# Structural Analysis II. - BMEEOTMAS42

## I. Subject Specification

1. Basic Data

1.1 Title

Structural Analysis II.

1.2 Code

BMEEOTMAS42

1.3 Type

Module with associated contact hours

1.4 Contact hours

| Type | Hours/week / (days) |
|---|---|
| Lecture | 3 |
| Seminar | 1 |

1.5 Evaluation

Midterm grade

1.6 Credits

4

1.7 Coordinator

| | |
|---|---|
| name | Dr. Lógó János |
| academic rank | Professor |
| email | logo.janos@emk.bme.hu |

1.8 Department

Department of Structural Mechanics

1.9 Website

https://epito.bme.hu/BMEEOTMAS42
https://edu.epito.bme.hu/course/view.php?id=365

1.10 Language of instruction

hungarian and english

1.11 Curriculum requirements

Compulsory in the Civil Engineering (BSc) programme

1.12 Prerequisites

Weak prerequisites:

- Strength of Materials (BMEEOTMAS41)
- Mathematics A3 for Civil Engineers (BMETE90AX07)

Recommended prerequisites:

- Structural Analysis I. (BMEEOTMAT43)

1.13 Effective date

2 February 2022

**Structural Analysis II. - BMEEOTMAS42**

2. Objectives and learning outcomes

2.1 Objectives

The aim of the subject is to introduce the methods of formulating problems in mechanics. Major topics: Solution with approximative displacement functions, the Ritz method. Basics of the finite element mehod. Basics of the matrix displacement method and application for the calculation of structures. Equations of the Euler-Bernoulli beam model. Equations of the Timoshenko beam model. Models of bar structures: equations of models of trusses, grids, planar and spatial frames. Differential equations of the classical plate theory. Differential equations of the Mindlin plate theory. Analytic solution methods for the equations of plate problems, application of the finite element method. Differential equations of discs in planar stress state and in planar strain state. Analytic solutions for disc problems, application of the finite element method. Derivation of shell models, shell elements in the finite element method.

2.2 Learning outcomes

Upon successful completion of this subject, the student:

A. Knowledge

1. knows the fundamental equations of mechanics,
2. knows the solution of bar structures with the displacement method in matrix algebraic formulation,
3. knows the different beam theories and their mathematical formulations,
4. knows the assumptions required for the solution of grids and the meaning of the cross-distribution coefficient,
5. knows the different plate theories and their mathematical formulations,
6. knows the assumptions required for the solution of discs and the solution of the governing equation,
7. knows the method for the calculation of the approximative displacement function by the Ritz method,
8. knows the main steps of the finite element method,
9. knows the underlying principles of statics calculations in AxisVM and FEM-Design software packages.

B. Skills

1. is able to determine the internal forces of planar bar structures consisting of straight bars using the matrix displacement method,
2. is able to give approximate solution for torsion-free grids using the cross-distribution coefficients (Leonhardt's method),
3. is able to give analytic solution for discs with simple boundary conditions using Airy's stress functions,
4. is able to give approximate analytic solution for classical plates problems with simple boundary conditions using Navier's method,
5. is able to create various static models for real engineering structures,
6. is able to carry out statical computations for simple problems using AxisVM and FEM-Design software packages,
7. is able to express his/her thoughts in an organized way in oral and written communication.

C. Attitudes

1. co-operates with the teachers in improving his/her knowledge,
2. expands his/her knowledge by constant learning,
3. is open to the use of IT devices,
4. aims at accurate and flawless problem solving,

D. Autonomy and Responsibility

1. is able to individually think over structural mechanics problems and to solve them using the given resources,
2. is open to valid criticism,
3. applies a systematic approach in his/her reasoning.

2.3 Methods

Lectures with theoretical knowledge and computational examples, written and oral communication, use of IT devices and techniques, optional practice problems solved individually.

