SYLLABUS

Course	
Name	Mechanics of Composite Materials
Code	DIM-OPT-641
Degree	Master in Industrial Engineering (MII)
Year	2
Semester	2
ECTS credits	3 ECTS
Character	Elective
Department	Mechanical Engineering
Area	Continuum Mechanics
Universidad	Pontificia Comillas
Coordinator	Jesús R. Jiménez Octavio

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COURSE SPECIFICS

Context of the course

Contribution to the professional profile

This course is an introductory engineering course on mechanics of composite materials. Composite Mechanics Theory. Basic understanding of linear elasticity, isotropic and anisotropic material behavior. Stress-strain relationships. Analysis of fiber composites. Constitutive relationships for orthotropic materials. Laminate theory. Analysis of orthotropic plates and sandwich beams and plates.

In addition, this course covers both theoretical and practical aspects of mechanics. To the theoretical part a practical approach is added, therefore conceptual problems are enriched with more realistic ones by means of computational simulation using Finite Element Analysis.

At the end of this course, student should be able to:

- Basic understanding of composite micromechanics and classical lamination theory.
- Predict the strength of multi-axial laminates.

Pre-requisites

There are no prerequisites that formally prevent this course. However, by being immersed in a postgraduate program, it is based on concepts that have been studied before in previous courses:

- Linear Algebra
- Material Mechanics

Additional computational skills are also welcome, i.e. Matlab and ANSYS

Competences – Goals

Generic competences

CG3.	Knowledge of basic and technological subjects, which enables students to learn new methods and theories, and gives them versatility to adapt to new environments.
CG4.	Ability to solve problems with initiative, decision, creativity, and critical reasoning; and to communicate and transfer knowledge, abilities and skills in the field of Engineering.
CG8.	Apply the acquired knowledge to solve problems in new or unfamiliar environments within broader and multidisciplinary contexts
CG11.	Acquire learning skills that will allow further study in a self-directed or autonomous manner

Specific Competences and Learning Results[1]
By the end of the course students should be able to: RA1. Understand the differences between the composites and traditional materials. Know the current and emerging applications of composites in the industry. RA2. Demonstrate understanding of the different materials (fibres, resins, cores) used in composites. RA3. Calculate the elastic and strength properties of unidirectional laminates using micromechanics theory. RA4. Explain and understanding of linear elasticity, isotropic and anisotropic material behavior. RA5. Basic understanding of laminate theory. Analysis of orthotropic plates and sandwich beams and plates.

CONTENTS AND MODULES

Contents
1: Introduction to Elasticity
1.1 General equations: equilibrium, behavior and compatibility **1.2** Failure criteria for isotropic materials
2: Introduction to Material Mechanics
2.1 Basic assumptions **2.2** Composite beams **2.3** Plane Stress
3: Micromechanical analysis of a lamina
3.1 Linear elastic stress-strain relations **3.2** Elastic constants based on micromechanics **3.3** Elastic constants based on a global coordinate system **3.4** Coefficients of thermal and moisture expansion
4: Laminate analysis
4.1 Basic equations **4.2** Kinematics of deformation of a laminate **4.3** Effective elastic constants of a laminate **4.4** Application in Matlab
5: Failure theories of a lamina
5.1 Maximum stress **5.2** Maximum strain **5.3** Tsai-Hill **5.4** Tsai-Wu
6: Introduction to homogenization and damage mechanics
6.1 Eshelby method **6.2** Introduction to damage mechanics
7: Cellular Materials
7.1 Introduction to foams **7.2** Introduction to honeycombs

[1] Learning results are observable indicators of the competences acquired, which allow assessing the degree of competence of the students. The competences are usually more general and abstract. Learning results are observable indicators of competences.

