



POLITÉCNICA

INTERNATIONAL
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LEARNING ACTIVITIES
PR/CL/001



E.T.S. de Ingenieros de
Caminos, Canales y Puertos

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

2022/23 - Semester 2



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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 of 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	2022-23

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
Juan Carlos Mosquera Feijoo	2 planta	juancarlos.mosquera@upm.es	W - 10:45 - 12:45 Th - 10:45 - 12:45 F - 10:45 - 12:45

* 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

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

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

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

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. 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 I_1, I_2, I_3 The invariants i_1, i_2, i_3

5. Constrained elastic materials

5.1. Incompressibility Stress-deformation relations Invariants I_1, I_2 Invariants i_1, i_2 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. Residual stress

8.1. Response in the presence of residual stress. Invariants. Extension, inflation and torsión of a tube 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	Classroom activities	Laboratory activities	Distant / On-line	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 Not Presential 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	Assignmmt related to topics 4,5 and 6 Individual work Continuous assessment Not Presential 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				Assignmmt related to topics 7,8 and 9 Individual work Continuous assessment Not Presential Duration: 00:00 Asistence to lectures Other assessment Continuous assessment Not Presential Duration: 00:00 Submission of assignments Other assessment Final examination Not Presential Duration: 00:00
17				

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 schedule is based on an a priori planning of the subject; it might be modified during the academic year, especially considering the COVID19 evolution.

6. Activities and assessment criteria

6.1. Assessment activities

6.1.1. Assessment

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

6.1.2. Global examination

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

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	CB6 CB9 CB10 CT3 CG1 CG4 CG5

6.2. Assessment criteria

The students grades will be based on the assignments that will be given and assistance to the lectures. The students must attend to 80% of the lectures (either online or classroom lessons) 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