Sana'a University
Faculty of Engineering
Mechanical Engineering Department
Mechanical Engineering Program

68. Elective 3

Course Specification of Introduction to Finite Element Method

I. Course Identification and General information:

1.	Course Title:	Introduction to Finite Element Method (Elective).				
2.	Course Code & Number:	ME405				
3.	Credit hours:	C.H				TOTAL CR. HRS
		Th.	Seminar/Tu	Pr	Tr.	
		2	-	-	-	2
4.	Study level/ semester at which this course is offered:	Fifth Year-First Semester.				
5.	Pre –requisite (if any):	Mechanics of Materials - II (ME234) and CAD/CAM (ME233).				
6.	Co –requisite (if any):	None.				
7.	Program (s) in which the course is offered:	Mechanical Engineering Program.				
8.	Language of teaching the course:	English Language.				
9.	Location of teaching the course:	Mechanical Engineering Department.				
10.	Prepared By:	Asst. Prof. Dr. Abdulah Dhaiban.				
11.	Date of Approval					

II. Course Description:

This course is an introduction to the theoretical basis of finite element method and its application in solving engineering problems. Topics covered include: solid mechanics, fluid mechanics, heat transfer, and dynamic analysis. Students will learn how to judge the quality of the numerical solution and improve accuracy in an efficient manner by optimal selection of solution variables. Also, these topics are implemented in the use of a commercial finite element software package, such as ANSYS.

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III. Alignment course intended learning outcomes (CILOs) of the course		Referenced PILOs
a1	Recognize the basic concepts, mathematical formulation and numerical implementation of finite element analysis.	**A.4** Understand knowledge tools and analytical skills in solving problems relevant to Mechanical Engineering.
b1	Analyze more complex real-world problems in the mechanical engineering fields including mechanics of solids, heat transfer, and design of dynamical systems.	**B.2** Design the Mechanical systems or processes within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
b2	Create appropriate assumptions, select proper elements and develop FEA models that adequately and efficiently represent physical systems;	
c1	Use the commercial FEA code (ANSYS) to solve static, linear elastic, structural mechanics problems.	**C.1** Use the various techniques, skills, equipment and modern engineering tools and methods necessary for Mechanical Engineering practice.
c2	Develop appropriate models, analyze and interpret data and use engineering judgment to draw conclusions.	**C.2** Conduct experiments; analyze data and present results for various mechanical systems
d1	Judge the obtained numerical data and results.	**D.4** Perform searches of literature, use databases, as well as, evaluate information and evidence from various sources.
d2	Deliver a professional FEA report of work and give a well-organized presentation.	**D5.** Communicate effectively both orally and in writing technical reports.

(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- Recognize the basic concepts, mathematical formulation and numerical implementation of finite element analysis.	Active Lectures, Project	Written Exam, Homework, Presentations, Reports

(B) Alignment Course intended Learning Outcomes of intellectual Skills to Teaching Strategies and Assessment Strategies:		
Course intended Learning Outcomes	Teaching strategies	Assessment Strategies
b1- Analyze more complex real-world problems in the mechanical engineering fields including mechanics of solids, heat transfer, and design of dynamical systems.	Active Lectures, Project	Written Exam, Homework, Presentations, Reports
b2- Create appropriate assumptions, select proper elements and develop FEA models that adequately and efficiently represent physical systems;		

(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- Use the commercial FEA code (ANSYS) to solve static, linear elastic, structural mechanics problems.	Active Lectures, Project	Written Exam, Homework, Presentations, Reports
c2- Develop appropriate models analyze and interpret data, and use engineering judgment to draw conclusions.	Active Lectures, Project	Written Exam, Homework, Presentations, Reports

(D) Alignment Course intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:

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Course intended Learning Outcomes	Teaching strategies	Assessment Strategies
d1- Judge the obtained numerical data and results.	Problems Based Learning, Projects.	Presentations, Reports
d2- Deliver a professional FEA report of work and give a well-organized presentation.	Problems Based Learning, Projects.	Presentations, Reports

IV. Course Content:

A – Theoretical Aspect:

Order	Units/Topics List	Learning Outcomes	Sub topics List	Number of Weeks	Contact hours
1.	Introduction to FEA and Element Performance	a1, b1, b2, c1	▪ Introduction to Finite Element ▪ Modeling and Preliminary Decisions ▪ Elements Types and Their Properties ▪ Basic Concepts of Equilibrium & Compatibility ▪ General Factors Affecting Element Performance – Sources of Errors Convergence.	2	4
2.	FE Methods, Shape Functions, Stiffness Matrix and Transformation	a1,b1, b2, c1,c2	▪ Direct Stiffness Method, Energy Methods ▪ Shape Function: Linear and Quadratic Element ▪ Beam Elements, Truss Elements, Linear and Planar Elements ▪ Stiffness Matrix, Local to Global Co-Ordinate Transformation Assembly	3	6
3.	Static Structural Analysis	a1, b1,b2, c1,c2, d1	▪ Modeling and Analysis of 1D, 2D and 3D Structures Under Static Loading	2	4
4.	Mid-Term Exam	a1, b1,b2, c1,c2	▪ All previous Topics	1	2

