Course Specification of Finite Element Method in Structural Analysis

I. Course Identification and General Information:

1.	**Course Title:**	Finite Element Method in Structural Analysis				
2.	**Course Code & Number:**	CE581				
3.	**Credit hours:**	C.H				**Credit Hours**
		Lecture.	**Laboratory**	**Seminars.**		
		2	2	-		3
4.	**Study semester at which this course is offered:**	2nd semester				
5.	**Pre –requisite (if any):**	Advanced structural analysis				
6.	**Co –requisite (if any):**	Non				
7.	**Program (s) in which the course is offered:**	Master of Science in Structural Engineering Program				
8.	**Language of teaching the course:**	English + Arabic				
9.	**Course type**	Required				
10.	**Location of teaching the course:**	Class room				
11.	**Prepared By:**	Prof. Dr. Ahmed Hasan Alwathaf				
12.	**Date of Approval**					

II. Course Description:

The finite element method (FEM) is a design/research tool that is extensively used in industry and research institutions . It is an indispensable technique for engineers in all disciplines. This course deals with the finite element method and its applications to practical problems in structural engineering. The course covers the fundamentals and using of finite element method to solve problems related to structural analysis. The course emphasizes on the underlying theory, assumption, formulation and modeling issues as well as providing hands-on experience using commercial FEM program (SAP/ANSYS/ABAQUS) to model and analyze structural systems.

III. Course Intended learning outcomes (CILOs) of the course		**Referenced PILOs**
a1	Demonstrate in depth understanding of knowledge of numerical methods and mechanics of solids to the finite element method.	A1. Demonstrate in depth understanding of knowledge of applied mathematics and engineering science to the field of structural engineering.

a2	Explain the basic theory and formulation behind the finite element method.	A2. Recognize and Explain the contemporary engineering technologies and issues in the specialization field of structural engineering.
a3	Demonstrate understanding of finite element analysis of structures and software packages implementation.	
		A3. Explain in-depth the principles of sustainable design and development of structural engineering.
a4	Acquire advanced knowledge of finite element method as a powerful tool for analyzing complicated problems and research in the field of structural engineering .	A4. Acquire advanced knowledge of research principles and methods applicable to the field of work or academic in structural engineering and related fields.
b1	Apply effectively finite element technique in modelling of real structures and evaluate accurately structural response using a standard reliable software package.	B1. Assess, select and apply appropriate principles, methodologies, techniques, tools and packages in the analysis, specification, development and evaluation of structural engineering systems.
b2	Identify the application and characteristics of FE elements such as bars, beams, planes, plates and shells, 3D solids, and iso-parametric elements.	B2. Identify, formulate, analyze research and solve complex structural engineering problems.
b3	Use FEM to produce accurate prediction of displacements and stresses in linear and nonlinear elastic bodies of relevance to engineering practice using a standard software package.	B3. Apply acquired knowledge of analysis and design for complex structural engineering systems and implementation process.
c1	Develop proper simulation and discretization for engineering problems and critically assess a finite element analysis for accurate validation and prediction of structural response.	C1. Develop research to solve structural engineering problems.
		C2. Use advanced methodology and skills to solve structural engineering problems.
c2	Apply suitable boundary conditions, limitations, assumptions to a global equation for bars, trusses, beams, planes, plates and shells, 3D solids problems and solve them to find displacements, stress and strains induced using program package.	C3. Design structural system, component, or process to meet desired needs within realistic constraints.
d1	Write a professional engineering report and present their problem solving outcomes	D1. Prepare a complete thesis and term-

	using FEM.	courses works/ tasks, write their documents and defend on them.
		D2. Demonstrate ethical principles, awareness of professional and ethical responsibility as well as knowledge of the standards utilized in related fields.
d2	Conduct independently research that advances and extends knowledge in advanced analysis of structural systems using FEM.	D3. Conduct independently and communicate research that advances and extends knowledge and scholarship in related fields.
		D4. Own intellectual independence, with initiative and creativity in new situations and/or for further learning, plan and execute original research with full responsibility and accountability for personal outputs.

(A) Alignment Course Intended Learning Outcomes of Knowledge and Understanding to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
a1. Demonstrate in depth understanding of knowledge of numerical methods and mechanics of solids to the finite element method.	Lecture self-study presentation	Written exam Assignment Student presentation
a2. Explain the basic theory and formulation behind the finite element method.		
a3. Demonstrate understanding of finite element analysis of structures and software packages implementation.		
a4. Acquire advanced knowledge of finite element method as a powerful tool for analyzing complicated problems and research in the field of structural engineering .		

