CES505 - Computational Mechanics and Applications

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<tr><td>Course Title</td><td colspan="5">Computational Mechanics and Applications</td></tr>
<tr><td>Course Code</td><td colspan="5">CES505</td></tr>
<tr><td>Course Type</td><td colspan="5">Compulsory</td></tr>
<tr><td>Level</td><td colspan="5">MSc (Level 2)</td></tr>
<tr><td>Year / Semester</td><td colspan="5">1st Year / 1st Semester</td></tr>
<tr><td>Teacher’s Name</td><td colspan="5">Dr. Petros Christou</td></tr>
<tr><td>ECTS</td><td>7</td><td>Lectures / week</td><td>3</td><td>Laboratories / week</td><td></td></tr>
<tr><td>Course Purpose</td><td colspan="5">The course will cover the most common finite elements, their properties and their appropriate use for the modelling of structural systems. The aim is to increase the competency of the students to the development of structural models and further enhance their ability and confidence in the use of software to analyse structures. Upon completion of this course the student will:
1. Choose correct modelling elements,
2. Choose correct load representation,
3. Develop appropriate geometry and boundary conditions,
4. Apply software to attain displacements and stresses,
5. Interpret output in terms of stated goals of analysis,
6. Validate results using simplified models and hand calculations.</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">1. Illustrate the various steps in the Finite Element Method from an assumed displacement polynomial to the determination of stresses,
2. Evaluate the degree of approximation,
3. Employ an analysis system for the determination of stresses and strains in small displacement, linear elastic problems,
4. Formulate a series of smaller studies, benchmarks or experimental tests in support of a FEA modelling strategy,
5. Select appropriate idealisation(s) for components / structures, which are consistent with the objectives of the analyses.</td></tr>
<tr><td>Prerequisites</td><td colspan="2"></td><td>Co-requisites</td><td colspan="2"></td></tr>
<tr><td>Course Content</td><td colspan="5"><u>General</u>
• Finite element concepts; modeling; discretization; element selection; testing; model validation,
• Matrix operations, numeric integration (Gauss-quadrature) and Mathcad.
<u>Direct Stiffness Method</u>
• Formulation of the stiffness and external load matrices,
• Solution of equations for the recovery of the internal forces,
• Check equilibrium and draw shear and bending moment diagrams.</td></tr>
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	Line elements (1-D) • Axial line element (bar); C0 shape functions (interpolation functions); element matrix formulation; integration; loads; assembly of global matrices; solution; force recovery; coordinate transformations, • Element matrix formulation techniques, • Flexural line element (beam); C1 shape functions (interpolation functions); element matrix formulation; integration; loads; assembly of global matrices; solution; force recovery; coordinate transformations. **Surface (area) elements (2-D)** • Shape functions; strain-displacement relationships; constitutive relationships (stress-strain relationships, material models), • Plane-stress, plane-strain, and axi-symmetric analysis using rectangular elements; locking; full vs. reduced integration; spurious modes; incompatible modes; stress recovery; interpretation of analysis results (principal stress, effective stress), • Isoparametric surface element formulations; shape functions; consistent loads; effects of element distortion; stress recovery, extrapolation, and smoothing, • Plate bending elements; Kirchoff vs. Mindlin formulations; constitutive relationships; interpretation of analysis results (principal moments and shears), • Flat shell elements; superposition of membrane and plate bending; drilling DOF, • Axisymmetric elements. **Volume (solid) elements (3-D)** Isoparametric volume (solid brick) elements; shape functions; constitutive relationships.
Teaching Methodology	The course will be presented through theoretical lectures in class. The lectures will present to the student the course content and allow for questions. Part of the material will be presented using visual aids. The aim is to familiarize the student with the different and faster pace of presentation and also allow the instructor to present related material (photographs etc.) that would otherwise be very difficult to do. The learning process will be enhanced with the requirement from the student to solve exercises. These include self-evaluation exercises which will be solved in class. These exercises will not be graded. Exercises will also be given as homework (final project) which will be part of their assessment. Besides from the notes taken by students in class, all of the course material will be made available through the class website and also through the eLearning platform. Finally the instructor will be available to students during office hours or by appointment in order to provide any necessary tutoring.
Bibliography	**Textbooks:** 1. "Finite Element Modelling for stress analysis", R. Cook, Wiley, 1995; 2. "Structural Analysis: Principles, Methods and Modelling", Gianluca Razni, Raymond Ian Gilbert, CRC - Taylod and Francis, 2018; **References:** 1. "Matrix Methods for Advanced Structural Analysis", Manolis Papadrakakis, Evangelos Sapountzakis, Elsevier Science, Nov 2017.

	2. “Introductory Lectures on the Finite Element Method”, Olgierd C. Zienkiewicz, Springer, 2014.
Assessment	The course is assessed through mid-term examinations, assignments and a final examination. The criteria for assessment can be found on the individual assignments and exams. The weights of the course assessment are as follows: Midterm Exams: 30% Assignments: 20% Final Exam: 50%
Language	English