5.	Heat Transfer and Thermal Stress Analysis:	a1, b1, b2, c1,c2, d1	▪ Introduction to Heat Transfer, Thermal and Thermal Stress Analysis Concepts ▪ Selection of Boundary Conditions Based on the Identification of Problem ▪ Thermal Analysis (Steady State) ▪ Thermal Stress Analysis	3	6
6.	Fluid Mechanics Analysis	a1, b1, b2, c1,c2, d1	▪ Finite Element Modeling of Incompressible Inviscid Fluid Flows.	2	4
7.	Dynamic Analysis	a1, b1, b2, c1,c2, d1,	▪ Introduction to Different Types of Dynamic Analysis ▪ Modal Analysis, Frequency Response Analysis, Transient Response Analysis, Master Degrees of Freedom	2	4
8.	Final Exam	a1, b1, b2, c2,d1,	▪ All Topics	1	2
Number of Weeks /and Units Per Semester				**16**	**32**

V. Teaching strategies of the course:

- Active Lectures.
- Projects.
- Problems Based Learning,

VI. Assignments:

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark
1	Homework	a1, b1, b2, c1,c2, d1	weekly	10
2	Presentations	b1, c1,c2, d2	weekly	5

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3	Project: Presentation and Reports	b1, b2, c1,c2, d1, d2	3rd , 7th , 11th and 14th weeks	10
	Total			**25**

VII. 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	weekly	25	25 %	a1, b1, b2, c1,c2, d1, d2
2	Mid Term Exam	8th week	15	15 %	a1, b1, b2, c1,c2, d1
3	Final Exam	16th week	60	60 %	a1, b1,b2,c2, d1
Total			**100**	**100 %**	

VIII. Learning Resources:

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

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

1. Chen X. & Liu Y., 2015, Finite Element Modeling and Simulation with ANSYS Workbench, - Taylor & Francis Group, LLC.
2. David V. Hutton, 2004, Fundamentals of Finite Element Analysis, Mc Graw Hill.

2- Essential References.

1. Saeed Moaveni, Finite Element Analysis – Theory and Applications with ANSYS, Fourth Edition, Prentice Hall.
2. M J Fagan, Finite Element Analysis – Theory and Practice, Pearson Publications.
3. Desai Y.M, Eldho T.I, Shah A.H (2011), "Finite Element Method with Applications in Engineering", Pearson Education India.
4. Rajshekaran S. ,2008, "Finite Element Analysis", Wheeler Publishing.

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	5. Cook, R.D, "Concepts and Application in Finite Element Analysis", 3rd Ed, The Wiley & Sons
3- Electronic Materials and Web Sites *etc.*	
	1. http://web.iitd.ac.in/~hegde/fem/notes.html 2. https://www.colorado.edu/engineering/CAS/courses.d/IFEM.d/ 3. www.nptel.ac.in/courses/112104116/ 4. www.iitg.ernet.in/engfac/rtiwari/resume/usdixit.pdf 5. https://open.umich.edu/find/open-educationalresources/engineering/introduction-finite-element-methods

I. Course Policies:

1	**Class Attendance:** - The student should be attending not less than 75% of total contact hours of the subject, otherwise he will not able to take exam and be considerd as an exam failure. If the student is absent due to illness, he/she should bring an approved statement from university Clinic.
2	**Tardy:** - For lateness in attending the class, the student will be initially notified. If he repeates late in attending class he will be considered absent.
3	**Exam Attendance/Punctuality:** - The student should attend the exam on time. He is permitted to attend the exam half one hour from exam beginning, after that he/she will not be permitted to take exam and he/she is considered absent in the exam.
4	**Assignments & Projects:** - In general one assignment is given after each chapter of a course. The student should submit the assignment on time, mostly one week after giving the assignment
5	**Cheating**: - For cheating in exam, the student is considered as failure. In case the cheating is repeated three times during study the student will be disengaged from the Faculty
6	**Plagiarism**: Plagiarism is the attending of the student the exam of a course instead of other student. If the examination committee proved a plagiarism of a student, he will be disengaged from the Faculty. The final disengagement of the student from the Faculty should be confirmed from the Student Affair Council of the university.
7	**Other policies:** - The mobile phone is not allowable to be used during class lecture. It must be switched off, otherwise the student will be ordered to leave the lecture room.

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	- The mobile phone is not allowed to be taken during the examination time. - Lecture notes and assignments may be given directly to students using soft or hard copy.

