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

- lectures: 2 hours/week
- seminars/exercise classes: 2 hours/week

1.5. Evaluation

examination

1.6. Credits

5

1.7. Coordinator

Dr. Sándor Ádány, associate professor (@: adany.sandor@epito.bme.hu)

1.8. Department

Department of Structural Mechanics (http://www.epito.bme.hu/me)

1.9. Website

http://www.epito.bme.hu/BMEEOTMMS51

1.10. Language of instruction

Hungarian and English

1.11. Curriculum requirements

- compulsory in the Structural engineering (MSc) programme

1.12. Prerequisites

- Recommended subjects
  - BMEEOTMAS42: Structural Analysis II.
- Exclusive subjects
  Finite Element Method I. (BMEEOTMMST0, BMEEOTMMST2)

1.13. Effective date

from 1 September 2017.

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 vactors and matrices used in the FEM,
3. knows the calculation mathods 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 gometric 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 accurring in transient heat transfer problems,

B. Skills

1. produces tha 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 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 ordr theories
12.	FEM formulation of stationar 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

1. Attendance at lectures is mandatory.
2. 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.

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.

SUBJECT REQUIREMENTS

3. 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.
- 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 (type)	abbrev.	assessed learning outcomes (2.2)
1st mid-term test (summarizing check)	**ZH1**	A 1-4, B 1-2
2nd mid-term test (summarizing check)	**ZH2**	A 1-10, B 3-4, B 6
1st homework (continuous partial check)	**HF1**	A 1-10, B 1-6, C 1-4, D 1-2
2nd homework (continuous partial check)	**HF2**	A 1-10, B 1-6, C 1-4, D 1-2
Oral exam (summarizing check)	**V**	A 1-10, B 1-6, C 2-4, D 1-2

Dates and deadlines of evaluations can be found in the „Detailed course schedule” on the subject’s website.

3.3. Evaluation system

Evaluation	score
ZH1 (1st mid-term test)	15%
ZH2 (2nd mid-term test)	15%
HF1 (1st homework)	10%
HF2 (2nd homework)	10%
sum in the midterm	50%
oral exam	50%
Sum	100%

3.4. Requirement and validity of signature

- Signature and eligibility for the exam is granted if
  - the student participates in 70% of the lecturess,
  - each test and homework is succesfull (has at least 40%),
  - average of the mid-term test results is at least 50%,
  - average of the homework results is at least 50%, .
- A signature obtained previously will remain valid at a re-registering for the subject, but the new results are to be considered nevertheless.

3.5. Grading system

- In the case of complying with the requirements on attendance the results are determined as follows.
- Mid-term tests below 40% are regarded unsuccessful, and two successful mid-term tests are required for the completion of the semester.
- No requirements are made on the successfulness of the laboratory tasks.
- Homeworks are to be submitted following at least one consultation at 95% completion level or higher by the deadline given by the detailed semester schedule.
- The semester result is computed by the weighted average A of the best two mid-term tests, the homeworks, and the laboratory tasks as in section 3.3.:

Average	grade
85%≤A	5 (Excellent)
72,5%≤A<85%	4 (Good)
65%≤A<72,5%	3 (Satisfactory)
50%≤A<65%	2 (Passed)
A<50%	1 (Failed)

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.

3.7. Estimated workload

activity	hours/semester
contact lesson	**28x2=56**
preparation for lessons during the semester	**28x1=28**
preparation for the checks	**3x4=12**
preparation of homeworks	**30**
preparation for the oral exam	**24**
in total	**150**

3.8. Effective date

from 1 September 2017.