Course guide
220331 - 220331 - Composite Materials

Last modified: 26/09/2024

Unit in charge: Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 737 - RMEE - Department of Strength of Materials and Structural Engineering.

Degree: MASTER'S DEGREE IN AERONAUTICAL ENGINEERING (Syllabus 2014). (Optional subject).
MASTER'S DEGREE IN SPACE AND AERONAUTICAL ENGINEERING (Syllabus 2016). (Optional subject).

Academic year: 2024 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: José Ignacio Velasco, Joaquin Hernandez

Others: José Ignacio Velasco, Joaquin Hernandez

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEEVEHI3. MUEA/MASE: Applied knowledge of composite materials technology and a capacity for designing the basic elements of these materials (specific competency for the specialisation in Aerospace Vehicles).
CEEESPAC2. MUEA/MASE: Advanced applied knowledge of orbital dynamics and space vehicle design (specific competency for the specialisation in Space).
CEEPROP2. MUEA/MASE: Advanced applied knowledge of the design, manufacture and maintenance of propulsion systems (specific competency for the specialisation in Propulsion).

TEACHING METHODOLOGY

The course is divided into parts:
Theory classes
Practical classes
Self-study and work by teams for doing exercises and activities.
In the theory classes, teachers will introduce the theoretical basis of the concepts, methods and results and illustrate them with examples appropriate to facilitate their understanding.
In the practical classes (in the classroom and/or in the laboratory), teachers guide students in applying theoretical concepts to solve problems, always using critical reasoning. We propose that students solve exercises in and outside the classroom, to promote contact and use the basic tools needed to solve problems.
Students, independently, need to work on the materials provided by teachers and the outcomes of the sessions of exercises/problems, in order to fix and assimilate the concepts.
The teachers provide the syllabus and monitoring of activities (by ATENEA).

LEARNING OBJECTIVES OF THE SUBJECT

Applied knowledge of materials science and technology; mechanics and thermodynamics; fluid mechanics; aerodynamics and flight mechanics; navigation systems and air traffic; aerospace technology; structural theory; economy and production; projects; environmental impact.

STUDY LOAD

Type	Hours	Percentage
Self study	80,0	64.00
Hours large group	30,0	24.00
Hours small group	15,0	12.00

Total learning time: 125 h

CONTENTS

Module 1: Introduction to composite materials for aerospace applications

Description:
1. Composites: Definitions and components. Types and classifications of composites. General properties. Aerospace applications of composites.

Related activities:
- Theory and practical classes

Full-or-part-time: 6h
Theory classes: 3h
Self study : 3h

Module 2: Raw materials for aerospace composites

Description:
Reinforcements for aerospace composites. Fibres. Basic properties of fibres and engineering materials. Fibre types. Fibre finishes. Fabrics. Fabric types. Core materials for sandwich panels. Foam Cores. Honeycombs. Design considerations. Polymer matrixes. Thermosetting polymer matrix. Types of resins. Gelation, curing and post-curing. Thermoplastic polymer matrixes. Engineering and high performance thermoplastics. Comparison of resin properties.

Related activities:
- Theory and practical classes
- Laboratory session: Physic-chemical analysis of components of composites

Full-or-part-time: 15h
Theory classes: 4h
Practical classes: 2h
Self study : 9h

Module 3: Processing routes of composites

Description:
Fabrication of laminates and profiles. Forming methods. Lay-up methods. Filament Winding. Pultrusion. Resin Transfer Moulding (RTM). Infusion processes. Secondary bonding. Science of adhesion. Pre-treatment prior to bonding. Adhesive selection. Joint design. Core materials. Core formats. Thermoforming. Sandwich construction. Wet laminating and infusion. Pre-impregnates.

Related activities:
- Theory and practical classes
- Laboratory session: Fabrication of composites

Full-or-part-time: 15h
Theory classes: 4h
Practical classes: 2h
Self study : 9h

Module 4: Inspection and testing

Description:
Inspection by non-destructive testing methods. Visual inspection. Tap testing and ultrasonic testing. Radiography and computed tomography. Thermography. Other NDT methods. Destructive testing. Mechanical testing. Other testing methods.

