(Module Name)

Approximate Methods in Mechanical Engineering

Course Catalogue

2023-2024

College/ Institute	**Erbil Technical engineering**	
Department	**Mechanical and Energy Tech. Engineering**	
Module Name	**Approximate Methods in Mechanical Engineering**	
Module Code	**AMM102**	
Degree	**Technical Diploma ☐ Bachler ☐ High Diploma ☐ Master ☐ PhD ■**	
Semester	**1**	
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	"Approximate Method in Mechanical Engineering (AMM)" This course presents a study on approximate methods. Approximate methods mean analytical procedures for developing solutions in the form of functions that are close, in some sense, to the exact, but usually unknown, solution of the nonlinear problem. Therefore, numerical methods fall into a separate category, because they result in tables of values rather than functional forms. Approximate methods may be divided into three broad interrelated categories; “iterative,” “asymptotic,” and “weighted residual.” The iterative methods include the development of series, methods of successive approximation, rational approximations, and so on. Asymptotic procedures have at their foundation a desire to develop solutions that are approximately valid when a physical parameter (or variable) of the problem is very small, very large or in close proximity to some characteristic value. Typical of these methods are the perturbation procedures, both regular and singular. Realistic error bounds or estimates exist for some approximate processes. Perhaps the best known of these is that for the Taylor series and the method of successive approximations for integral equations. The numerical analytical methods are used to obtain an approximate solution of partial differential equations that are difficult to solve analytically. First, an object of interest is divided into elements that each has a simple shape and a finite size. Next, physical quantities (temperature, stress, etc.) of each element are approximated by a simpler equation, and then the equations for the elements are combined to construct simultaneous equations. By solving the obtained simultaneous equation under the boundary conditions of the physical quantities at surfaces of the elements, the distribution of the physical quantities over the object are obtained. Since an object is subdivided to polyhedrons, FEM can be conveniently applied to complicated-shape objects. In electron microscopy, the method is used for calculation of mechanical strength and thermal distribution, calculation of distributions of magnetic fields and electrostatic fields of magnetic lenses and electrostatic lenses, etc. In the development of lens polepieces, aberration coefficients are obtained by calculation of electron trajectories using the magnetic field distributions obtained by FEM, and then the shapes of magnetic poles are optimized.

<table>
<tr><td rowspan="1">Course objectives</td><td colspan="4">This course aims to develop a practical approach to mathematical 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.

1. To provide the fundamental concepts of the theory of the finite element method so as to learn basic principles of finite element analysis procedure:
2. To develop proficiency in the application of the finite element method (modelling, analysis, and interpretation of results) to realistic engineering problems through the use of a major commercial general-purpose finite element code.
3. To learn the theory and characteristics of finite elements that represent engineering structures.
4. To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses performed by others.
5. Learn to model complex geometry problems and solution techniques.
6.</td></tr>
<tr><td>Student's obligation</td><td colspan="4">Class attendance, preparing seminar presentation. Quiz for each chapter. (more than 4 quiz at the
end), homework after each chapter.</td></tr>
<tr><td>Required Learning Materials</td><td colspan="4">Data show, power point, white board, seminar, pictures.</td></tr>
<tr><td rowspan="13">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>
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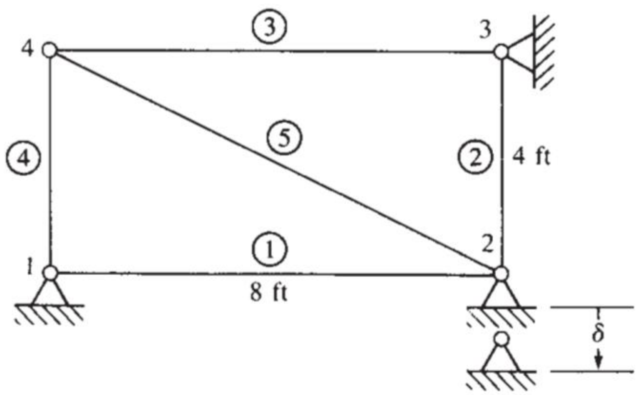
	Total	100%		
Specific learning outcome:	This course will develop your Technical Competence capability. Upon successful completion of this course, you should: 1. Familiar with the theoretical basis for FEA in solid mechanics 2. Be able to use the commercial Finite Element package ANSYS to build Finite Element models and solve a selected range of engineering problems. 3. Be able to validate a Finite Element model using a range of techniques. 4. Be able to discuss the accuracy of the Finite Element solutions. 5. Are able to numerically solve for stresses, strains and deformation of a structural component due to axial load, torsion, and bending, acting individually or in combination. 6. Are able to numerically solve for stresses, strains and deformation of a structure under either plane-stress or plane strain conditions. 7. Familiar with the theoretical basis for FEA in solid mechanics 8. Able to set up and solve solid mechanics problems using ANSYS (or matlab / mathematica for simple problems) 9. Able to develop user elements and user materials for ANSYS (or implement elements/materials in open source codes			
Course References:	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. 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.			

Course topics (Theory)	**Week**	**Learning Outcome**
Introduction, Mathematical Foundations	1	
Governing Equations in Solid Mechanics	2	
Elastic Constitutive Laws	3	
Finite Element Analysis of Solids and Structures	4	
Governing Equations in Porous Media	5	
Finite Element Analysis of Porous Media	6	
Methods of Nonlinear Analysis	7	
Theory of Rate-Independent Elasto-Plasticity	8	
Methods of Integrating Elasto-Plastic Constitutive Equations	9	

The von Mises Model and Its Integration	10	
The Drucker–Prager Model and Its Integration	11	
Computational Homogenisation for Non-Linear Heterogeneous Solids	12	
Two-Scale Asymptotic Homogenisation-Based Finite Element. Analysis of Composite Materials	13	
Multi-Scale Boundary Element Modelling of Material Degradation and Fracture	14	
Non-Uniform Transformation Field Analysis: A Reduced Model for Multiscale Non-Linear Problems in Solid Mechanics	15	

Questions Example Design:

Q): For the plane truss shown in the figure, node ***2*** settles an amount $\delta = 0.05$ *in*. Determine the forces and stresses in each element due to the settlement. Let $E = 30x10^6$ *psi* and $A = 2$ in^2 for each element.



Extra notes:

External Evaluator

Assist. Prof. Dr. Gailan Ismail Hassan