Teaching Guide				
Identifying Data				2020/21
Subject (*)	FEM of Structures		Code	730G03069
Study programme	Grao en Enxeñaría Mecánica			
Descriptors				
Cycle	Period	Year	Type	Credits
Graduate	1st four-month period	Fourth	Optional	6
Language	Spanish			
Teaching method	Hybrid			
Prerequisites				
Department	Enxeñaría Naval e Industrial			
Coordinador	Gutierrez Fernandez, Ruth Maria	E-mail	ruth.gutierrez@udc.es	
Lecturers	Gutierrez Fernandez, Ruth Maria	E-mail	ruth.gutierrez@udc.es	
Web	https://sites.google.com/site/structuralanalysislab/home			
General description	This course is intended for the acquisition of the specific skills to design solids and structures under tension and compression forces, and bending and torsion moments. Besides, you will know how calculate the stress field and the deformations in solids and structures.			
Contingency plan	1. Modifications to the contents 2. Methodologies *Teaching methodologies that are maintained *Teaching methodologies that are modified 3. Mechanisms for personalized attention to students 4. Modifications in the evaluation *Evaluation observations: 5. Modifications to the bibliography or webgraphy			

Study programme competences	
Code	Study programme competences
A1	FB1 - Capacidade para a resolución dos problemas matemáticos que poidan formularse na enxeñaría. Aptitude para aplicar os coñecementos sobre: álxebra lineal; xeometría; xeometría diferencial; cálculo diferencial e integral; ecuacións diferenciais e en derivadas parciais; métodos numéricos; algorítmica numérica; estatística e optimización.
A23	TEM4 - Coñecementos e capacidades para aplicar os fundamentos da elasticidade e resistencia de materiais ao comportamento de sólidos reais.
B1	CB01 - Que os estudantes demostren posuír e comprender coñecementos nunha área de estudo que parte da base da educación secundaria xeral e adoita encontrarse a un nivel que, aínda que se apoia en libros de texto avanzados, inclúe tamén algúns aspectos que implican coñecementos procedentes da vangarda do seu campo de estudo
B2	CB02 - Que os estudantes saiban aplicar os seus coñecementos ao seu traballo ou vocación dunha forma profesional e posúan as competencias que adoitan demostrarse por medio da elaboración e defensa de argumentos e a resolución de problemas dentro da súa área de estudo
B4	CB04 - Que os estudantes poidan transmitir información, ideas, problemas e solucións a un público tanto especializado como leigo
B5	CB05 - Que os estudantes desenvolvan aquelas habilidades de aprendizaxe necesarias para emprenderen estudos posteriores cun alto grao de autonomía

B6	B3 - Ser capaz de concibir, deseñar ou poñer en práctica e adoptar un proceso substancial de investigación con rigor científico para resolver calquera problema formulado, así como de comunicar as súas conclusións ?e os coñecementos e razóns últimas que as sustentan? a un público tanto especializados como leigo dun xeito claro e sen ambigüidades
B7	B5 - Ser capaz de realizar unha análise crítica, avaliación e síntese de ideas novas e complexas
B9	B8 - Adquirir unha formación metodolóxica que garanta o desenvolvemento de proxectos de investigación (de carácter cuantitativo e/ou cualitativo) cunha finalidade estratéxica e que contribúan a situarnos na vangarda do coñecemento
C4	C6 - Valorar criticamente o coñecemento, a tecnoloxía e a información dispoñible para resolver os problemas cos que deben enfrontarse.
C6	C8 - Valorar a importancia que ten a investigación, a innovación e o desenvolvemento tecnolóxico no avance socioeconómico e cultural da sociedade.

Learning outcomes			
Learning outcomes	Study programme competences		
Use the main laws of computational analysis of elastic solids and structures	A1 A23	B1 B2 B4 B5 B6 B7 B9	C4 C6
Solve exercises and problems in a reasoned and complete way	A1 A23	B1 B2 B4 B5 B6 B7 B9	C4 C6
Properly apply theoretical concepts in the laboratory. Make mathematical models of mechanical and structural systems	A1 A23	B1 B2 B4 B5 B6 B7 B9	C4 C6
Employ a correct language for the structural engineering field in order to show and to explain information and results		B1 B2 B4 B5 B6 B7 B9	C4 C6

Contents	
Topic	Sub-topic
Chapter 0. The following topics develop the contents set up in the verification memory.	The finite element method; structural elements; numerical analysis of structures by means of computer programs. Mechanics of soil and foundations.
Chapter 1. Formulation of the Finite Element Method FEM for the static problem	Formulation of the structural static problem. Principle of virtual displacements. Discretization. Interpolation. Stiffness matrix and Load vector. Assembly. Transformation of element local and structure global degrees of freedom.

Chapter 2. Formulation of the FEM for the dynamic problem	Formulation of the structural dynamic problem. Mass and damping matrices. Imposition of displacement boundary conditions. Master and sleeve degrees of freedom. Displacement, deformation and stress fields
Chapter 3. Approximating element displacement field	Classification of various elastic problems. Generalized stress-strain matrices. Interpolation functions for generalized coordinate finite element family. Lagrange and Serendip elements. Lagrange interpolation. Convergence criteria of FEM. Parcel test
Chapter 4. Isoparametric elements	Introduction. Isoparametric elements. Geometric and natural coordinate system. Finite elements with a variable number of nodes.
Chapter 5. Isoparametric elements for plain stress and plain strain.	Plain stress and plain strain elastic problem. Formulation of an isoparametric element for plain stress. Jacobian matrix of isoparametric transformation. Singularities. Discretization errors. Mass and stiffness matrices.
Chapter 6. Computational issues.	Numerical integration. Method of Newton-Cotes. Gauss quadrature. Two-dimensional and three-dimensional integration. Full integration, reduced integration, selective integration. Recommendations for the type and order of integration. Construction of the numerical stiffness matrix of two-dimensional isoparametric linear element. Volume and surface load vectors. Thermal loads. Convergence criteria for isoparametric elements.
Chapter 7. Beam structural elements	Introduction. Euler-Bernoulli beam theory, Timoshenko beam theory. Equilibrium equations of beams. Formulation of the Hermitian beam finite element. Two-dimensional beam element. Three-dimensional beam element
Chapter 8. Plate and Shell elements	Behaviour of elastic plates. Kirchhoff plate theory. Reissner-Mindlin plate theory. Formulation of a finite element for plates. Equilibrium equations. Behaviour of elastic Shells. A flat Shell finite element.

