ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

43000440 - Non linear elasticity in continuum mechanics

DEGREE PROGRAMME

04AM - Master Universitario Ingenieria De Estructuras, Cimentaciones Y Materiales

ACADEMIC YEAR & SEMESTER

2018/19 - Semester 2

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	43000440 - Non linear elasticity in continuum mechanics
No of credits	4.5 ECTS
Type	Optional
Academic year ot the programme	First year
Semester of tuition	Semester 2
Tuition period	February-June
Tuition languages	English
Degree programme	04AM - Master universitario ingenieria de estructuras, cimentaciones y materiales
Centre	04 - Escuela Tecnica Superior de Ingenieros de Caminos, Canales y Puertos
Academic year	2018-19

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Jose Merodio Gomez (Subject coordinator)	1º Planta	jose.merodio@upm.es	W - 15:00 - 17:00 Th - 15:00 - 17:00 F - 12:00 - 14:00

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

3. Skills and learning outcomes *

3.1. Skills to be learned

CB10 - Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

CB6 - Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación

CB9 - Que los estudiantes sepan comunicar sus conclusiones y los conocimientos y razones últimas que las sustentan a públicos especializados y no especializados de un modo claro y sin ambigüedades

CE5 - Capacidad para la participación en actividades de I+D+i mediante la utilización de recursos de modelización predictiva en Métodos computacionales para Mecánica estructural

CE9 - Capacidad para la participación en actividades de I+D+i mediante la utilización de recursos de modelización predictiva en Comportamiento mecánico de materiales

CG1 - Polivalencia para extender a ámbitos afines las competencias generales adquiridas en el ámbito temático del título.

CG4 - Capacidad de comunicación académica de contenido técnico y científico, oral y escrita en lengua inglesa.

CG5 - Capacidad de utilización de los servicios de comunicación y de obtención de información para su transformación en conocimiento aplicable al ejercicio de las competencias específicas.

CT3 - Compromiso y capacidad de aplicación de los estándares de deontología en investigación y ejercicio profesional avanzado

3.2. Learning outcomes

RA19 - familiarizarse con la metodología científica de las disciplinas en que se apoya la asignatura

RA20 - Conoce las causas de no linealidad geométrica en estructuras y los métodos de cálculo en los distintos niveles.

RA8 - Utiliza con eficacia recursos de modelización predictiva en una o más de las materias del módulo

RA9 - Participa en debates en lengua inglesa

RA2 - Presenta comunicaciones orales, escritas y gráficas, estructurada y argumentadamente, en lengua española e inglesa

RA21 - Conoce las causas de no linealidad debida al material en estructuras, sus leyes constitutivas y los métodos de cálculo estructural aplicables.

RA24 - Conoce los métodos numéricos para resolver los cálculos estructurales no lineales.

RA4 - Utiliza con eficacia recursos de información y comunicación

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

4. Brief description of the subject and syllabus

4.1. Brief description of the subject

This course deals with continuum mechanics within the subject of nonlinear elasticity. The classical linear elasticity is extended into the nonlinear regime.

4.2. Syllabus

1. 1. Kinematics

   1.1. Bodies, configurations and motions The material time derivative Differentiation of Cartesian tensor fields Deformation and velocity gradients

   1.2. Deformation of area and volume elements Some results from tensor algebra The square root theorem The polar decomposition theorem Analysis of deformation Stretch, extension, shear and strain Homogeneous deformations Analysis of motion

2. Balance laws and equations of motion

   2.1. Mass Mass conservation Force, torque and momentum Body and surface forces Momentum and angular momentum Euler?s laws of motion The theory of stress Cauchy?s theorem Normal and shear stresses Energy Stress tensors

3. Constitutive equations

   3.1. Elastic materials Objectivity Material symmetry Important example: isotropy Noll?s rule Isotropic functions of a second-order tensor Isotropic elasticity Hyperelastic materials

4. Stress-deformation relations for an isotropic material

   4.1. Unconstrained materials Stress-deformation relations in terms of invariants The invariants I1, I2, I3 The invariants i1, i2, i3

5. Constrained elastic materials

   5.1. Incompressibility Stress-deformation relations Invariants I1, I2 Invariants i1, i2 Other constraints Examples of strain-energy functions Application to homogeneous deformations

6. Boundary-value problems

   6.1. Extension and inflation of a thick-walled tube

7. Anisotropic elastic materials

   7.1. Transverse isotropy Application to pure homogeneous deformation Plane strain Two preferred directions Pure homogeneous strain Simple shear Extension and inflation of a thick-walled tube

8. 8. Residual stress

   8.1. Response in the presence of residual stress. Invariants. Extension, inflation and torsión of a tuve with residual stress.