Reviewed By	**Vice Dean for Academic Affairs and Post Graduate Studies: Asst. Prof. Dr. Tarek A. Barakat** **President of Quality Assurance Unit: Assoc. Prof. Dr. Mohammed Algorafi** **Name of Reviewer from the Department: Assoc.Prof. Dr. Khalil Al-Hatab**
	Deputy Rector for Academic Affairs Asst. Prof. Dr. Ibrahim AlMutaa **Assoc. Prof. Dr. Ahmed Mujahed** **Asst. Prof. Dr. Munasar Alsubri**

68. Course Plan of Introduction to Finite Element Method

I. Information about Faculty Member Responsible for the Course:

Name of Faculty Member	Dr. Abdullah Dhaiban	**Office Hours**					
Location& Telephone No.	Mechatronics Engineering Department	**SAT**	**SUN**	**MON**	**TUE**	**WED**	**THU**
E-mail	a.dhaiban@eng-su.edu.ye adaiban2@gmail.com						

II. Course Identification and General information:

1.	Course Title:	Introduction to Finite Element Method (Elective).				
2.	Course Number & Code:	ME405				
3.	Credit hours:	C.H				TOTAL CR. HRS
		Th.	Seminar/Tu	Pr	Tr.	
		2	-	-	-	2
4.	Study level/year at which this course is offered:	Fifth Year-First Semester.				
5.	Pre –requisite (if any):	Mechanics of Materials (ME234) and CAD/CAM (ME233).				

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6.	Co –requisite (if any):	None.
7.	Program (s) in which the course is offered	Mechanical Engineering Program.
8.	Language of teaching the course:	English Language.
9.	System of Study:	Semesters.
10.	Mode of delivery:	Lectures**.**
11.	Location of teaching the course:	Mechanical Engineering Department.

III. Course Description:

This course is an introduction to the theoretical basis of finite element method and its application in solving engineering problems. Topics covered include: solid mechanics, fluid mechanics, heat transfer, and dynamic analysis. Students will learn how to judge the quality of the numerical solution and improve accuracy in an efficient manner by optimal selection of solution variables. Also, these topics are implemented in the use of a commercial finite element software package, such as ANSYS.

IV. Intended learning outcomes (ILOs) of the course:

- Brief summary of the knowledge or skill the course is intended to develop**:**

1. Recognize the basic concepts, mathematical formulation and numerical implementation of finite element analysis.
2. Analyze more complex real-world problems in the mechanical engineering fields including mechanics of solids, heat transfer, and design of dynamical systems.
3. Create appropriate assumptions, select proper elements and develop FEA models that adequately and efficiently represent physical systems;
4. Use the commercial FEA code (ANSYS) to solve static, linear elastic, structural mechanics problems.
5. Develop appropriate models, analyze and interpret data and use engineering judgment to draw conclusions.
6. Judge the obtained numerical data and results.
7. Deliver a professional FEA report of work and give a well-organized presentation.

V. Course Content:

- Distribution of Semester Weekly Plan of Course topics/Items and Activities.

A – Theoretical Aspect:

Order	Topics List	Sub topics List	Week Due	Contact Hours
1.	Introduction to FEA and Element Performance	- Introduction to Finite Element - Modeling and Preliminary Decisions - Elements Types and Their Properties - Basic Concepts of Equilibrium & Compatibility - General Factors Affecting Element Performance – Sources of Errors Convergence.	1st and 2nd weeks	4
2.	FE Methods, Shape Functions, Stiffness Matrix and Transformation	- Direct Stiffness Method, Energy Methods - Shape Function: Linear and Quadratic Element - Beam Elements, Truss Elements, Linear and Planar Elements - Stiffness Matrix, Local to Global Co-Ordinate Transformation Assembly	3rd, 4th and 5th weeks	6
3.	Static Structural Analysis	- Modeling and Analysis of 1D, 2D and 3D Structures Under Static Loading	6th and 7th weeks	4
4.	Mid-Term Exam	- All previous Topics	8th week	2

5.	Heat Transfer and Thermal Stress Analysis:	- Introduction to Heat Transfer, Thermal and Thermal Stress Analysis Concepts - Selection of Boundary Conditions Based on the Identification of Problem - Thermal Analysis (Steady State) - Thermal Stress Analysis	9th, 10th and 11th weeks	6
6.	Fluid Mechanics Analysis	- Finite Element Modeling of Incompressible Inviscid Fluid Flows.	12th and 13th weeks	4
7.	Dynamic Analysis	- Introduction to Different Types of Dynamic Analysis - Modal Analysis, Frequency Response Analysis, Transient Response Analysis, Master Degrees of Freedom	14th and 15th weeks	4
8.	Final Exam	- All Topics	16th week	2
Number of Weeks /and Units Per Semester			**16**	**32**

VI. Teaching strategies of the course:

- Active Lectures.
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VII. Assignments:

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3- Electronic Materials and Web Sites *etc.*
1. http://web.iitd.ac.in/~hegde/fem/notes.html 2. https://www.colorado.edu/engineering/CAS/courses.d/IFEM.d/ 3. www.nptel.ac.in/courses/112104116/ 4. www.iitg.ernet.in/engfac/rtiwari/resume/usdixit.pdf 5. https://open.umich.edu/find/open-educationalresources/engineering/introduction-finite-element-methods

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