UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2020/2021
MASTER'S DEGREE (MSC)	MECHANICAL ENGINEERING
SUBJECT	NUMERICAL SIMULATION FOR MECHANICAL ENGINEERING
TYPE OF EDUCATIONAL ACTIVITY	B
AMBIT	50370-Ingegneria meccanica
CODE	06435
SCIENTIFIC SECTOR(S)	ING-IND/14
HEAD PROFESSOR(S)	PANTANO ANTONIO Professore Ordinario Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	9
INDIVIDUAL STUDY (Hrs)	144
COURSE ACTIVITY (Hrs)	81
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	1
TERM (SEMESTER)	2° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**PANTANO ANTONIO** Tuesday 10:00 12:00 Ufficio Prof. A. Pantano Friday 11:00 13:00 Ufficio Prof. A. Pantano

DOCENTE: Prof. ANTONIO PANTANO

PREREQUISITES	Mechanics of solids, Theory of structures, Mechanical Engineering Design.
LEARNING OUTCOMES	Knowledge and ability to understand • At the end of the course, the student will have acquired knowledge and methodologies to face and solve in an original way mechanical engineering problems through numerical simulation methods. The student will also be able to solve optimization problems through numerical simulation. Ability to apply knowledge and understanding • The student will have acquired knowledge and methodologies to analyze, solve and optimize problems typical of design with the aid of numerical methods. Autonomy of judgment • The student will have acquired a methodology of analysis proper in the use of the finite element method to simulate problems of engineering interest. Communication skills • The student will be able to communicate with competence and language skills regarding complex numerical simulation problems for mechanical engineering. Learning skills • The student will be able to deal with several problems concerning the use of numerical techniques for mechanical engineering. The student will be able to deepen complex issues regarding the use of the finite element method and optimization.
ASSESSMENT METHODS	The oral exam consists of a colloquium aimed at certifying the possession of the competences and disciplinary knowledge provided by the course, the ability to contextualize and expose. The maximum score is thirty. The student will have to answer at least four oral questions on the entire program, with reference to the suggested texts. The final exam aims to assess whether the student has knowledge and understanding of the subjects, has acquired interpretative competence and autonomy in judging real problems. The threshold of sufficiency will be reached when the student demonstrates the knowledge and understanding of the topics at least in the general guidelines and has minimum application skills for the resolution of real cases. He must also have presenting and arguing skills that will enable them to pass their knowledge to the examiner. Below this threshold, the examination will be insufficient. The maximum score is obtained if the exam ensures full possession of the following three aspects: a judgmental ability that can describe emerging and/or unexplored aspects of discipline; a strong ability to highlight the impact of the contents of the course within the sector/discipline; mastering the ability to represent innovative ideas and/or solutions within the professional, technological or sociocultural context of reference. As far as the presenting capacity is concerned, there is a minimum assessment in case the student demonstrates a language property that is appropriate to the reference context but this is not sufficiently articulated, whereas the maximum evaluation can be obtained by those who demonstrate full knowledge of technical language as well. In short, the final evaluation will be graded according to the following grid of judgments. Excellent 30-30 and praise excellent knowledge of the subjects, excellent language properties, good analytical skills, the student is able to apply the knowledge to effectively deal with the required problems. Very good 26-29 Good command of the subjects, full language properties, the student is able to apply the knowledge to adequately address the requested problems. Good 24-25 Basic knowledge of the main topics, discreet language properties, with limited ability to autonomously apply the knowledge to the solution of the requested problems. Satisfactory 21-23 He does not have full mastery of the main topics, satisfactory language properties, lack of ability to independently apply the acquired knowledge. Sufficient 18-20 Minimum basic knowledge of the main topics and of the technical language, very little or no ability to independently apply the acquired knowledge Insufficient It does not possess an acceptable knowledge of the contents of the topics covered in the teaching. Insufficient 0-17 Negative Result, the student demonstrates that he has not achieved the minimum learning outcomes foreseen for the course.
EDUCATIONAL OBJECTIVES	At the end of the course, the student will have acquired practical knowledge and methodologies to analyze, solve and optimize problems typical of design with the aid of numerical methods. The student will be able to analyze the results of the simulations conducted and to refine the numerical models in order to obtain accurate results.
TEACHING METHODS	Lessons, practice.

SUGGESTED BIBLIOGRAPHY	F. Cappello, A. Pantano: "Metodo degli Elementi Finiti - Corso in Simulazione Numerica per l'Ingegneria Meccanica " - Rapp. Int. del Dip. di Meccanica, 2020. G.Belingardi: "Principi e metodologie della progettazione meccanica", Levrotto & Bella, 1995 O.C. Zienkiewicz, R.L. Taylor: "The finite element method" - McGraw Hill Book Company, London, 1989 J. N. Reddy: "An Introduction to the Finite Element Method", McGraw Hill Book Company, London, 1993. S.L. Crouch, A.M. Starfield: "Boundary element meth. in solid mechan.", G. Allen & Unwin, London, 1983 V. Hubka, W.E. Eder: "Design science" – Springer, London, 1992.

SYLLABUS

Hrs	Frontal teaching
1	Introduction to the course. Methods of structural analysis. Brief summary of theory of elasticity.
2	Displacement method.
4	Finite element method (FEM). Shape functions. Stiffness matrix of the element and of the structure. Boundary conditions. Evaluating displacements and strains. Convergence criteria. Displacement functions with generalized coordinates.
3	Type of elements: one dimensional, plane, plate, shell, solid tetrahedra, parallelepipeds.
4	Isoparametric element. Numerical integration. Discretization criteria. Hierarchical elements. Nonlinear analysis. Dynamic problems. Implicit and explicit integration methods.
28	Use of commercial codes based on FEM for the analysis of mechanical components and structures. Examples of mechanical problems solved with framed elements (rods or beams), plane elements, axisymmetric elements, solid elements, shells elements. Analysis of composite structures. Problems with geometric nonlinearity. Buckling. Nonlinearities of the material. Contact problems. Analysis of thermal and thermo-mechanical problems. Analysis via hierarchical elements. Modal analysis. Analysis of harmonic response. Dynamic Analysis. Direct analysis of problems coupled via special elements having all the necessary degrees of freedom (eg, direct resolution of an electro-thermo-mechanical problem). Adaptive meshing. Wave propagation problems.
3	Optimization. Optimization techniques: Methods based on gradients, Subproblem approximation method, Genetic algorithms. Unconstrainded minimum. Penalty functions. Optimization of mechanical components and structures by FEM.
2	Finite difference Method.
3	How to write a FEM code.
7	Boundary elements method: Use of singular solutions. Internal and external problems. Direct and indirect methods. Reciprocity theorem. Properties of the test solutions. Influence coefficients. Results at the internal points. Formulas of Somigliana. Discretization criteria. Structure of a BEM program.

Hrs	Practice
3	One dimensional elements.
18	Use of commercial codes based on FEM for the analysis of mechanical components and structures. Examples of mechanical problems solved with framed elements (rods or beams), plane elements, axisymmetric elements, solid elements, shells elements. Analysis of composite structures. Problems with geometric nonlinearity. Buckling. Nonlinearities of the material. Contact problems. Analysis of thermal and thermo-mechanical problems. Analysis via hierarchical elements. Modal analysis. Analysis of harmonic response. Dynamic Analysis. Direct analysis of problems coupled via special elements having all the necessary degrees of freedom (eg, direct resolution of an electro-thermo-mechanical problem). Adaptive meshing. Wave propagation problems.
3	Example of optimization of mechanical components and structures by FEM.