BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS

FACULTY OF MECHANICAL ENGINEERING

SUBJECT DATASHEET

I. SUBJECT DESCRIPTION

1. GENERAL DATA

1.1. Subject name (in Hungarian, in English)

Fundamentals of finite element method ● Fundametals of the finite element method

1.2. Neptun code

BMEGEMMBXVE

1.3. Type

study unit with contact hours

1.4. Course types and number of hours (weekly / semester)

course type	number of hours (weekly)	nature (connected / stand-alone)
lecture (theory)	2	-
exercise	-	-
laboratory exercise	1	coupled

1.5. Type of assessments (quality evaluation)

mid-term grade

1.6. ECTS

3

1.7. Subject coordinator

name:	Dr. Kossa Attila
post:	associate professor
contact:	kossa@mm.bme.hu

1.8. Host organization

Department of Applied Mechanics (http://www.mm.bme.hu)

1.9. Course homepage

http://www.mm.bme.hu/targyak/?BMEGEMMBXVE

1.10. Course language

hungarian, english

1.11. Primary curriculum type

mandatory

1.12. Direct prerequisites

Strong prerequisite: BMEGEMMBXN2, BMETE9_BG03
Weak prerequisite: -
Parallel prerequisite: -
Milestone prerequisite: -
Excluding condition: BMEGEMMAGMV, BMEGEMMAGM5
(the subject cannot be taken if you have previously completed any of the following subjects or groups of subjects)

2. AIMS AND ACHIEVEMENTS

2.1. Aim

The main objective of the course is to introduce students to the fundamentals of the finite element method, primarily through the solution of elasticity problems. The course aims to cover the following main topics: calculation of deformations of bar structures using matrix formalism; basic equations of elasticity; the principle of minimum total potential energy; finite element discretization; definition of shape functions; fundamental finite element equations; solution strategies for finite element problems; introduction to two-dimensional truss and beam elements under axial and bending loads; finite element analysis of two-dimensional truss and beam structures; introduction to two-dimensional quadrilateral elements; calculation of the stiffness matrix for two-dimensional quadrilateral elements; solving two-dimensional problems with the finite element method; introduction to Gaussian quadrature; analytical and finite element analysis of the longitudinal vibration of bars; finite element calculation of the bending vibration of beams; introduction to consistent and lumped mass matrices; estimation of natural frequencies.

2.2. Learning outcomes

Competences that can be acquired by completing the course:

A. Knowledge

- Understands the essence of the finite element method and its limitations, as well as the principle of minimum total potential energy and the principle of virtual work;
- Knows the fundamental equations of linear elasticity and the structure of the finite element method;
- Knows the concept of shape functions and the meaning and significance of discretization;
- Understands the solution methods of finite element equations and the finite element formulation of bar and beam elements;
- Understands the finite element formulation of two-dimensional four-node elements;
- Understands the concept of quadratic elements and Gaussian quadrature;
- Has an overview of the possibilities and limitations of solving vibration problems using the finite element method;
- Is familiar with the concept and significance of the consistent mass matrix;
- Is aware of the basic solution approaches for nonlinear finite element equations;
- Possesses basic user-level knowledge of at least one commercial finite element software.

B. Ability

- Is able to determine the displacements of plane-loaded truss structures under tension/compression and the stresses in the bars using the finite element method, even by hand calculation;
- Is able to determine the displacements/rotations of plane-loaded beam structures under tension/compression and bending, as well as the stresses in the beams using the finite element method, even by hand calculation;
- Is able to describe the displacement functions within the elements from the nodal displacements and rotations using shape functions;
- Prepares and builds finite element models for elasticity problems using plane elements;

- Determines the natural frequencies of bars under longitudinal vibration using analytical methods;
- Provides finite element estimates for the natural frequencies of bars under longitudinal vibration and calculates the mode shapes;
- Provides finite element estimates for the natural frequencies of beams under bending vibration and calculates the mode shapes;
- Applies Gaussian quadrature, even for triple integrals;
- Interprets the results obtained from finite element computations;
- Solves nonlinear equations using the Newton–Raphson method.

C. Attitude

- Strives to perform studies at the highest possible level, aiming to acquire in-depth knowledge capable of independent creation by maximizing personal capabilities;
- Cooperates with instructors and fellow students in expanding knowledge, while striving for independent work;
- Continuously broadens knowledge through independent learning, supplementing the material presented during classes;
- Is open to using information technology and computer tools (such as word processing software, mathematical software, image editing software, etc.);
- Is open to learning about and routinely using the toolsets necessary for solving tasks;
- Aims for accurate, error-free, and precise task solutions;

D. Independence and responsibility

- Feels responsible for setting an example to peers through the quality of work and adherence to ethical standards;
- Feels responsible for the proper application of the knowledge acquired during the course, considering its limitations;
- Is open to accepting well-founded critical feedback;
- Accepts the frameworks of cooperation and is capable of performing work independently or as part of a team, depending on the situation;
- Verifies the reliability of results obtained with the help of information technology tools.

2.3. Teaching methodology

The subject consists of two hours of theoretical classes and one hour of laboratory sessions per week. The understanding of the theoretical content presented during the lectures is aided by the demonstration of sample problems in the laboratory. The derivation of the most important theoretical topics takes place on the board during the lectures to facilitate collaborative work and enhance students' comprehension of the subject matter. Additionally, using a projector, we present supplementary materials. Animated visuals and sample problems projected during the theoretical classes further support the students' learning process. The materials used in both lectures and labs will be available for download to the students. Regular consultations will be provided throughout the semester.

2.4. Support materials

a) Textbooks

Editor: Ádám Kovács: Finite element method. ISBN 9789632795393. 2011.

b) Lecture notes

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c) Online materials

Electronic notes and example collection: a constantly updating set of notes available in the Teams group dedicated to the subject. Visit https://www.mm.bme.hu/ for more information.

