Introduction to structural analysis

Academic Year: (2022 / 2023) **Review date: 20-01-2023**

Department assigned to the subject: Continuum Mechanics and Structural Analysis Department

Coordinating teacher: VAZ-ROMERO SANTERO, ALVARO

Type: Compulsory ECTS Credits : 6.0

Year : 2 Semester : 2

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Calculus II
Linear Algebra
Physics I
Mechanics applied to Aerospace Engineering

We strongly advise you not to take this course if you have not passed Physics I and Mechanics applied to Aerospace Engineering

OBJECTIVES

Capacity to formulate the elasticity equations, to assess the hypotheses and to interpret the results.
Knowledge and application of principles of Strength of Materials
Knowledge of the basic techniques for Structural Analysis of deformable bodies.
Capacity of analysis and evaluation with critical sense of results of structural calculus

DESCRIPTION OF CONTENTS: PROGRAMME

CHAPTER 1. INTRODUCTION TO SOLID MECHANICS (Nº of sessions: 3)

Subject 1: Kinematic of deformable bodies

- Motion: Basic concepts
- Strain Tensor
- Infinitesimal strain
- Geometrical meaning of the components of infinitesimal strain tensor
- Principal Strains
- Equations of compatibility

Subject 2: Equilibrium in deformable bodies

- Body and surface forces
- Concept of stress
- Stress tensor
- Stress equations of equilibrium
- Stationary stresses

Subject 3: Constitutive equations

- Behaviour laws
- Hyperelastic behaviour
- Linear elastic behaviour
- Material symmetries
- Physical meaning of the constants

CHAPTER 2. ELASTICITY (Nºof sessions: 3)

Subject 4: Formulation of Elasticity

- Elasticity equations
- Boundary and contact conditions
- Theorem of Virtual Works

- Theorem of Minimum Potential Energy
- Reciprocity Theorems
- General Principles

Subject 5: Failure criteria

- Failure by yielding
- Haig-Westergaard representation
- Von Mises-Hencky-Nadai yield criterion
- Tresca-Guest yield criterion
- Alternate yield criteria
- Equivalent stress and safety factor

Subject 6: Two dimensional theory of Elasticity

- Plain Stress and Plain Strain
- Plane Elasticity in term of displacement
- Plane Elasticity in terms of stresses
- Methods of solutions
- Mohr´s circle in 2D

CHAPTER 3. STRENGTH OF MATERIALS (Nºof sessions: 7)

Subject 7 and 8: Reaction and internals forces
- External degrees of freedom in a mechanical system
- External link in a mechanical system
- External degree of static indeterminacy
- Internal link
- Internal degree of static indeterminacy
- Total degree of static indeterminacy
- Computation of reactions

Subject 9: Introduction to beam theory

- Definition of a beam
- Types of loads acting in beams
- Internal forces and moments in beams

Subject 10 and 11 : Bending and shear in beamss
- Normal stresses in beam
- Neutral axis
- Sections with symmetries
- Shear stresses due to shear force
- Sections with symmetries
- Shear stresses due to torque

Subject 12: Deflections of beams
- Equilibrium equations of beams
- Internal forces and moments equations
- Deflections by integration of the internal forces (Navier-Bresse equations)
- Moment-area method(Mohr´s theorems)

Subject 13: Isostatically indeterminate structures
- Kinematic definitions
- Introduction to the force (or flexibility) method
- Application to continuum beams

LEARNING ACTIVITIES AND METHODOLOGY

In each week one lecture session (master class) and one practical session (in reduced groups) will be taught. The first is geared to the acquisition of theoretical knowledge, and the second to the acquisition of practical skills related to theoretical concepts. Additionally, students will complement the classes

with work at home, using material provided on Aula Global.

In addition to these sessions, four laboratory practical sessions in reduced groups (maximum 20 students) will be impart. These practices are mandatory.

At the end of the semester tutorial session will be held. Students also have the possibility of individual tutorials.

ASSESSMENT SYSTEM

Final exam (obligatory): 60%
Continuum evaluation: 40%
- Laboratory report: 25%
- Evaluation controls: 15%

If the mark obtained in the final exam is lower than 4.5, the final mark of the student will be computed only with the final exam.

In order to pass the course, attendance and successful completion of the laboratory practices foreseen in the weekly planning are mandatory. The weighting of the laboratory practice mark in the continuous assessment corresponds to what it is established in the course, in accordance with the regulations of the university. In the Introduction to Structural Analysis course, the weighting of the laboratory practices takes the value of 25% of the continuous assessment grade

% end-of-term-examination:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

BASIC BIBLIOGRAPHY

- Barber, J.R. Elasticity, Kluwer Academic Publishers, 1992
- Garrido, J.A. y Foces, A. Resistencia de Materiales, Secretariado de Publicaciones. Universidad de Valladolid, 1994
- Oliver, X.; Agelet, C. Mecánica de medios continuos para ingenieros, Ed. UPC, 2000
- Ortiz Berrocal, L Elasticidad, Ed. McGraw Hill, 1998
- Paris Carballo, F. Teoría de la elasticidad, Grupo de Elasticidad y Resistencia, 1998
- Pilkey, W.D. y Wunderlich, W. Mechanics of structures. Variational and Computational Methods, CRC Press, 1994
- Samartin Quiroga, A. Resistencia de Materiales, Servicio de Publicaciones. Colegio de Ingenieros de Caminos, canales y Puertos, 1995
- Sanmartín Quiroga, A. Curso de Elasticidad, Ed. Bellisco, 1990

ADDITIONAL BIBLIOGRAPHY

- Benham, P.P. y Crawford, R.J. Mechanics of engineering materials, Longman Scientific & Technical, 1987
- Chung T.J. Applied continuum mechanics, Cambridge University Press, 1996
- Doblaré Castellano, M. y Gracia Villa, L. Fundamentos de la Elasticidad Lineal, Ed. Síntesis, 1998
- Shames, I.H. y Cozzarelli, F.A. Elastic and inelastic stress analysis, CRC Press, 1997
- Wunderlich, W. y Pilkey, W.D. Mechanics of structures: Variational and Computanional Methods, CRC Press, 1992