UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2022/2023
MASTER'S DEGREE (MSC)	CIVIL ENGINEERING
SUBJECT	COMPUTATIONAL STRUCTURAL MECHANICS
TYPE OF EDUCATIONAL ACTIVITY	B
AMBIT	50353-Ingegneria civile
CODE	09136
SCIENTIFIC SECTOR(S)	ICAR/08
HEAD PROFESSOR(S)	PARRINELLO FRANCESCO Professore Associato Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	98
COURSE ACTIVITY (Hrs)	52
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	2
TERM (SEMESTER)	2° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**PARRINELLO FRANCESCO** Tuesday 10:00 13:00 Ex dipartimento di Ingegneria strutturale

DOCENTE: Prof. FRANCESCO PARRINELLO

PREREQUISITES	Structural and solid mechanics.
LEARNING OUTCOMES	The student at the end of the course will have 'knowledge of the problems concerning the structural calculation through the use of computers; he will have 'knowledge of mathematical procedures that lead to the resolution of the elastic problem for frame structures (direct method of stiffness) and continuous systems (finite element method). It will be 'able to understand the functioning of the structural calculation programs, to know the limits and the range of applicability of fields.
ASSESSMENT METHODS	Evaluation of the exam occurs with minimum 18 and maximum 30 cum laude, as a vote in the oral examination and student's ability to solve structural calculation problems by the use of finite elements program. During the oral examination the student is asked to answer to 3 or 4 questions related to the theoretical arguments discussed during the course.
EDUCATIONAL OBJECTIVES	The main objective of the course is the knowledge of the basic theory of computational mechanics, allowing the student the direct use of finite element calculation tools, through the resolution of a sufficient number of structural analysis problems.
TEACHING METHODS	Lectures and computational practical
SUGGESTED BIBLIOGRAPHY	•J- N. Reddy, An introduction to the finite element method, International student edition. ISBN: 0071127992 •J. Fish and T.Belytschko, A First Course in Finite Elements, John Wiley & Sons, 2007. ISBN-13: 9780470035801 •K. J. Bathe, Finite element Procedure, Prentice Hall, 1996. ISBN 978-0-9790049-5-7 •O.C. Zienkiewicz, R.L. Taylor, J.Z. Zhu, The Finite Element Method: Its Basis and Fundamentals, Sixth edition. Butterworth Heinemann 2005, ISBN 0 7506 6320 0.

SYLLABUS

Hrs	Frontal teaching
2	A1. Direct stiffness method. Idealization and discretization of the structure. Break down into finite elements. Finite element modelling of the individual structural element. Transformation of reference system between local and global axes. Assembly, boundary conditions and resolution. Programming in MathLab a finite element code for analysis of truss structurees.
3	A2. One-dimensional finite element. Modelling of finite element trusses. Modelling of beam element for the flexural behaviour. Calculation of the local stiffness matrix for the two-dimensional beam. Programming in MathlaB a simple finite element code for analysis of two-dimensional frame structures.
2	A3. Node numbering optimization and the Gauss-Jordan linear equation solver, with its implementation in MathLab.
2	B0. Strong form and weak form of the governing equations of the elastic problem. Principle of virtual work. Variational methods and functional of total potential energy.
2	B1. Trial displacement function. Interpolating formulation and shape functions. Nodal degrees of freedom. Methods for the error minimization. Reylight-Ritz method.
2	B2. Euler-Bernoulli beam formulation. Hermitian shape functions and relevant degrees of freedom. Calculation of the element stiffness matrix. End release.
2	B3. Timoshenko beam formulation. Shear equivalent area. Shape functions and relevant degrees of freedom. Resolution and comparison with Elero-Bernoulli model.
2	B4. Convergence of the finite element solution. Error in FEM. Convergence of the approximate solution. Refinement of the solution: p and h refinement.
3	B5. Plane stress and plane strain problems. Axisymmetric problem. Triangular and rectangular finite element. Resolution of some two-dimensional problems.
2	B6. Isoparametric Mapped Element. Finite Element in the local reference and in the cartesian reference. One-to-one mapping between the two elements. Coordinate transformation and Jacobian of the transformation. Finite element stiffness matrix.
2	B7. Numerical integration techniques. Gauss integration method. Gauss points and weights. Integration error. Full and reduced integration.
2	B8. Higher-order finite elements. Quadratic shape functions. Six nodes triangular element. Nine nodes quadrilateral finite element. Serendipity Elements.
2	B9. Volumetring locking in quasi-incompressible solids. Analysis by reduced numerical integration or by mixed formulation.

Hrs	Practice
3	Study of a finite element program developed in MathLab or by Excel spreadsheet.
3	Analysis of frames structure by use of MAthlab code or by an Excel spreadsheet F.E. code.

Hrs	Practice
2	Analysis of frames structure by use of a commercial F.E. code.
2	Analysis of frames structures and introduction of internal constraints by end release and by Master slave elimination method.
2	Finite element analysis of a structural problems under plane stress and plain strain conditions..
2	Writing and programming a Fortran subroutine for modeling a finite element in an open source code (FEAP).
10	Study and critical analysis of the results, carried out in small working groups, of a civil engineering structure, through a commercial F.E. program. Drafting of a brief structural calculation report.