FEM for Civil Engineers - BMEEOTMMS51

I. Subject Specification

1. Basic Data

1.1 Title

FEM for Civil Engineers

1.2 Code

BMEEOTMMS51

1.3 Type

Module with associated contact hours

1.4 Contact hours

Type	Hours/week / (days)
Lecture	2
Seminar	2

1.5 Evaluation

Exam

1.6 Credits

5

1.7 Coordinator

name	Dr. Ádány Sándor
academic rank	Associate professor
email	adany.sandor@emk.bme.hu

1.8 Department

Department of Structural Mechanics

1.9 Website

https://epito.bme.hu/BMEEOTMMS51
https://fiek2.mywire.org/course/view.php?id=1996

1.10 Language of instruction

hungarian and english

1.11 Curriculum requirements

Compulsory in the Structural Engineering (MSc) programme

1.12 Prerequisites

Recommended prerequisites:

- Structural Analysis II. (BMEEOTMAS42)

1.13 Effective date

1 September 2022

2. Objectives and learning outcomes

2.1 Objectives

The goal of the subject is to present the theoretical bases of the finite element method and its practical application to typical structural engineering problems. The classic approach to the finite element method will be followed in presenting the basic idea of the method, the element types, the applied interpolation functions, the various matrices and the basic steps of their construction, the resulting system of equation and the solution techniques of it. All these will be demonstrated and practiced through examples, showing how the various structure types (trusses, beams, frames, plates, shells, 3D solids) can be analysed. An introduction to nonlinearities from various sources will be given, with special focus on the effect and handling of geometric nonlinearity. Beside the static problems, the application of the finite element method to some heat transfer problems of the structural engineering practice will also be discussed.

2.2 Learning outcomes

Upon successful completion of this subject, the student:

A. Knowledge

1. knows the differential equations of basic engineering structures,
2. familiar with the vectors and matrices used in the FEM,
3. knows the calculation methods of the typical shape functions of 1-, 2- and 3-dimensional elements.
4. familiar with the specific characteristics of the finite element models of trusses, beams, plates, shells and solid elements,
5. familiar with the physical meaning of certain elements of the stiffness matrix,
6. familiar with the formulation of boundary value problem in a mechanical problem,
7. knows the variational formulation of mechanical problems,
8. understands the methodology on how the geometric nonlinearity is taken into account,
9. knows the meaning of the vectors and matrices occurring in stationary heat transfer problems,
10. knows the meaning of the vectors and matrices occurring in transient heat transfer problems,

B. Skills

1. produces the base function of an element according to the required continuity condition,
2. selects the required steps for the calculation of an arbitrary entry of he stiffness matrix of a finite element,
3. constructs the boundary conditions according to behaviour of the mechanical model,
4. during a numerical analysis chooses appropriate element with respect to the mechanical problem,
5. during a numerical analysis chooses the relevant parameters for the mechanical problem,
6. interprets the results of the finite element analysis of a heat transfer problem,

C. Attitudes

1. works together with the tutor/lecturer and the fellow students while learning,
2. endeavors to discover and routinely use the tools necessary to the problem solving of structural mechanical problems,
3. endeavors to the precise and error-free problem solving,
4. aspires to prepare a well-organized documentation in writings, and pursues the precise self-expression in oral communication,

D. Autonomy and Responsibility

1. independently carries out the conceptual and numerical analysis of structural engineering problems, based on the literature,
2. is open to accept well-founded critical comments.

2.3 Methods

Lectures, exercises, oral and written communication, application of IT tools and technologies, individual assignment.