Related activities:
- Theory and practical classes
- Laboratory session: Mechanical characterization of composites

Full-or-part-time: 10h
Theory classes: 2h
Practical classes: 2h
Self study : 6h

Module 5: Bibliographic research project

Description:
Bibliographic research by teams on suggested topics of the course subject. Writing of a bibliography-based document on suggested topics. Presentation of bibliography-based works made by teams.

Related activities:
- Bibliographic research-based work on a proposed topic, realised by teams.
- Workshop of bibliographic research about project topics.
- Delivering and oral presentation of bibliographic research works.

Full-or-part-time: 17h
Theory classes: 2h
Practical classes: 2h
Self study : 13h

Module 6: Micromechanical analysis

Description:
6. Micromechanical approaches (mechanistic, analytics and empirics); Volume and mass fractions; Representative volume element RVE; Serial-parallel rule of mixtures and modified; Evaluation of the composite elastic properties; Ultimate strengths; Micromechanical failures; Damage models; Hygrothermoelastic (HTE) effects.

Related activities:
Theory and practical classes

Full-or-part-time: 16h
Theory classes: 5h
Practical classes: 1h
Self study : 10h

Module 7: Mesomechanical analysis

Description:
Terminology and notation; Compatibility, constitutive and equilibrium equations; Generalized Hook's Law; Stress-strain relations of elastic materials; Degrees of anisotropy; Engineering constants; Plane stress state and constitutive relations; Constitutive relations of unidirectional ply; Stiffness of on-axis ply; Engineering constants of on-axis ply; Global and local coordinate references; Multiangle transformation matrices; Coupling effects; Mutual influence coefficients; Hygrothermoelastic (HTE) effects; Ply strength; Failure theories; Polynomial criteria; Failure envelopes.

Related activities:
Theory and practical classes

Full-or-part-time: 23h
Theory classes: 5h
Practical classes: 3h
Self study : 15h

Module 8: Macromechanical analysis

Description:
Stacking sequence and laminate code; Classical laminated plate theory; Kirchhoff hypothesis; Strain-stress relations; In-plane force and moment resultants; General load-deformation relations; Laminate stiffnesses; ABD matrices; Laminate coupling relationships; Classification of laminates; Effective engineering constants; Design considerations; Normalized matrices; Laminate effective engineering constants; Sandwich laminates.

Related activities:
Theory and practical classes

Full-or-part-time: 23h
Theory classes: 5h
Practical classes: 3h
Self study : 15h

GRADING SYSTEM

Part 1 (50%): Exam 1 (40%) + Practical work (10%)
Part 2 (50%): Exam 2 (40%) + Practical work (10%)

Eventual low marks obtained in the first exam, will be able to recuperate by means of a procedure that will be provided.

For those students who meet the requirements and submit to the reevaluation examination, the grade of the reevaluation exam will replace the grades of all the on-site written evaluation acts (tests, midterm and final exams) and the grades obtained during the course for lab practices, works, projects and presentations will be kept.
If the final grade after reevaluation is lower than 5.0, it will replace the initial one only if it is higher. If the final grade after reevaluation is greater or equal to 5.0, the final grade of the subject will be pass 5.0.

BIBLIOGRAPHY

Basic:
- Hull, D.; Clyne, T.W. An introduction to composite materials. 2nd ed. New York: Cambridge University Press, 1996. ISBN 0521381908.
- Matthews, F.L.; Rawlings, R.D. Composite materials: engineering and science. Boca Raton: Cambridge: CRC; Woodhead Publishing, 1999. ISBN 0849306213.
- Chawla, K.K. Composite materials: science and engineering. 3rd ed. New York: Springer, 2012. ISBN 9780387743646.
- Miravete, A. [et al.]. Materiales compuestos. Zaragoza: A. Miravete, 2000. ISBN 9788492134977.

Complementary:
- Mouritz, Adrian P. Introduction to aerospace materials. Cambridge: Woodhead Publishing, 2012. ISBN 9781855739468.
- Aerospace composites: a design and manufacturing guide. Wheat Ridge, CO: Gadner Publications, 2008. ISBN 9781569904299.