(Module Name)

Computational Stress Analysis

Course Catalogue

2023-2024

College/ Institute	Erbil Technical engineering
Department	Mechanical and Energy Tech. Engineering
Module Name	Computational Stress Analysis
Module Code	CSA204
Degree	Technical Diploma ☐ Bachler ☐ High Diploma ☐ Master ■ PhD ☐
Semester	2
Qualification	PhD in Mechanical Engineering
Scientific Title	Assistant professor
ECTS (Credits)	6
Module type	Prerequisite ☐ Core ■ Assist. ☐
Weekly hours	3
Weekly hours (Theory)	(3)hr Class (8)Total hrs Workload
Weekly hours (Practical)	( )hr Class ( )Total hrs Workload
Number of Weeks	15
Lecturer (Theory)	Assist. Prof. Dr. Younis Khalid Khdir
E-Mail & Mobile NO.	younis.khdir@epu.edu.iq , 07504790685
Lecturer (Practical)	
E-Mail & Mobile NO.	
Websites	

Course Book

Course Description	The goal of this course is to introduce computational methods based on stress analysis encountered in many engineering applications. In particular, the focus will be on the Finite Element Method and its application to linear elasticity problems. Other methods such as von Mises simulation and so on commonly employed in material science and physics will also be discussed. First, we will discuss how to discretize a FEM problem and construct a model that can be solved numerically. Subsequently, we will discuss the principle of other methods of stress analysis and its application to solve a mechanical system with discrete degrees of freedom. We will then introduce the more general form formulation and the solution of stress concentration. Introduction into the use of computational techniques in applied mechanics stress analysis of 2-dimensional rod structures/trusses (with the direct stiffness method); applications, basic relations, matrix problem formulation, laboratory work. Linear elastic stress analysis of 2- and 3-dimensional solid bodies; applications, basic relations, FE formulation, laboratory work. One- and multi-dimensional heat conduction analysis; applications, basic relations, FE formulation, laboratory work. Orientation regarding other application fields for FEM such as transient dynamics, structural optimisation, material mechanics, heat transfer, including laboratory work Evaluation of results including material-related questions (standing issue in the course)
Course objectives	This course aims to develop a practical approach to computational stress analysis problem solving. The course will introduce to many commonly used tools and techniques in numerical work. Due emphasis will be placed on converting algorithms and techniques to working computer codes. Carefully designed examples will help in understanding the nuances of the numerical techniques and computer applications of the same. Also to introduce the students to the basic concepts, mathematical formulation and general procedure of the finite element method (FEM) as related to solving engineering problems in solids and heat transfer. To provide students with a working knowledge of computer-aided engineering analysis tools and their use in design.
Student's obligation	**Class attendance, preparing seminar presentation. Quiz for each chapter. (more than 4 quiz at the end), homework after each chapter.**