(B) Alignment Course Intended Learning Outcomes of Intellectual Skills to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
b1. Apply effectively finite element technique in modelling of real structures and evaluate accurately structural response using a standard reliable software package.	Lecture, self-study, presentation, Analysis and Problem Solving.	Written exam, Written assignment, Presentations/ Presenting, researches
b2. Identify the application and characteristics of FE elements such as bars, beams, planes, plates and shells, 3D solids, and iso-parametric elements.		

b3. Use FEM to produce a reliable prediction of displacements and stresses in linear and nonlinear elastic bodies of relevance to engineering practice using a standard software package.		

(C) Alignment Course Intended Learning Outcomes of Professional and Practical Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	**Teaching strategies**	**Assessment Strategies**
c1. Develop proper simulation and discretization for engineering problems and critically assess a finite element analysis for accurate validation and prediction of structural response.	Lecture, self-study, presentation, Analysis and Problem Solving.	Written exam Written assignment Presentations/ Presenting researches
c2. Apply suitable boundary conditions, limitations, assumptions to a global equation for bars, trusses, beams, planes, plates and shells, 3D solids problems and solve them to find displacements, stress and strains induced using program package.		

(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	**Teaching strategies**	**Assessment Strategies**
d1. Write a professional engineering report and present their problem solving outcomes using FEM.	Presentation, independent study, Presenting reports, Presenting researches	present the paper, presentation, written report.
d2. Conduct independently research that advances and extends knowledge in advanced analysis of structural systems using FEM.		

IV. Course Content:

A – Lecture Aspect:

Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	contact hours
1	An Introduction to FE Method	a1, a2, a3, a4, b1 b2, b3	• Physical Problems in Engineering • Computational Modelling using the FEM Simulation	1	2
2	Mechanics of Solids and Structures	a1, a2, a3, a4, b1 b2, b3, c1, c2	• Three-Dimensional Solids • Two-Dimensional Solids • Truss Members • Beams • Plates and shells	2	4

3	Fundamentals for FE Method	a1, a2, a3, a4, b1 b2, b3, c1, c2	• Strong and Weak Forms • Hamilton's Principle • FEM Procedure • Shape Functions • Gauss Integration • Static Analysis	2	4
4	Formulations of Finite Element	a1, a2, a3, a4, b1 b2, b3, c1, c2	• Bar Element • Flexural Element • Two-Dimensional Element • Plates and Shells Element • 3D Solid Element	2	4
	Midterm Exam			1(8)	3
5	Special Purpose Elements	a1, a2, a3, a4, b1 b2, b3, c1, c2	• Iso-parametric Finite Element • Crack Tip Elements • Methods for Infinite Domains • Finite Strip Elements • Strip Element Method (SEM)	2	4
6	Finite Element Modeling Techniques	a1, a2, a3, a4, b1 b2, b3, c1, c2, d2	• Geometry Modelling • Meshing • Mesh Compatibility • Use of Symmetry • Modelling of Offsets • Modelling of Supports • Modelling of Joints • Applications and Implementations	2	4
7	Non-Linear Finite Element Analysis	a1, a2, a3, a4, b1 b2, b3, c1, c2, d2	• Nonlinear material models • Failure criteria • Solution Procedure • Solution solvers • Iterative procedure	2	4
	Presentation of course-project 1	a1, a2, a3, a4, b1 b2, b3, c1, c2, d1, d2	Seminar in Structural Engineering Topics	1	3
	Final Exam			1	3
Number of Weeks /and Units Per Semester				**16**	**34**

B - Laboratory Aspect (Software Practice):

Order	Tasks/ Experiments	Number of Weeks	contact hours	Learning Outcomes
1	Software installation	1	2	a3, b1, b3, c2
2	Introduction to the software tools	2	4	a3, b1, b3, c2
3	Modelling and analyzing of Trusses	1	2	a1, a2, a3, a4, b1, b2, b3, c1, c2, d1
4	Modelling and analyzing of beams and frames	1	2	a1, a2, a3, a4, b1,

				b2, b3, c1, c2, d1
5	Modelling and analyzing of Two-Dimensional structures	2	4	a1, a2, a3, a4, b1, b2, b3, c1, c2, d1
	Midterm exam	1 (8)	2	
6	Modelling and analyzing of Plates and Shells	2	4	a1, a2, a3, a4, b1, b2, b3, c1, c2, d1
7	Modelling and analyzing of 3D Solid structures	2	4	a1, a2, a3, a4, b1, b2, b3, c1, c2, d1
8	Special modeling and analyses cases	2	4	a1, a2, a3, a4, b1, b2, b3, c1, c2, d1
	Presentation of course-project 2	1	3	a1, a2, a3, a4, b1, b2, b3, c1, c2, d1, d2
	Final Exam	1	3	
Number of Weeks /and Units Per Semester		**16**	**34**	

