

Course guide 220056 - EAC - Computational Aerospace Engineering

	Last modified: 02/04/2024		
Unit in charge:	Terrassa School of Industrial, Aerospace and Audiovisual Engineering		
Teaching unit:	737 - RMEE - Department of Strength of Materials and Structural Engineering.		
Degree:	BACHELOR'S DEGREE IN AEROSPACE TECHNOLOGY ENGINEERING (Syllabus 2010). (Compulsory subject).		
Academic year: 2024	ECTS Credits: 4.5 Languages: Spanish		
LECTURER			
Coordinating lecturer:	Joaquín A. Hernández Ortega		
Others:	Joaquín A. Hernández Ortega		

PRIOR SKILLS

Students should have a solid knowledge base in ordinary and partial differential equations for modelling engineering problems. Knowledge of theory of structures and basis of fluid mechanics are also required.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:

1. Adequate and applied knowledge in the engineering of: design and project calculation methods in aeronautics; the use of aerodynamic experimentation and the most significant parameters in theoretical application; handling of experimental techniques, equipment, and measurement instruments specific to the discipline; simulation, design, analysis, and interpretation of experimentation and flight operations; aircraft maintenance and certification systems. (Specific technology module)

TEACHING METHODOLOGY

The teaching methodology is based on three complementary activities: lectures, computer work and assignments. In the lectures, basic concepts and practical exercises are developed. If it were the case, computer algorithms are also formulated.

Computer work intends, on the one hand, familiarize students with the basic ideas of programming the algorithms proposed in the theory. On the other hand, introduce the student to the use of commercial software as a design tool; including aspects as hypotheses, constraints, element types, error estimation and results analysis.

The assessments include tests and hands-on computger assignments. Group homework assignments are allowed.

LEARNING OBJECTIVES OF THE SUBJECT

Learning the fundamentals of the finite element method as a general numerical tool for solving engineering problems governed by ordinary and partial differential equations. Learning the methodology used to obtain weak forms for the governing equations and the finite element discretization. Becoming familiar with the development of finite element code and also with its application using commercial software package.

STUDY LOAD

Туре	Hours	Percentage
Hours large group	31,0	27.56
Hours small group	14,0	12.44
Self study	67,5	60.00



Total learning time: 112.5 h

CONTENTS

Fundamental concepts; Boundary value problem: one-dimensional case

Description:

- Strong form. System of differential equations. Boundary conditions
- Weak form. Discretization, discrete problem.
- Equivalence between the strong and weak forms. Natural boundary condition
- Galerkin's approximation method
- Stiffness matrix; system of equations; gauss elimination
- The element point of view; elemental matrix, elemental forces
- Elastic problem 1D and Euler-Bernoulli beam theory

Specific objectives:

Learning of the fundamentals of the FEM

Related activities:

Activity 1: theory classes Activity 2: practical classes Activity 3: mid-term exam

Full-or-part-time: 27h 30m

Theory classes: 8h Practical classes: 3h Self study : 16h 30m

General formulation of the Boundary value problem: 2D and 3D cases

Description:

Preliminary concepts. Elastic and heat conduction problem Heat conduction: strong form, weak form, and equivalence Heat conduction: Galerkin formulation, properties of the stiffness matrix Heat conduction: Element stiffness matrix and element force vector Elastic problem: strong form, weak form and the equivalence Elastic problem: Galerkin formulation, properties of the stiffness matrix Elastic problem: Element stiffness matrix and element force vector

Specific objectives:

Fundamentals of the FEM applied to 2D and 3D problems

Related activities:

Activity 1: theory classes Activity 2: practical classes Activity 3: mid-term exam

Full-or-part-time: 30h

Theory classes: 8h Practical classes: 4h Self study : 18h



Isoparametric elements

Description:

Bilinear quadrilateral element Linear triangular element Trilinear hexahedral element Higher order elements; Lagrange polynomials Numerical Integration; Gaussian Quadrature Shape functions and Derivatives of shape functions

Specific objectives: Element technology description

Related activities:

Activity 1: theory classes Activity 2: practical classes Activity 4: final exam

Full-or-part-time: 25h Theory classes: 7h

Practical classes: 3h Self study : 15h

Mixed and penalty methods applied to incompressibility problems

Description:

Limitations of the standard FEM Stokes flow formulation Mixed and penalty methods Strong form, weak form Galerkin approximation, discrete system of equations Penalty: selective and reduced integration Stabilized techniques Introduction to fluid-structure interaction

Specific objectives:

Extension of FEM to incompressibility problems. Fundamentals of fluid-structure interaction

Related activities:

Activity 1: theory classes Activity 2: practical classes Activity 4: final exam

Full-or-part-time: 30h Theory classes: 8h Practical classes: 4h Self study : 18h



GRADING SYSTEM

NF = 0,3 EM + 0,3 EF + 0,4 I NF : Final mark EP : Midterm exam ER : Midterm exam - extra EM : max (EP, ER) EF : Final exam I: Report assignments

The remedial exam will consist of a written test (on the day of the final exam) on the contents of the first partial examination. All students can make the test, regardless of their grade. The exam grade of the first part will be the highest of the two, ie: EM = max (EP, ER).

EXAMINATION RULES.

Both partial and final tests are written exams and should be carried out individually, on the dates fixed by the School. On the other hand, both class assignments and homework could be done in groups (maximum 2 students per group)

BIBLIOGRAPHY

Basic:

- Hughes, Thomas J.R. The finite element method: linear static and dynamic finite element analysis [on line]. Mineola, NY: Dover Publications, 2000 [Consultation: 09/07/2024]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=1894 765. ISBN 0486411818.

- Fish, J.; Belytschko, T. A first course in finite elements [on line]. Chichester: John Wiley & Sons, 2007 [Consultation: 13/05/2022]. Available on: <u>https://onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/book/10.1002/9780470510858</u>. ISBN 9780470035801.

Complementary:

- Cook, Robert [et al.]. Concepts and applications of finite element analysis. 4th ed. New York: John Wiley & Sons, 2002. ISBN 9780471356059.

- Zienkiewicz, O.C.; Taylor, R.L.; Zhu J.Z. The finite element method: its basis and fundamentals. 6th ed. Amsterdam: Elsevier Butterworth-Heinemann, 2005. ISBN 0750663200.

- Johnson, Claes. Numerical solution of partial differential equations by the finite element method. Mineola: Dover, 2009. ISBN 9780486469003.

RESOURCES

Computer material:

- MATLAB
- ANSYS