Teaching Guide				
Identifying Data				2021/22
Subject (*)	Boundary element methods		Code	614855230
Study programme	Mestrado Universitario en Matemática Industrial (2013)			
Descriptors				
Cycle	Period	Year	Type	Credits
Official Master's Degree	2nd four-month period	First	Optional	3
Language	Spanish			
Teaching method	Hybrid			
Prerequisites				
Department	Matemáticas			
Coordinador	Gonzalez Taboada, Maria	E-mail	maria.gonzalez.taboada@udc.es	
Lecturers	Gonzalez Taboada, Maria	E-mail	maria.gonzalez.taboada@udc.es	
Web	http://www.m2i.es			
General description	We provide an introduction to boundary element methods. Using as a model a potential problem, we present the direct method and the indirect methods based on single layer and double layer formulations to solve problems in two and three dimensions. We also discuss the application of boundary element methods to acoustic scattering and radiation problems, fluid mechanics and linear elastostatics. Finally, we show some basis techniques to couple boundary element methods with finite element methods, so that the applicability of these techniques can be widened.			
Contingency plan	1. Modifications to the contents There will be no changes. 2. Methodologies *Teaching methodologies that are maintained All. *Teaching methodologies that are modified None. 3. Mechanisms for personalized attention to students E-mail: The teacher will check it every day in order to solve quick questions, fix virtual meetings to solve students doubts and to follow the development of the supervised projects. Teams: There will be two weekly sessions to advance in the contents and supervised projects. These sessions will take place within the assigned timetable.It is possible to fix virtual meetings to solve possible doubts. 4. Modifications in the evaluation None. *Evaluation observations: 5. Modifications to the bibliography or webgraphy None. The working materials will be given to students through e-mail or via Teams.			

Study programme competences / results	
Code	Study programme competences / results

A4	Ser capaz de seleccionar un conjunto de técnicas numéricas, lenguajes y herramientas informáticas, adecuadas para resolver un modelo matemático.
A8	Saber adaptar, modificar e implementar herramientas de software de simulación numérica.
B3	Ser capaz de integrar conocimientos para enfrentarse a la formulación de juicios a partir de información que, aun siendo incompleta o limitada, incluya reflexiones sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos.
B5	Poseer las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo, y poder emprender con éxito estudios de doctorado.

Learning outcomes			
Learning outcomes	Study programme competences / results		
To know the advantages and limitations of the boundary element method	AC4	BC2 BR1	
To know the steps to solve a boundary value problem using the boundary element method		BC2 BR1	
To know the fundamental solutions, the integral representation formula and the boundary integral equations related to the problems considered in this subject	AC4	BC2 BR1	
Be able to construct Matlab programs that solve an elliptic problem using the boundary element method.	AC8	BC2 BR1	
To know and be able to apply the direct and indirect methods	AC4	BC2 BR1	
Given a boundary integral equation, be able to discretize it using the boundary element method and to derive the associated linear system	AC8	BC2 BR1	

Contents	
Topic	Sub-topic
Introduction and some preliminaries	1. Introduction 2. Integral equations 3. Singular integrals 4. Fractional index Sobolev spaces
Potential problems	1. The model problem 2. Fundamental solution for the Laplace operator 3. The transmission property 4. Jump relations 5. Boundary integral equations 6. The boundary element method 7. Indirect formulations 8. Implementation in MATLAB

Other applications of the boundary element methods	1. Acoustics: the Helmholtz equation 2. The Stokes problem 3. Linear elastostatics
Introduction to the coupling of boundary elements and finite elements	1. Introduction 2. The one integral equation method 3. The two integral equations methods 4. The uncoupling method

Planning				
Methodologies / tests	Competencies / Results	Teaching hours (in-person & virtual)	Student?s personal work hours	Total hours
Guest lecture / keynote speech	A4 B5 B3	14	35	49
Laboratory practice	A8 B5 B3	7	7	14
Supervised projects	A4 A8 B5 B3	1	9	10
Personalized attention		2	0	2
(*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.				

Methodologies	
Methodologies	Description
Guest lecture / keynote speech	The theoretical contents will be presented through lectures.
Laboratory practice	The implementation in Matlab of the boundary element method to solve the problems considered in the subject will be shown.
Supervised projects	At the end of the course, a project will be proposed to each student.

Personalized attention	
Methodologies	Description
Supervised projects	Students can ask to the teacher any questions that arise during the performance of the project that has been proposed to them.

Assessment			
Methodologies	Competencies / Results	Description	**Qualification**
Supervised projects	A4 A8 B5 B3	The evaluation of the knowledge acquired in this subject will take into account the completion of the exercises presented in the lectures (50% of the final grade) and the supervised work that will be proposed at the end of the subject (50% remaining).	100

Assessment comments
The evaluation criteria are the same in June and July.

Sources of information

Basic	- K.-C. Ang (2007). Introducing the boundary element method with MATLAB. Int. J. Math. Education in Sci. and Technology - G. Chen y J. Zhou (1992). Boundary Element Methods. Academic Press - G.C: Hsiao y W.L. Wendland (2021). Boundary Integral Equations. Springer - S.A. Sauter y C. Schwab (2011). Boundary Element Methods. Springer
Complementary	- R. Adams (1979). Sobolev spaces. Academic Press - G. Beer (2001). Programming the Boundary Element Method. John Wiley & Sons - W. Hackbusch (1995). Integral Equations. Birkhauser - W. McLean (2000). Strongly elliptic systems and boundary integral equations. Cambridge University Press

Recommendations
Subjects that it is recommended to have taken before
Numerical methods and programming/614855201 Numerical methods for partial differential equations/614855204
Subjects that are recommended to be taken simultaneously
Subjects that continue the syllabus
Other comments
It is recommended that students take the subject up to date and use the tutorial hours to solve their doubts.

(*)The teaching guide is the document in which the URV publishes the information about all its courses. It is a public document and cannot be modified. Only in exceptional cases can it be revised by the competent agent or duly revised so that it is in line with current legislation.