TEACHING METHODOLOGY

General methodological aspects	
The best way to achieve a fundamental understanding of the basics of mechanics of composite materials and industrial applications is a practical approach to these concepts. Both classroom sessions and independent study are developed to imply the students within the learning activities, mostly computationally driven by Matlab and ANSYS. The contents are developed to keep the student attention and following the competencies acquisition by the students.	
In-class activities	**Competences**
Lectures and problem-solving sessions (20 hours) The lecturer will introduce the fundamental concepts of each chapter, along with some practical recommendations, and will go through worked examples to support the explanation. Active participation will be encouraged by raising open questions to foster discussion and by proposing short application exercises to be solved in class either on paper or using a software package.	CG8, CG11
Lab sessions (6 hours) Under the instructor's supervision, students, divided in small groups, will apply the concepts and techniques covered in the lectures to real problems and will become familiar with the most widespread software tools and libraries.	CG4, CG8, CG11
Tutoring For groups or individual students will be organized upon request.	
Non-Out-of-class activities	**Competences**
Personal study of the course material and resolution of the proposed exercises (35 hours)	CG8, CG11
Lab results analysis and report writing (5 hours).	CG11
Development of a final project during the last third of the course (20 hours).	CG4, CG8, CG11

SUMMARY OF THE STUDENT WORKING HOURS			
CLASSROOM ACTIVITIES			
Lectures	**Problems solving**	**Lab sessions**	**Assessment**
12	8	6	4
NON-CLASSROOM ACTIVITIES			
Self study - Theory	**Self study - Problems**	**Lab report writing**	**Final project**
10	15	5	20
		ECTS:	**3.0 (90 hours)**

EVALUATION AND GRADING CRITERIA

Evaluation activities	Grading criteria	Weight
Mid-term exam	- Understanding of concepts - Application of concepts to problem solving - Analysis and interpretation of problem results	20%
Final exam	- Understanding of concepts - Application of concepts to problem solving - Analysis and interpretation of problem results	50%
To pass the course you must get at least 4 out of 10 on the final exam		
Lab reports	- Application of theoretical concepts to real problem-solving. - Ability to use and develop computer vision software. - Written communication skills	10%
Final project	- Problem analysis - Information search skills - Quality of the proposed solution - Teamwork - Oral presentation and written communication skills	20%

Grading

In-class activities
Competences

- Theory will account for 70%, of which:
  - Mid-term: 20%
  - Final exam: 50%

- Lab will account for the remaining 30%, of which:
  - Lab practices: 10%
  - Final project: 20%

In order to pass the course, the mark of the final exam must be greater or equal to 4 out of 10 points and the mark of the final project must be at least 5 out of 10 points. Otherwise, the final grade will be the lower of the two marks.

Retakes

A new project could have to be developed and handed in. In addition, all students will take a final exam. The resulting grade will be computed as follows:

- Final exam: 70%
- Final project: 30%

As in the regular assessment period, in order to pass the course, the mark of the final exam must be greater or equal to 4 out of 10 points and the mark of the final project must be at least 5 out of 10 points. Otherwise, the final grade will be the lower of the two marks.

Course rules

Class attendance is mandatory according to Article 93 of the General Regulations (Reglamento General) of Comillas Pontifical University and Article 6 of the Academic Rules (Normas Academicas) of the ICAI School of Engineering. Not complying with this requirement may have the following consequences:

- Students who fail to attend more than 15% of the lectures may be denied the right to take the final exam during the regular assessment period.

- Regarding laboratory, absence to more than 15% of the sessions can result in losing the right to take the final exam of the regular assessment period and the retake. Missed sessions must be made up for credit.

Students who commit an irregularity in any graded activity will receive a mark of zero in the activity and disciplinary procedure will follow (cf. Article 168 of the General Regulations (Reglamento General) of Comillas Pontifical University).

WORK PLAN AND SCHEDULE[2]

Non-classroom activities	Date
Mid-term exam	Week 9
Final exam	May
Review and self-study of the concepts covered in the lectures	After each lesson
Proposed problem solving	Weekly
Final project	Last month

REFERENCES AND RESOURCES

Basic references

- **Notes prepared by the lecturer (available in Moodle).**
- **Mechanics of Composite Materials with MATLAB, G. Z. Voyiadjis, P. I. Kattan,Springer, 2005**

Complementary references

- Mechanics of Composite Materials, Robert M. Jones, 2nd ed., Taylor and Francis, 1999
- Mechanics of Composite Materials, Autar K. Kaw, 2nd ed., CRC Press, 2006
- Finite Element Analysis of Composite Materials, E. J. Barbero, CRC Press, 2008
- Introduction to Composite Materials Design, 2nd ed., Ever J. Barbero, CRC Press, 2011

[2] A detailed planning of the course may be found in the schedule. This planning is indicative and may change along the course