9. Other boundary value problems

   9.1. Shear-Azimuthal. Torsion. Hollow sphere under internal pressure.

5. Schedule

5.1. Subject schedule*

Week	Face-to-face classroom activities	Face-to-face laboratory activities	Other face-to-face activities	Assessment activities
1	**Tema 1** Duration: 02:00 Lecture		**Ejercicios Tema 1** Duration: 01:00 Problem-solving class	
2	**Tema 1** Duration: 02:00 Lecture		**Ejercicios Tema 1** Duration: 01:00 Problem-solving class	
3	**Tema 2** Duration: 02:00 Lecture		**Ejercicios Tema 1** Duration: 01:00 Problem-solving class	
4	**Tema 2** Duration: 02:00 Lecture		**Ejercicios Tema 2** Duration: 01:00 Problem-solving class	
5	**Tema 3** Duration: 01:00 Lecture		**Ejercicios Tema 2** Duration: 02:00 Problem-solving class	
6	**Tema 3** Duration: 02:00 Lecture		**Ejercicios Tema 3** Duration: 01:00 Problem-solving class	
7	**Tema 4** Duration: 02:00 Lecture		**Tema 3** Duration: 01:00 Problem-solving class	
8	**Tema 4** Duration: 01:00 Lecture		**Tema 4** Duration: 02:00 Problem-solving class	**Assignment related to topics 1, 2 and 3** Individual work Continuous assessment Duration: 00:00
9	**Tema 5** Duration: 02:00 Problem-solving class		**Tema 5** Duration: 01:00 Lecture	
10	**Tema 5** Duration: 01:00 Lecture **Tema 6** Duration: 01:00 Lecture		**Tema 5** Duration: 01:00 Problem-solving class	
11	**Tema 6** Duration: 02:00 Lecture		**Tema 6** Duration: 01:00 Lecture	
12	**Tema 7** Duration: 02:00 Lecture		**Tema 6** Duration: 01:00 Lecture	

13	**Tema 7** Duration: 01:00 Lecture		**Tema 7** Duration: 02:00 Lecture	**Assignmnt related to topics 4,5 and 6** Individual work Continuous assessment Duration: 00:00
14	**Tema 8** Duration: 02:00 Lecture		**Tema 7** Duration: 01:00 Problem-solving class	
15	**Tema 9** Duration: 02:00 Lecture		**Tema 8** Duration: 01:00 Problem-solving class	
16				**Assignmnt related to topics 7,8 and 9** Individual work Continuous assessment Duration: 00:00 **Asistence to lectures** Other assessment Continuous assessment Duration: 00:00 **Submission of assignments** Other assessment Final examination Duration: 00:00
17				

The independent study hours are training activities during which students should spend time on individual study or individual assignments.

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

* The subject schedule is based on a previous theorical planning of the subject plan and might go to through experience some unexpected changes along throughout the academic year.

6. Activities and assessment criteria

6.1. Assessment activities

6.1.1. Continuous assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
8	Assignment related to topics 1, 2 and 3	Individual work	Face-to-face	00:00	30%	5 / 10	CB9 CB10 CG1 CG4 CE5 CT3 CE9 CG5 CB6
13	Assignmnt related to topics 4,5 and 6	Individual work	Face-to-face	00:00	30%	5 / 10	
16	Assignmnt related to topics 7,8 and 9	Individual work	Face-to-face	00:00	30%	5 / 10	
16	Asistence to lectures	Other assessment	No Presential	00:00	10%	5 / 10	CG4 CT3 CG5

6.1.2. Final examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
16	Submission of assignments	Other assessment	No Presential	00:00	100%	5 / 10	CB9 CB10 CG1 CG4 CE5 CT3 CE9 CG5 CB6

6.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Submission of assignments	Other assessment	Face-to-face	00:00	100%	5 / 10	CB9 CB10 CG1 CG4 CE5 CT3 CE9 CG5 CB6

6.2. Assessment criteria

The students grades will be based on the assignments that will be given and assitance to the lectures. The studnets must attend to 80% of the lectures to pass the course.

7. Teaching resources

7.1. Teaching resources for the subject

Name	Type	Notes
Non-Linear Elastic Deformations By: R. W. Ogden	Bibliography	Básica
L.E. Malvern. Introduction to the Mechanics of a Continuous Medium. Prentice-Hall, Englewood Cliffs, N.J., 1969.	Bibliography	Básica

Mase. Schaum?s Outline on Theory and Problems of Continuum Mechanics. McGraw-Hill, N.Y., 1970	Bibliography	Básica
A.J.M. Spencer. Continuum Mechanics. Longman,London, 1980	Bibliography	Básica
M.E. Gurtin. An Introduction to Continuum Mechanics. Academic Press, N.Y., 1981.	Bibliography	Básica
C.A. Truesdell. A First Course in Rational Continuum Mechanics. Academic Press, Boston, 2nd edn., 1991.	Bibliography	Básica