Subject Guide –Finite Element Method

Shortened Name	FEM	**Semester**	1-2023
Class Time (weekly)	Thurs, 9-12	**Lecture hours**	3h x 15w
Subject Code	090125101	**Assignment and self-study**	5h x 15w
ECTS credits	6	**Preparation for exam**	30
KMUTNB Credits	3(3-0-6)	**Total working hours/semester**	150

1 Revision date of this document, reasons for revision

- 20.06.2022

2 Course description

Overview of numerical methods; Finite elements for 2D trusses, beams, 2D and 3D continua; Matrix methods (force and displacement method); Stiffness matrix for springs, rods, 2D trusses, bending of beams, 2D elastic continua; Mass matrices for dynamic analysis; Triangle element, higher order (quadratic and cubic) displacement functions; Quadrilateral elements; Isoparametric elements; Elements for 3D analysis (tetrahedron, cube). The course will include the use of non-commercial and/or commercial software.

3 Lecturer

- Assoc. Prof. Dr. Julaluk Carmai

4 Expected learning outcomes (in accordance with the MAE program ELOs)

Primary LOs (primary content of class, knowledge is explicitly evaluated (for example, by exams), larger share of overall grade)

- Knowledge and understanding methodology of simulation and design (SELO 1)
- Knowledge and understanding of scientific fundamentals relevant for the understanding of the finite element method (SELO 2)
- Skills of using commercial software for simulation in engineering applications (SELO 5)

Secondary LOs (not primary content of class, but implicitly taught and evaluated by application (for example, by project work or assignments), lower share of overall grade)

- Ability to define a technical task or problem, to analyze/structure it and formulate a strategy to solve it (GELO 1)
- Ability to write a technical report (GLO3)
- Ability to present a project in front of a professional audience (GELO 6)
- Ability to explore information from various resources (GLO8)

Note: These ELOs correspond to the Program ELOs (referenced in parentheses).

5 Assessment

Each student will be individually assessed based on the performance on written exams and seminar, with the overall grade resulting from the shares in the table below:

Evaluated items	**shares**
Homwork in content of lectures 2,5,6,8,9	6%
Quizes in content from lectures 2,3,4,7	7%
Midtern exam in content from lectures 5,7,8	35%
Final exam in content from lectures 1,11,13,14,15	35%
Computer assignments and Mini project	17%
Total	**100%**

- Both exams are closed-book and paper-based.

6 Teaching materials

- Power-point presentation of each lecture is given before class.

7 Books and references

- A First course in the Finite Element Method by Daryl L.Logan
- The finite element method Volume 1: The Basis (fifth edition) by O. C. Zienkiewicz and R. L. Taylor
- Fundamental of finite element analysis by David V. Hutton
- The finite element method in engineering by S. S. Rao
- Finite Element Method in Engineering lecture handouts by Julaluk Carmai.

8 Course schedule

Week	Date/Month	Activity, Topics	Evaluation %	Class Hours
1	10/08	Introduction to FEM course; Concept of finite element method and examples of FEM applications (Topic 1)		3
2	17/08	General procedures of finite element method. The direct stiffness method (Topic 2)		3
3	24/08	Element interpolation function (Topic 3); Derivation of bar element equations using direct approach (Topic 4)		3
4	31/08	Variational approach, Methods of Weight Residuals (Topic 4)		3
5	07/09	Plane truss problem (Topic 5)		3
6	14/09	Computer workshop session I		3
7	20/09	**D**erivation of beam element equations (Topic 6)		3
7	21/09	Quiz I (Topics2,3,4)	4%	1
8	28/09	Plane frame structural problem (Topic 6)		3
9	05/10	Midterm **** (Topics from lecture 5,6,7) ****	35%	3
10	12/10	2D elastic continua element formulation Plane stress and Plane strain problems (Topic7)		3
11	19/10	Axisymmetric elements Three-dimensional solid element (Topic 7)		3
12	26/10	Quiz II (Topics from lecture 7) Computer workshop session II	3%	1 2
13	08/11	Isoparametric formulation (Topic 8)		3
14	02/11	Heat transfer problem, (Topic 9) Dynamics Problem (Topic 10)		3
15	09/11	Practical considerations in finite element modeling (Topic 11)		3
16	23/11	Final Examination (Topics1,8,9,10,11)	35%	3
17	30/11	**Mini project Presentation**		2
		Sum	100%	45

9 Content details

Lecture no.	Topics	Lesson (L) Contents
1	Introduction to FEM	• Overview of finite element method • Concept of finite element method • FEM applications
2	General procedures of FEM and the direct stiffness approach	• Overall steps in development of FEM • The direct stiffness method • Development of spring elements
3	Element interpolation fuction	• Method of obtaining interpolation fuctions • Formulation of interpolation fuction for 1 D bar elements
4	Derivation of bar element equations.	• Derivation of bar element equations using direct approach • Derivation of bar element equiation using variational approach • Derivation of bar element equations using method of weight residule.
5	Plane truss problem	• Relation between local and global coordinates • Derivation of plane truss element equations global coordinate system. • Using finite element method to solve plane truss problem
6	Beam element equatons and plane frame problem	• Derivation of beam element equations in local and global coordinate systems • Using finite element method to solve plan frame problem.
7	2D and 3D continuum elelements	• Derivation of 2D element equations • Using finite element method to solve plane stress problem • Using finite element method to solve plane strain problem • Using finite element method to solve axisymetric problem • Derivation of 3D elelement equations • Using finite element method to solve 3D solid element problem
8	Isoparametric formulation	• Isoparametric formulation • Derivationof line (1D) isoparametric element • Derivationof plane (2D) isoparametric element
9	Heat transfer problem	• Derivation of 1D heat transfer element equations • Derivation of 2D heat transfer element equations • Using finite element method to sove heat transfer problem
10	Dynamics problem	• Derivationof bar element equations for 1D dynamic problem • Using finite element method to sove 1D dynamics problem
11	Practical considerations in finite element modeling	• Identification of spatial domains of the solutions • Selection of elements • Important things to consider in mesh design. • Definition of material and geometric properties • Selection of proper load support and constrains • Adaptive meshing • Verification and validation • Types of errors.

10 Details on Evaluation of Expected Learning Outcomes

		Midterm Exam	Final Exam	Quiz	Homework	Mini project Computer assignments	
		35%	**35%**	**7%**	**6%**	**17%**	
SELO1	Knowledge and understanding methodology of simulation and design	15.0%	13.0%		3%	4%	**35%**
SELO2	Knowledge and understanding of scientific fundamentals relevant for the understanding of finite element method in engineering	20.0%	10.0%	7%	3%		**40%**
SELO5	Skills of using commercial software for simulation in engineering					5.0%	**5%**
GELO1	Ability to define a technical task or problem, to analyze/structure it and formulate a strategy to solve it		12%			2%	**14%**
GLO03	Ability to write a technical report.					2%	**2%**
GLO06	Ability to present a project in front of a professional audience					2%	**2%**

GLO08	Ability to explore information from various resources				1%	1%	**2%**