	1
Class Attendance (practical) [PRESENCIAL][Project/Problem Based Learning (PBL)]	1
Computer room practice [PRESENCIAL][Project/Problem Based Learning (PBL)]	1

Unit 13 (de 14): ELLIPTIC PROBLEMS. LAPLACE EQUATION: Laplacian. Nature of problems with boundary conditions. Dirichlet problems.

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	2
Group tutoring sessions [PRESENCIAL][Problem solving and exercises]	.5
Study and Exam Preparation [AUTÓNOMA][Combination of methods]	1
Class Attendance (practical) [PRESENCIAL][Project/Problem Based Learning (PBL)]	3

Unit 14 (de 14): NUMERICAL METHODS FOR PDE: Finite difference method applied to heat, wave and Laplace equations. Use of MATLAB to solve PDE numerically.

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	1
Group tutoring sessions [PRESENCIAL][Problem solving and exercises]	.5
Study and Exam Preparation [AUTÓNOMA][Combination of methods]	8
Class Attendance (practical) [PRESENCIAL][Project/Problem Based Learning (PBL)]	2
Computer room practice [PRESENCIAL][Project/Problem Based Learning (PBL)]	3

Global activity

Activities	hours
Class Attendance (theory) [PRESENCIAL][Lectures]	20

Group tutoring sessions [PRESENCIAL][Problem solving and exercises]	5
Final test [PRESENCIAL][Assessment tests]	5
Computer room practice [PRESENCIAL][Project/Problem Based Learning (PBL)]	10
Progress test [PRESENCIAL][Problem solving and exercises]	5
Study and Exam Preparation [AUTÓNOMA][Combination of methods]	70
Class Attendance (practical) [PRESENCIAL][Project/Problem Based Learning (PBL)]	20
Total horas:	135

10. Bibliography and Sources

Author(s)	Title/Link	Publishing house	Citv	ISBN	Year	Description
Campbell, Stephen L.	Introducción a las ecuaciones diferenciales : con problemas	Mc-Graw Hill,		970-10-1872-9	1997	
Bronson, Richard.	Ecuaciones diferenciales /	McGraw-Hill Interamericana,		978-970-10-6509-9	2008	
Simmons, George Finlay	Differential equations with applications and historical note	CRC Press,		978-1-4987-0259-1	2017	
Boyce, William E.	Ecuaciones diferenciales y problemas con valores en la front	Limusa		968-18-4974-4	1998	
Ayres, Frank1901-	Ecuaciones diferenciales	McGraw-Hill		0-07-002654-8	1991	
Farlow, Stanley J.	Partial differential equations : for scientists and engineer	Dover,		0-486-67620-X	1993	
Zill, Dennis G. (1940-)	Ecuaciones diferenciales con problemas de valores en la fron	Cengage Learning,		978-607-526-630-5	2018	
Chapra, Steven C.	Métodos numéricos para ingenieros /	McGraw-Hill,		978-1-4562-6734-6 (	2015	