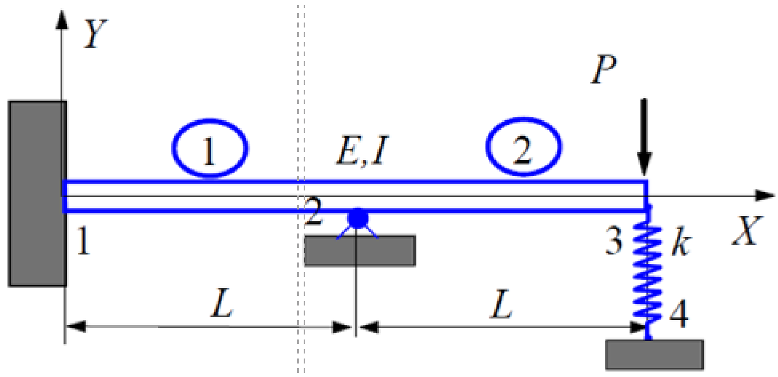
<table>
<tr><td>Required Learning Materials</td><td colspan="5">Data show, power point, white board, seminar, pictures.</td></tr>
<tr><td rowspan="14">Evaluation</td><td colspan="2">Task</td><td>Weight (Marks)</td><td>Due Week</td><td>Relevant Learning Outcome</td></tr>
<tr><td colspan="2">Paper Review</td><td></td><td></td><td></td></tr>
<tr><td rowspan="7">Assignments</td><td>Homework</td><td></td><td></td><td></td></tr>
<tr><td>Class Activity</td><td></td><td></td><td></td></tr>
<tr><td>Report</td><td>5%</td><td></td><td></td></tr>
<tr><td>Seminar</td><td>10%</td><td></td><td></td></tr>
<tr><td>Essay</td><td></td><td></td><td></td></tr>
<tr><td>Project</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Quiz</td><td>10%</td><td></td><td></td></tr>
<tr><td colspan="2">Attendance</td><td>5%</td><td></td><td></td></tr>
<tr><td colspan="2">Midterm Exam</td><td>20%</td><td></td><td></td></tr>
<tr><td colspan="2">Final Exam</td><td>50%</td><td></td><td></td></tr>
<tr><td colspan="2">Total</td><td>100%</td><td></td><td></td></tr>
<tr><td>Specific learning outcome:</td><td colspan="5">This course will develop your Technical Competence capability. Upon successful completion of this course, you should:
1. Demonstrate a basic understanding of the concepts, mathematical formulation and numerical implementation underlying the FEM as applied to solid mechanics and thermal analysis;
2. Create his/her own FEM computer programs to solve simple mechanical and heat transfer problems;
3. Analyze more complex mechanical and heat transfer problems using commercial FEA software ANSYS;
4. Demonstrate the ability to invoke appropriate assumptions, select proper elements and develop FEA models that adequately and efficiently represent physical systems;
5. Demonstrate the ability to perform parametric and convergence studies for mechanical and thermal analysis and design;
6. Demonstrate the ability to give a professional and well organized presentation and report of their work;
7. Familiar with the theoretical basis for FEA in solid mechanics and heat transfer.</td></tr>
<tr><td>Course References:</td><td colspan="5">1. Computational Methods in Elasticity and Plasticity – Solids and Porous Media, A. Anandarajah.
2. Multiscale Modeling in Solid Mechanics – Computational Approaches, Ugo Galvanetto, M. H. Ferri Aliabadi.
3. A First Course in the Finite Element Method Fourth Edition Daryl L.</td></tr>
</table>

	Logan. Thomson, 2007. 4. Textbook of finite element analysis, P. Seshu, PHI Learning Private Limited, India, 2012. 5. Finite Element Analysis theory and application with ANSYS, Saeed Moaveni, Pearson, 2015. 6. O. C. Zienkiewicz and R. L. Taylor, The Finite Element Method, 4thed (McGraw-Hill, New York, 1989). 7. J. N. Reddy, An Introduction To The Finite Element Method, Second Edition ed (McGraw-Hill, New York, 1993). 8. R. D. Cook, Finite Element Modeling For Stress Analysis (John Wiley & Sons, Inc., New York, 1995). 9. K. J. Bathe, Finite Element Procedures (Prentice Hall, Englewood Cliffs, NJ, 1996). 10. T. R. Chandrupatla and A. D. Belegundu, Introduction To Finite Elements in Engineering, 3rd ed (Prentice Hall, Upper Saddle River, NJ, 2002). 11. R. D. Cook, D. S. Malkus, M. E. Plesha, and R. J. Witt, Concepts and Applications of Finite Element Analysis, 4th ed (John Wiley & Sons, Inc., New York, 2002). 12. S. Moaveni, Finite Element Analysis - Theory and Application with ANSYS, 2nd ed (Prentice-Hall, Upper Saddle River, NJ, 2002).

Course topics (Theory)	Week	Learning Outcome
Fundamental of stress analysis	1	
Introduction to computational methods in structural mechanics	2	
Computational stress analysis (The procedure)	3	
Finite Element Analysis of bar and beam element	4	
Two-dimensional problem – review of the basic theory and finite element of 2D problems	5	
Finite element modeling and solution technique	6	
Stress concentration	7	
Plates and shell elements	8	
Solid element for 3D problems stress analysis	9	
Typical 3D solid element	10	
Structural vibration and dynamics (Basic equations and free vibration)	11	
Structural vibration and dynamics (Damping and modal equation)	12	
Structural vibration and dynamics (Frequency and transient response analysis)	13	
Thermal analysis (Temperature field)	14	

Questions Example Design:

Q):



Given: $P = 50$ kN, $k = 200$ kN/m, $L = 3$ m,

$E = 210$ GPa, $I = 2\times10^{-4}$ m^4.

Find: Deflections, rotations and reaction forces.

Solution:

The beam has a roller (or hinge) support at node 2 and a spring support at node 3. We use two beam elements and one spring element to solve this problem.

Extra notes:

External Evaluator

Assist. Prof. Dr. Gailan Ismail Hassan