I. Schedule of Assessment Tasks for Students During the Semester:

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment	Aligned Course Learning Outcomes
1	Assignments	3,4,6,8,10,12	7.5	5%	a1, a2, a3, a4, b1, b2, b3, c1, c2, d1
2	Software practice assignment	4, 5, 7, 9, 11,13	7.5	5%	a1, a2, a3, a4, b1, b2, b3, c1, c2, d1
3	Midterm exam	8	15	10%	a1, a2, a3, a4, b1, b2, b3, c1, c2, d1
4	Practical Midterm exam	8	15	10%	a1, a2, a3, a4, b1, b2, b3, c1, c2, d1
5	Course project 1 (research)	15	15	10%	a1, a2, a3, a4, b1, b2, b3, c1, c2, d1, d2
6	Course project 2 (software modeling)	15	15	10%	a1, a2, a3, a4, b1, b2, b3, c1, c2, d1, d2
7	Final exam	16	60	40%	a1, a2, a3, a4, b1, b2, b3, c1, c2, 1
8	Software Practical Final exam	16	15	10%	a1, a2, a3, a4, b1, b2, b3, c1, c2, d1, d2
Total			**150%**	**100%**	

II. Assignments:

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark

1	Modelling and analyzing of Trusses	a1, a2, a3, a4, b1, b2, b3, c1, c2, d1	**4**	**1.5**
2	Modelling and analyzing of Two-Dimensional structures	a1, a2, a3, a4, b1, b2, b3, c1, c2, d1	**6**	**1.5**
3	Modelling and analyzing of Plates and Shells	a1, a2, a3, a4, b1, b2, b3, c1, c2, d1	**8**	**1.5**
4	Modelling and analyzing of 3D Solid structures	a1, a2, a3, a4, b1, b2, b3, c1, c2, d1	**10**	**1.5**
5	Special modeling and analyses cases	a1, a2, a3, a4, b1, b2, b3, c1, c2, d1	**12**	**1.5**
6				
Total				**7.5**

III. Learning Resources and Facilities:

- Written in the following order: (Author - Year of publication – Title – Edition – Place of publication – Publisher).

1- Required Textbook(s) (maximum two).

1. Logan, D. L. A First Course in The Finite Element Method. 5th, Cengage Learning, 2012.
2. G. R. Liu, S. S. Quek. The Finite Element Method: A Practical Course. Butterworth-Heinemann, 2003.

2- Essential References.

1. Zienkiewicz, O. C., Taylor, R. L., and Fox D.D. The Finite Element Method for Solid and Structural Mechanics, 7th edition, Butterworth- Heinemann, 2014.
2. Cook, R. D. Finite element modelling for stress analysis. John Wiley & Sons Inc.1995.

3- Electronic Materials and Web Sites *etc*.

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Educational and research Facilities and Equipment Required

Technology Resources
(AV, data show, Smart Board, software, etc.)

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Other Resources
(Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list)

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IV. Course Policies:

1.	**Class Attendance:** The students should have more than 75 % of attendance according to rules and regulations of the faculty.
2.	**Tardy:** The students should respect the timing of attending the lectures. They should attend within 10 minutes from starting of the lecture.
3.	**Exam Attendance/Punctuality:** The student should attend the exam on time. The punctuality should be implemented according to rules and regulations of the faculty for midterm exam and final exam.
4.	**Assignments & Projects**: The assignment is given to the students after each chapter, the student has to submit all the assignments for checking on time.
5.	**Cheating**: If any cheating occurred during the examination, the student is not allowed to continue and he/she has to face the examination committee for enquires.
6.	**Plagiarism**: The student will be terminated from the Faculty, if one student attends the exam on another behalf according to the policy, rules and regulations of the university.
7.	**Other policies**: • All the teaching materials should be kept out the examination hall. • the mobile phone is not allowed. • There should be a respect between the student and his teacher.

Reviewed By	

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