



| Teaching Guide      |  |        |  |         |
|---------------------|--|--------|--|---------|
| Identifying Data    |  |        |  | 2019/20 |
| 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     | Face-to-face   |        |  |         |
| Prerequisites       |  |        |  |         |
| Department          | Enxeñaría Naval e Industrial   |        |  |         |
| Coordinador         | Gutierrez Fernandez, Ruth Maria  | E-mail | ruth.gutierrez@udc.es                              |         |
| Lecturers           | Gutierrez Fernandez, Ruth Maria<br>López López, Manuel   | E-mail | ruth.gutierrez@udc.es<br>manuel.lopez.lopez@udc.es |         |
| Web                 | <a href="https://sites.google.com/site/structuralanalysislab/home">https://sites.google.com/site/structuralanalysislab/home</a>  |        |  |         |
| 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. |        |  |         |

| Study programme competences / results |  |
|---------------------------------------|--|
| Code                                  | Study programme competences / results  |
| B5                                    | CB05 - Que os estudantes desenvolvan aquelas habilidades de aprendizaxe necesarias para emprenderen estudos posteriores cun alto grao de autonomía   |
| 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 |

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

| 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 slave 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. Patch 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 / Results        | Teaching hours (in-person & virtual) | Student's personal work hours | Total hours |
| Laboratory practice            | B1 B2 B4 B5 B6 B7<br>B9 C4 C6 | 4                                    | 24                            | 28          |
| Supervised projects            | B1 B2 B4 B5 B6 B7<br>B9 C6 C4 | 16                                   | 28                            | 44          |
| Guest lecture / keynote speech | B1 B2 B4 B5 B6 B7<br>B9 C4 C6 | 18                                   | 45                            | 63          |
| Problem solving                | B1 B2 B4 B5 B6 B7<br>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 | Guidance and revision about specific problems posed at the development of the different activities proposed in the course. |
| Supervised projects | Revision and help when making supervised projects.   |

### Assessment

| Methodologies       | Competencies / Results        | Description  | Qualification |
|---------------------|-------------------------------|--|---------------|
| Laboratory practice | B1 B2 B4 B5 B6 B7<br>B9 C4 C6 | 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 | B1 B2 B4 B5 B6 B7<br>B9 C6 C4 | 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