2.4 Course outline

Week	**Topics of lectures and/or exercise classes**
1.	Displacement method, differential equation of basic mechanical problems
2.	Solution of a 2D-frame problem with matrix displacement method, stiffness matrix
3.	Generalization of the matrix displacement method, tools of the FEM
4.	1D elements, base functions, matrices of elements
5.	FEM formulation of 2D plane elements
6.	FEM formulation of a Kirchhoff-plate model
7.	FEM formulation of a Mindlin-plate model
8.	Application of shell elements in FEM
9.	FEM formulation of 3D elements
10.	Formulation of mechanical problems, strong and weak solutions
11.	Consideration of geometric nonlinearities, second order theories
12.	FEM formulation of stationer heat transfer problems
13.	FEM formulation of transient heat transfer problems
14.	Special questions of finite element techniques

The above programme is tentative and subject to changes due to calendar variations and other reasons specific to the actual semester. Consult the effective detailed course schedule of the course on the subject website.

2.5 Study materials

Books:

- Zienkiewicz, O.C. . Taylor, R. L.: The finite element method I-III,

- Bojtár - Gáspár: Végeselemmódszer építőmérnököknek

2.6 Other information

- Attendance at lectures is mandatory.
- Students attending tests/exams must not communicate with others without explicit permission during the test/exam, and must not have an electronic or non-electronic device capable of communication switched on.
- A signature obtained previously will remain valid at a re-registering for the subject, but the new results are to be considered nevertheless.

2.7 Consultation

The instructors are available for consultation during their office hours, as advertised on the department website. Special appointments can be requested via e-mail: adany.sandor@epito.bme.hu.

This Subject Datasheet is valid for:

2023/2024 semester I

II. Subject requirements

Assessment and evaluation of the learning outcomes

3.1 General rules

- Evaluation of learning outcomes described in Section 2.2. is based on two mid-term written checks, the completion of two compulsory homeworks, and an oral exam.
- The duration of each mid-term test is 90 minutes.
- Mid-term tests below 40% are regarded unsuccessful.
- Homworks below 40% are regarded unsuccessful.
- The dates of checks and the deadlines of homeworks can be found in the "Detailed semester schedule" on the website of the subject.

3.2 Assessment methods

Evaluation form	**Abbrev.**	**Assessed learning outcomes**
1st mid-term test (summarizing check)	ZH1	A.1-A.4; B.1-B.2
2nd mid-term test (summarizing check)	ZH2	A.1-A.10; B.3-B.4, B.6
1st homework (continuous partial check)	HF1	A.1-A.10; B.1-B.6; C.1-C.4; D.1-D.2
2nd homework (continuous partial check)	HF2	A.1-A.10; B.1-B.6; C.1-C.4; D.1-D.2
Oral exam (summarizing check)	V	A.1-A.10; B.1-B.6; C.2-C.4; D.1-D.2

The dates of deadlines of assignments/homework can be found in the detailed course schedule on the subject's website.

3.3 Evaluation system

Abbreviation	**Score**
ZH1	15%
ZH2	15%
HF1	10%
HF2	10%
V	50%
Sum	**100%**

3.4 Requirements and validity of signature

A student is to obtain signature and have eligibility for the exam if all of the followings requirements met: -participated in 70% of the lectures, -all mid-term tests are successful (after retakes if any), -the average of the tests reaches or exceeds 50%. -the second homework is submitted and accepted, -the weighted average of the mid-terms and homeworks reaches or exceeds 50%.

3.5 Grading system

In the case of complying with the requirements on attendance the semester result is computed by the weighted average A of the best two mid-term tests, the homeworks, and the oral exam as in section 3.3.:

Grade	**Points (A)**
excellent (5)	85%≤A
good (4)	75%≤A <85%
satisfactory (3)	65%≤A <75%
passed (2)	50%≤A <65%
failed (1)	A<50%

3.6 Retake and repeat

- The mid-term test with lower result can be retaken in a summarizing retake test.
- We use the better result from the original and the retake to calculate the A average.
- There is no second retake option.
- If the second homework was not submitted by deadline, it can be submitted after paying late fee until the deadline specified in the schedule.

3.7 Estimated workload

Activity	**Hours/semester**
contact lesson	28×2=56
preparation for lessons during the semester	28×1=28
preparation for the checks	6×2=12
preparation of homeworks	30
preparation for the oral exam	24
Sum	**150**

3.8 Effective date

1 September 2022

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2023/2024 semester I