UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH

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220056 - Computational Aerospace Engineering

Coordinating unit: 205 - ESEIAAT - Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 737 - RMEE - Department of Strength of Materials and Structural Engineering
Academic year: 2019
Degree: BACHELOR'S DEGREE IN AEROSPACE TECHNOLOGY ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
ECTS credits: 4,5 Teaching languages: Spanish

Teaching staff

Coordinator: Joaquín A. Hernández Ortega

Others: Joaquín A. Hernández Ortega

Opening hours

Timetable: Announced in class.

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. GrETA - An adequate understanding of the following, as applied to engineering: calculation methods for aeronautical design and development; the use of aerodynamic experimentation and the most important parameters in theoretical application; the experimental techniques, equipment and measuring instruments used in the discipline; simulation, design, analysis and interpretation of in-flight experiments and operations; aircraft maintenance and certification systems.

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.

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Study load

Total learning time: 112h 30m	Hours large group:	31h	27.56%
	Hours small group:	14h	12.44%
	Self study:	67h 30m	60.00%

Content

Fundamental concepts; Boundary value problem: one-dimensional case	Learning time: 27h 30m Theory classes: 8h Practical classes: 3h Self study : 16h 30m

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

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

Specific objectives:
Learning of the fundamentals of the FEM

General formulation of the Boundary value problem: 2D and 3D cases	Learning time: 30h Theory classes: 8h Practical classes: 4h Self study : 18h

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

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

Specific objectives:
Fundamentals of the FEM applied to 2D and 3D problems

Isoparametric elements	Learning time: 25h Theory classes: 7h Practical classes: 3h Self study : 15h

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

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

Specific objectives:
Element technology description

Mixed and penalty methods applied to incompressibility problems	Learning time: 30h Theory classes: 8h Practical classes: 4h Self study : 18h

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

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

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

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Qualification 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).

Regulations for carrying out activities

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. Englewood Cliffs: Prentice-Hall International, 1987. ISBN 0133170179.

Fish, J.; Belytschko, T. A first course in finite elements [on line]. Chichester: John Wiley & Sons, 2007 [Consultation: 16/05/2014]. Available on: <http://onlinelibrary.wiley.com/book/10.1002/9780470510858>. 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.

Others resources:

Computer material

MATLAB

ANSYS