Planning				
Methodologies / tests	Competencies	Ordinary class hours	Student?s personal work hours	Total hours
Laboratory practice	A1 A23 B1 B2 B4 B5 B6 B7 B9 C6 C4	4	24	28
Supervised projects	A1 A23 B1 B2 B4 B5 B6 B7 B9 C4 C6	16	28	44
Guest lecture / keynote speech	A1 A23 B1 B2 B4 B5 B6 B7 B9 C6 C4	18	45	63
Problem solving	A1 A23 B1 B2 B4 B5 B6 B7 B9 C6 C4	4	9	13
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
Laboratory practice	Methodology that allows the realization of activities of practical character, with computer, such as modelization, analysis and simulation of mechanical and structural elements, as well as experimental studies in the workshop of structures, for studying its deformation and resistance
Supervised projects	Methodology designed to promote autonomous learning of students, solving a problem that involves the contents of the course and involves specific skills, under teacher supervision.
Guest lecture / keynote speech	Oral lecture supplemented with the use of audiovisual means, aiming transmit knowledge and facilitate the learning within the scope of structural analysis
Problem solving	Técnica a través da cal hai que resolver unha situación problemática específica, a partir da coñecemento que se traballou e que pode ter máis dunha solución.

Personalized attention	
Methodologies	**Description**
Laboratory practice Supervised projects	Guidance and revision about specific problems posed at the development of the different activities proposed in the course. Revision and help when making supervised projects.

Assessment			
Methodologies	**Competencies**	**Description**	**Qualification**
Laboratory practice	A1 A23 B1 B2 B4 B5 B6 B7 B9 C6 C4	Students must systematically attend practices. The proposed activities have to be done along the practical sessions, in order to be revised and evaluated by the teacher. The practices that aren?t developed during the practical classes, and periodically revised by the teacher will not be considered in the qualification. The evaluation process of the laboratory lessons includes a two hour practice session, where the student solves with the computer the problems proposed by the teacher, individually.	30
Supervised projects	A1 A23 B1 B2 B4 B5 B6 B7 B9 C4 C6	The projects include the theoretical and practical contents of the course. They are to be done individually. The projects will be developed during the practical sessions along the course and completed at home on the student personal work hours. The tasks will be followed and revised during the practical lessons. If the projects aren?t matured during the practical classes, nor periodically revised by the teacher, will not be considered in the qualification.	70

Assessment comments
Students, whose presence throughout the semester where insufficient to track their work, by academic waiver or other causes, must also develop and present practices and tutored work for their evaluation. The follow-up of this work shall be carried out in tutoring sessions. In this case, the process of evaluation may include in addition to the presentation of practices and tutored work, a practice session, individually or in group, in which the student addresses manually or with the computer the problems raised by the teacher. For the second chance you can present or improve practices and tutored work. The tracking is done in tutorial sessions. The assessment is done through presentation of practices and tutored work pending and/or improved. The process of evaluation may include, in addition to the presentation of practices and tutored work, a practical session, individually or in group, in which the student addresses manually or with the computer the problems posed by the teacher.

Sources of information	
Basic	- R. Gutiérrez, E. Bayo, A. Loureiro, LE Romera (2010). Estructuras II. Reprografía del Noroeste. Santiago de Compostela - Dassault Systèmes Simulia Corp. (2011). Abaqus Analysis User?s Manual. © Dassault Systèmes. Providence, RI, USA. - Bathe K.J. (2006). Finite Elements Procedures.. Prentice-Hall, Pearson Education, Inc. USA - Eugenio Oñate (1995). Calculo de estructuras por el método de elementos finitos. CIMNE, Barcelona, España
Complementary	

Recommendations
Subjects that it is recommended to have taken before
Strength of Materials/730G03013 Theory of Structures /730G03021
Subjects that are recommended to be taken simultaneously
Tecnology and Design of Structures/730G03071
Subjects that continue the syllabus
Theory of Vibration/730G03040 Structural Typologies/730G03070
Other comments
<p class="MsoNormal">To help achieve a sustained immediate environment and meet the objective of the action number 5: "Teaching and healthy and sustainable environmental and social research" of the "Plan of action Green Campus Ferrol".</p><p class="MsoNormal"> </p><p class="MsoNormal">Documentary work presented in this matter: </p><p class="MsoNormal">* Should be requested in virtual format or computer support </p><p class="MsoNormal">* Will take place through Moodle, in digital format without having to print them </p><p class="MsoNormal">* Should be required on paper:</p><p class="MsoNormal">   -Not be they used plastic </p><p class="MsoNormal">   -There will be double-side printing.   </p><p class="MsoNormal">   -Will use recycled paper.   </p><p class="MsoNormal">   -Prevent printing drafts. </p><p class="MsoNormal"> </p><p class="MsoNormal">You should make a sustainable use of resources and the prevention of negative impacts on the natural environment</p>

(*)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.