UNIVERSITÀ DI PISA

AEROSPACE STRUCTURES

LUISA BONI

Anno accademico	2019/20
CdS	AEROSPACE ENGINEERING
Codice	501II
CFU	12

Moduli	Settore/i	Tipo	Ore	Docente/i
AEROSPACE STRUCTURES I	ING-IND/04	LEZIONI	60	LUISA BONI
AEROSPACE STRUCTURES II	ING-IND/04	LEZIONI	60	LUISA BONI

Learning outcomes

Knowledge
The student who successfully completes the course will have the ability to compute the distribution of stress for typical aerospace structures (wing-boxes, fuselages) adopting the elementary theory approach and methods to account for the hyper-static nature of the analysed components; will be able to demonstrate a solid knowledge of the buckling behavior of compressed structures; will be aware of the energetic approaches to the study of structural problems.

Assessment criteria of knowledge
The evaluation is based primarily on the verification of the basic knowledge necessary for the study of aerospace structures (equilibrium, shear flow and normal stress computation in thin walled structures). The uncertainty of these skills is not allowed. Also the knowledge of buckling phenomena and the knwoledge of methods for the solution of buckling problems represent an important part of the preparation and evaluation of the student. The uncertainty of these skills is not allowed. The examination is based on the solution of exercises and on a subsequent discussion of the results and, if it is necessary, on the discussion of some theoretical aspects.
Methods:

- Final oral exam.

Skills
Course Contents

(PART I) - Basic Structural Analysis - Statics (October-December)

Introduction to structural mechanics.
Beams in bending, shear and torsion.
Principles of aerospace structures construction
Bending, shear and torsion of thin-walled tubes
Stresses in multi-cell tubes
Discrete models of aerospace structures (wing-box, fuselage): elementary theory
Correction of the elementary theory results
Second order approach: shear diffusion and axial constraint effects in the aerospace structures
Matrix method of structural analysis (Force Method and Displacements Method)

(PART II) - Analysis of Aerospace Structures - Statics (February-April)

Energy methods of structural analysis
Theory of thin plates
Theory of structural instability (buckling of beams, plates and stiffened panels)
Crippling of compressed structures (crippling of beams, plates and stiffened panels)

(PART III) - Introduction to Structural Dynamics (May)

Notes and exercises on the single-degree-of-freedom system
Analysis of multi-degrees-of-freedom systems

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Notes to the dynamics of continuous systems (bending and torsional vibrations of beams)
Modal analysis of structural systems
Notes and exercises on the energy methods for the dynamic analysis of structures

Assessment criteria of skills

The examination for all the students consists in a full exam.

Prerequisites

Students should have the ability to use and/or perform the following:

- Vector and tensor notation
- Concepts of stress and strain
- Basics of the elasticity theory
- Isotropic constitutive relations
- Classic Beam Theory

Teaching methods

Theoretical lessons and examples of applications of theories to real structures.
Delivery: face to face
Attendance: Advised
Learning activities:

- attending lectures
- participation in seminar
- individual study

Teaching methods:

- Lectures on theoretical aspects
- Development of exercises in class

Syllabus

The theory of elasticity: two-dimensional problems (stress function method). Elementary theory of thin walled beams (shear, bending and torsion). Study of lumped parameters structures (models of wing-boxes and fuselages). Shear diffusion and warping of thin walled beams. Lumped parameters structures as undetermined systems. Matrix methods: the forces method and the displacement method. Finite Element Analysis. Statics of plates and membranes. Global buckling of compressed beams: bending, torsion, bending and torsion. Buckling of compressed plate. Local buckling of compressed beams. Buckling of compressed stiffened panels. Crippling of both compressed beams and compressed stiffened panels. Dynamic analysis: modal analysis of discrete and continuous systems (cables and beams).

Bibliography

Spacecraft Structures and Mechanisms *T.P. Sarafin, 1995*

Aircraft Structures for Engineering Students *T.H.G. Megson, 1972*

Theory and Analysis of Flight Structures *R.M. Rivello, 1969*

Theory of Elasticity *S.P. Timoshenko, J.N. Goodier, 1970*

Mechanics of Materials *S.P. Timoshenko, J.M. Gere, 1972*

Introduction to Structural Dynamics and Aeroelasticity *D.H. Hodges, 2002*

Lectures and Exercises of Aerospace Structure L. Boni (e-learning)
Recommended reading includes the following works: T.H.G. Megson "Aircraft Structures for Engineering Students", R.M. Rivello "Theory and analysis of flight structures", E. F. Bruhn "Analysis and design of flight vehicle structures", S. P. Timoshenko, J. N. Goodier "Theory of Elasticity", O. A. Bauchau, J. I. Craig "Structural Analysis: with application to aerospace structures"

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