2.5. Validity of the course description

Start of validity:	2025. July 15.
End of validity:	2030. July 15.

II. SUBJECT REQUIREMENT

3. ACHIEVEMENT CONTROL AND EVALUATION

3.1 General rules

During the semester, students are required to complete one compulsory midterm test and two compulsory homework assignments. The midterm test primarily serves to assess theoretical knowledge, while the homework assignments mainly evaluate practical skills, but also require an understanding of the theoretical background. The midterm test can be retaken, improved, or repeated only once during the designated retake period. Homework assignments can be submitted late up to the specified deadline. The final grade for the course will be determined based on the combined evaluation of the midterm test and the homework assignments. Meeting the minimum requirements in both the midterm test and the homework assignments is necessary to pass the course. By completing optional extra assignments, students can earn additional points, which will be considered when evaluating the overall semester performance.

3.2 Assessment methods

A. Detailed description of mid-term assessments

1. Mid-term assessment

type:	summative assessment
count:	1
purpose, description:	The purpose of the midterm test is to assess the theoretical knowledge acquired during the course and to check the students' ability to understand and apply concepts and relationships. The test may consist of multiple-choice questions, short theoretical essay questions, and small numerical calculation tasks. The questions are designed to provide a comprehensive overview of the student's theoretical preparation and their ability to apply it in practice. The calculation tasks included in the test typically require simpler computations that can be performed by hand.

2. Mid-term assessment

type:	formative assessment, simple
count:	2
purpose, description:	The purpose of the homework assignments is to develop the ability to apply the practical knowledge acquired during the course and to deepen the understanding of the fundamentals of the finite element method. Solving the assignments requires the use of finite element software, writing small custom program codes, and performing numerical calculations. The solutions must be presented in detailed documentation, which should not only report the results but also clearly explain the methods, steps, and conclusions applied. Preparing the documentation contributes to the development of students' documentation skills and technical communication competencies.

B. Detailed description of assessments performed during the examination period (if relevant)

Elements of the exam:

1. written partial exam
   -
2. oral partial exam
   -
3. practical partial exam

-

4. inclusion of mid-term results

-

3.3 The weight of mid-term assessments in signing or in final grading

identifier	weight
1 . Mid-term assessment	50 %
2 . Mid-term assessment	50 %

3.4 The weight of partial exams in grade (if relevant)

type	weight
written partial exam	0 %
oral partial exam	0 %
practical partial exam	0 %
inclusion of mid-term results	0 %

3.5 Determination of the grade

grade • [ECTS]	the grade expressed in percents
very good(5) • Excellent [A]	above 90%
very good(5) • Very Good [B]	85% .. 90%
good(4) • Good [C]	70% .. 85%
satisfactory(3) • Satisfactory [D]	55% .. 70%
sufficient(2) • Pass [E]	40% .. 55%
insufficient(1) • Fail [F]	below 40%

The lower limit specified for each grade already belongs to that grade.

3.6 Attendance and participation requirements

Must be present at at least **70%** (rounded down) of lectures.

At least **70% of** laboratory practices (rounded down) must be actively attended.

3.7 Special rules for improving, retaken and replacement

The special rules for improving, retaken and replacement shall be interpreted and applied in conjunction with the general rules of the CoS (TVSZ).

Need mid-term assessment to individually complete?

yes

Can the submitted and accepted partial performance assessments be resubmitted until the end of the replacement period in order to achieve better results?

NO

The way of retaking or improving a summary assessment for the first time:

each summative assessment can be retaken or improved

Is the retaking-improving of a summary assessment allowed, and if so, than which form:

retake or grade-improving exam not possible

Taking into account the previous result in case of improvement, retaken-improvement:

new result overrides previous result

The way of retaking or improving a partial assessment for the first time:

partial assesment(s) in this group cannot be improved or repeated, the final result is assessed in accordance with Code of Studied 122. § (6)

Completion of unfinished laboratory exercises:

missed laboratory practices may be performed in the repeat period, non-mandatory

Repetition of laboratory exercises that performed incorrectly (eg.: mistake in documentation):

incorrectly performed laboratory practice (e.g. Incomplete/incorrect report) can be corrected upon improved re-submission

3.8 Study work required to complete the course

Activity	**hours / semester**
participation in contact classes	42
preparation for laboratory practices	14
preparation for summary assessments	16
elaboration of a partial assessment task	8
additional time required to complete the subject	10
summary	**90**

3.9. Validity of subject requirements

Start of validity: 2025. July 15.

End of validity: 2030. July 15.

4. ADDITIONAL INFORMATION

4.1 Primary course

The primary (main) course of the subject in which it is advertised and to which the competencies are related:

Mechanical engineering

4.2 Link to the purpose and (special) compensations of the Regulation KKK

This course aims to improve the following competencies defined in the Regulation KKK>

a) knowledge

- Student is familiar with the general and specific mathematical, scientific and social principles, rules, contexts and procedures needed to operate in the field of engineering.

b) ability

- Student has the ability to apply the general and specific mathematical, scientific and social principles, rules, relationships and procedures acquired in solving problems in the field of engineering.

c) attitude

- Student is open and receptive to learning, embracing and authentically communicating professional, technological development and innovation in engineering.

d) independence and responsibility

- Student has the ability to work independently on engineering tasks.

4.3 Prerequisites for completing the course

Knowledge type competencies (a set of prior knowledge, the existence of which is not obligatory, but greatly facilitates the successful completion of the subject)	-
Ability type competencies (a set of prior abilities and skills, the existence of which is not obligatory, but greatly contributes to the successful completion of the subject)	-