UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2016/2017
MASTER'S DEGREE (MSC)	MECHANICAL ENGINEERING
SUBJECT	MECHANICS OF COMPOSITE AND CERAMIC MATERIALS
TYPE OF EDUCATIONAL ACTIVITY	C
AMBIT	20933-Attività formative affini o integrative
CODE	04936
SCIENTIFIC SECTOR(S)	ING-IND/14
HEAD PROFESSOR(S)	ZUCCARELLO BERNARDO Professore Ordinario Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	1
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**ZUCCARELLO BERNARDO** Monday 10:00 12:00 UFFICIO EDIFICIO 8

DOCENTE: Prof. BERNARDO ZUCCARELLO

PREREQUISITES	Knowledge of Statics and Mechanics of Solids.
LEARNING OUTCOMES	1) Knowledge and ability to understand: at the end of the course, the student will have acquired knowledge and methods to address and solve the problems related to the mechanical design of composite materials. 2) Capacity to apply knowledge and understanding: the student will have acquired knowledge and methodologies to analyze and solve typical problems related to the use of composite materials in the engineering design and the industrial manufacturing. 3) Making judgments: the student will have acquired the methods for the analysis of components and structures made by composite materials. 4) Communication skills: the student will be able to communicate competently about complex issues of structural design based on the use of advanced composites. 5) Learning capacity: the student will be able to solve issues relating to the correct use and sizing of components and structures in any field of the mechanical design.
ASSESSMENT METHODS	Oral examination with discussion of the exercitations carried out during the course. The examination aimed to assess the knowledge and the disciplinary skills acquired by the student. The candidate will have to answer three questions on topics covered by the program, and discuss an exercitation carried out in classroom or in laboratory. The grade is out of thirty. Essential items of the student evaluation are in order: 1) knowledge and mastery of the topics, 2) ability to use the acquired knowledge for the solution of the proposed questions, 3) ability to comment the exercitations carried out in the classroom or in the laboratory, 4) language properties demonstrated during the examination. Each item is assigned a rating variable between 0 and 8 (excellent=8, good=7, sufficient=6, fairly good=5, scarce=3-4, very scarce 0-3) and the final grade will be obtained by adding all the single votes; the final grade of 30&Lode will be assigned if the sum of the single votes exceed the value of 30.
EDUCATIONAL OBJECTIVES	The course intends to train the student so that he is able to solve problems related to the structural design of composite materials, by applying the methods of calculation and design currently available, and taking into account both the theoretical innovations and the industry practices.
TEACHING METHODS	Lectures, classroom and laboratory excercitations.
SUGGESTED BIBLIOGRAPHY	Zuccarello, B., Dispense di PROGETTAZIONE MECCANICA CON MATERIALI NON CONVENZIONALI, Palermo, 2002. Agarwal, B.D., Broutman, L.J., ANALYSIS AND PERFORMANCE OF FIBER COMPOSITES, John Wiley & Sons, New York, 1980. Barbero, E.J., INTRODUCTION TO COMPOSITE MATERIAL DESIGN, Taylor and Francis, New, York, 1999. Wachtman, J.B., STRUCTURAL CERAMICS, Academic Press inc., Londra, 1989. Reddy, J.N., MECHANICS OF LAMINATED COMPOSITE PLATES, CRC Press, 1997. Kaw, A. K., Mechanics of Composite Materials, CRC Press, 1997. Musikant, S., CERAMICS, Marcel Dekker, New York 1991.