2.4 Course outline

| **Week** | **Topics of lectures and/or exercise classes** |
|---|---|
| 1. | Basic equations of mechanics. Beam theories (tension-compression bars, Euler-Bernoulli, Timoshenko). |
| 2. | Beam theories. Analytic solutions. |
| 3. | Solution of statically indeterminate planar frames using the matrix displacement method. |
| 4. | Calculation of grids. |
| 5. | Disc problems. Airy's stress function. Analytic solutions. |
| 6. | Calculation of grids. |
| 7. | Plate problems. The classical plate theory. Calculation of thin plates using Navier's method. |
| 8. | The Mindlin plate theory. Basics of shell elements. |
| 9. | The theorem of minimum potential energy and its applications. |
| 10. | The Ritz method. |
| 11. | Basics of the finite element method. Basic models. |
| 12. | Co-ordinate systems. |
| 13. | Finite element method. Modelling structures. Support models. |
| 14. | Issues of modelling. |

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

a) Books:

- Kurutzné Kovács Márta: Tartók statikája, 2003.,
- Bojtár Imre, Gáspár Zsolt: Végeselemmódszer építőmérnököknek, 2003.

c) Lecture notes:

- on the website of the subject https://edu.epito.bme.hu/course/view.php?id=365

b) Online materials:

- on the website of the subject https://edu.epito.bme.hu/course/view.php?id=365

2.6 Other information

- Students attending checks must not communicate with others during the check without explicit permission, and must not hold any electronic or other communication device 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: logo.janos@epito.bme.hu.

This Subject Datasheet is valid for:

Inactive courses

## 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 the solution and evaluation of two computer laboratory tasks.
- The duration of each mid-term test is 75 minutes, the duration of each laboratory tasks is 45 minutes.
- Compulsory homework must be submitted by the deadline specified in the "Detailed semester schedule" after at least one consultation, in a minimum of 95% completion level.
- The result of a homework assignment in the semester directly preceding the semester of study may be counted if it is worth at least 16 out of a maximum of 18 points.
- The dates of checks and the deadlines of homeworks can be found in the "Detailed semester schedule" on the website of the subject.
- Students failing to prove to have attended at least 70% of the lectures and 70% of the exercise classes based on their records of absences cannot obtain registry other than "Failed" or "Nem teljesítette".

3.2 Assessment methods

| **Evaluation form** | **Abbreviation** | **Assessed learning outcomes** |
|---|---|---|
| 1st mid-term test (summarizing check) | ZH1 | A.1-A.3; B.1-B.2 |
| 2nd mid-term test (summarizing check) | ZH2 | A.4-A.8; B.2-B.3 |
| 1st homework (continuous partial check) | HF1 | A.9; B.4-B.7; C.1-C.4; D.1-D.3 |
| 2nd homework (continuous partial check) | HF2 | A.9; B.4-B.7; C.1-C.4; D.1-D.3 |
| 1st laboratory task (summarizing check) | LAB1 | A.9; B.6-B.7 |
| 2nd laboratory task (summarizing check) | LAB2 | A.9; B.6-B.7 |

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 | 28% |
| ZH2 | 28% |
| HF1 | 7.5% |
| HF2 | 7.5% |
| lab1 | 14.5% |
| lab2 | 14.5% |
| **Sum** | **100%** |

3.4 Requirements and validity of signature

There is no signature from the subject.

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 as 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 a 95% completion level or higher by the deadline given by the detailed semester schedule. Uploading the assignment does not mean its acceptance yet, erroneous assignments worth zero points.
- Beyond the above requirements, the weighted average of the results must be above 50% for a passing grade.
- 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.:

| **Grade** | **Points (A)** |
|---|---|
| excellent (5) | 86%≤A |
| good (4) | 74%≤A<86% |
| satisfactory (3) | 62%≤A<74% |
| passed (2) | 50%≤A<62% |
| failed (1) | A<50% |

3.6 Retake and repeat

- Laboratory tasks cannot be retaken in this subject.
- Each mid-term test can be retaken once in this subject. The result of the retake overwrites the earlier result.
- Online retake of the mid-term tests must be validated through an oral report.
- Homeworks not submitted by the deadline can be submitted after paying a fee until the end of the next week after the deadline.
- There is no second retake in this subject.

3.7 Estimated workload

| **Activity** | **Hours/semester** |
|---|---|
| contact lesson | 14×3=42 |
| preparation for lessons during the semester | 14×2=28 |
| preparation for the checks | 2×12=24 |
| preparation of homeworks | 6 |
| study of the assigned written sources | 20 |
| **Sum** | **120** |

3.8 Effective date

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2 February 2022

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