SYLLABUS

Hrs	Frontal teaching
4	COMPOSITE MATERIALS: definitions, properties and classifications. PARTICLE COMPOSITES. FIBROUS COMPOSITES: long fibres, short fibres. MATRIXES: epoxy, polyester, phenolic and vinylic resins. FIBRES: glass, carbon, other fibres.
6	UNIDIRECTIONAL LAMINA: volume and weight fraction, specific weight, void fraction. MICROMECHANICHS: Longitudinal modulus, longitudinal tensile strenght, transversal modulus, transverse strenght, Poisson ratio. THERMAL COEFFICIENTS: longitudinal and transverse coefficients.
5	SHORT FIBER COMPOSITES: definition, load transfer, modulus of elasticity for unidirectional and random oriented fibres, tensile strenght, fatigue strenght, impact strenght, thoughness. RIBBON FIBRE COMPOSITES: definitions, elastic moduli, mechanical strenght.
5	MACROMECHANICS OF THE ORTHOTROPIC LAMINA: definitions, Hooke law, stiffness and compliance matrixes, relationships between elastic constants and matrixes, elastic constants in the generic direction.
6	CLASSIC THEORY OF LAMINATES: definitions, calculation of strain and curvature of the middle plane, calculation of the strain and stress distribution in the generic lamina. LAMINATE MATRIXES AND CONSTITUTIVE EQUATIONS: simmetric laminates, orthotropic laminates, laminates with D13=D23=0, quasi-isotropic laminates. STRESS ANALYSIS: matrixes inversion and solvent equations. THERMAL STRESSES: thermal force and thermal moments, thermal strains and thermal stresses.
5	DAMAGE MECHANISMES AND STRENGHT CRITERIA: longitudinal tensile failure, longitudinal compression failure, transversal tensile failure, transversal compression failure, shear failure. Maximum Stress Criterion, Maximum Strain Criterion, Tsai-Hill Criterion, Tsai-Wu Criterion, influence of the sign of the shear stress.

SYLLABUS

Hrs	Frontal teaching
6	LAMINTE ANALYSIS, INTERLAMINAR STRESSES AND FATIGUE: definitions, FPF load, post-FPF analysis, analysis of cross-ply laminates, use of automatic codes. FATIGUE LIFE: experimental analysis and fatigue relationships. HIGH MODULUS COMPOSITES: particular properties and influence of the stress and of the environmental conditions.
6	LEFM AND STRENGHT CRITERIA FOR NOTCHED COMPONENTS: Griffith theory, elastic theory. WHITNEY-NUSIMER CRITERIA: point stress criterion, average stress criterion. IMPACT STRENGHT: definitions, influence parameters (impact velocity, dimension and geometry of the component, fiber orientation and lay-up), delamination strenght. FAILURE MECHANISMS: fiber failure, matrix failure, pull-out, delamination. HYBRID COMPOSITES: fibre strenght and loading time, thermal aging of the matrix, water effects.
6	EXPERIMENTAL CHARACTERISATION OF COMPOSITES: tensile test, compression test, shear test, bending test, delamination test, fracture test. NON-DESTRUCTIVE TESTS: X-ray, ultrasounds, other techniques for the evaluation of the structural integrity.
5	JOINTS FOR COMPOSITE MATERIALS: definitions, classifications, advantages and disvantages. DOUBLE LAP BONDED JOINT: stress distribution, joint lenght and maximum load, effect of the joint thickness, of the unbalance, of the thermal coefficients mismatch, peeling stresses, peel strenght. DIFFERENT BONDED JOINTS: simple lap joint, scarf joint, double step joint, surface preparation. JOINT MANUFACTURE AND CONTROLS: pre-cured composites, non-cured composites. MECHANICAL JOINTS: analysis of the various failure modes.

Hrs	Practice
6	Desing of elementary components by using composite materials. Analysis of the critical fiber fraction in multi-reinforced composites. Micromechanics: evaluation of the reliability of the theoretical models. Use of short fibre composite and ribbon composites. Use of the Classical Theory of Laminates. Use fo the strength criteria for composite materials.

Hrs	Workshops
6	Manufacturing of composite laminates by using hand-lay up and vacuum-bagging. Mechanical characterization of composite laminates reinforced with glass, carbon and aramidical fibres, by tensile and shear tests.