# FEM in Structural Engineering

Politechnika Częstochowska
Wydział Budownictwa

Kierunek:

BUDOWNICTWO

Karta Opisu Przedmiotu

| Name of course | Code of course | Year / Semester | |
|---|---|---|---|
| **FEM in Structural Engineering**<br>***Metoda elementów skończonych w konstrukcjach inżynierskich*** | **WB-BUD-D2-MES-02** | **I** | **02** |

| Type of course | Profile | Level of qualification |
|---|---|---|
| **obligatory** | **generally academic** | **stationary second cycle programme – S2** |

| Rodzaj zajęć | | | | | | ECTS |
|---|---|---|---|---|---|---|
| Lecture | Exercises | Laboratory | Projects | Seminar | Exam | |
| **15** | **15** | **-** | **30** | **-** | **-** | **6** |

**Person leading of course::**

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## I.CARD OF COURSE

| | |
|---|---|
| **OBJECTIVE OF THE SUBJECT** | |
| **C01** | Understanding the course of proceedings in the construction of a numerical model in the finite element method |
| **C02** | Acquiring the skills of proper selection of a numerical model based on a physical model. |
| **C03** | Acquiring the ability to interpret the results of numerical simulations using the finite element method. |
| **PREREQUISITES FOR KNOWLEDGE, SKILLS AND OTHER COMPETENCE** | |
| **1** | The basic knowledge of the civil engineering. |
| **2** | The basic knowledge of the theoretical mechanics and the strength of materials and the skill to calculate the sections strength parameters. |
| **3** | The knowledge of the structural mechanics and the ability to solve the static equilibrium systems. |
| **4** | Ability to construct the building dividing walls. |
| **5** | Ability to use the standards of the construction loads. |
| **6** | The knowledge of the preparing principles of the technical drawings and the ability to read and apply them. |
| **LEARNING OUTCOMES:** | |
| **Knowledge:** the graduate knows and understands | |
| **EK1** | The graduate knows and understands the rules of conducting the analysis using MES. |
| **Skills:** the graduate can | |
| **EK2** | The graduate can explain the workflow using the finite element method, build a FEM model and optimize the MES model. |
| **Social competence:** The student is ready to | |
| **EK3** | The student is ready to work in a group and make his/her own decisions related with design metal structures. |

## II.CONTENTS OF COURSE

| Form of teaching - Lectures | | Number of hours |
|---|---|---|
| **W1** | Construction of the FEM program. An algorithm for the construction of the FEM model. | 1 |
| **W2** | Numerical model of a truss. One-dimensional elements (1D) of the "truss" type. | 1 |

| | | |
|---|---|---|
| **W3** | Numerical model of a truss. Concentrated loads | 1 |
| **W4** | Numerical model of a truss. Implementation of boundary conditions for a truss | 1 |
| **W5** | Numerical model of a truss. Analysis of results for a truss | 1 |
| **W6** | Numerical model of the beam. One-dimensional (1D) "beam" elements | 1 |
| **W7** | Numerical model of the beam. Types of beam loads | 1 |
| **W8** | Numerical model of the beam. Types of boundary conditions for beams | 1 |
| **W9** | Numerical model of the beam. Analysis of results for beams | 1 |
| **W10** | Discussion of the scope of the implemented own project | 1 |
| **W11** | Two-dimensional "shell" elements | 1 |
| **W12** | Analysis of results using elements of the "shell" type | 1 |
| **W13** | Three-dimensional elements (3D Solid). | 1 |
| **W14** | Analysis of results using 3D Solid elements. | 1 |
| **W15** | Final test. | 1 |
| | **TOTAL:** | **15** |

| **Form of teaching – Exercise** | | **Number of hours** |
|---|---|---|
| **Cw1** | Discussion of the procedure for modeling MES using an example | 1 |
| **Cw2** | An example of using truss elements for truss modeling | 1 |
| **Cw3** | Discussion of a truss load with concentrated forces on the example | 1 |
| **Cw4** | Discussion of defining complex boundary conditions for a truss example | 1 |
| **Cw5** | Discussion of the analysis of the calculation results for the truss on an example | 1 |
| **Cw6** | The use of beam-like elements for frame modeling. | 1 |
| **Cw7** | Loading of the frames with the examples | 1 |
| **Cw8** | Discussion of defining complex boundary conditions for frames on an example | 1 |
| **Cw9** | Discussion of the analysis of the calculation results for the frames on the example | 1 |
| **Cw10** | Discussing project tasks | 1 |
| **Cw11** | An example of using a two-dimensional "shell" element | 1 |
| **Cw12** | Analysis of the results of the FEM model with the use of "shell" type elements | 1 |
| **Cw13** | An example of using a three-dimensional element "3D Solid" | 1 |
| **Cw14** | Analysis of the results of the FEM model with the use of “3D Solid” elements | 1 |
| **Cw15** | Final assignment. | 1 |
| | **TOTAL:** | **15** |

| **Form of teaching – Project** | | **Number of hours** |
|---|---|---|
| **Pr1** | The assumptions of project. | 2 |
| **Pr2** | Creating geometry | 5 |
| **Pr3** | Loads | 1 |
| **Pr4** | Boundary conditions | 1 |
| **Pr5** | Building a FEM model | 5 |
| **Pr6** | Optimizing the FEM model | 5 |
| **Pr7** | Analysis of calculation results | 5 |
| **Pr8** | Creation of the project documentation | 6 |
| | **TOTAL:** | **30** |

| **TOOLS OF TEACHING** | |
|---|---|
| **1.** | The lecture carried out with the using of audio-visual means. |
| **2.** | The exercises carried out with the using of audio-visual means, PLATON platform, ADINA program |
| **3.** | The materials prepared by the teachers. |
| **4.** | Literature. |

**METHODS OF ASSESSMENT: (F - FORMATIVE; P - SUMMARY)**

| | |
|---|---|
| **F01** | The assessment of the individual preparation for the exercises. |
| **P01** | The assessment of the knowledge and skills to apply computational procedures according to ULS. |
| **P02** | The assessment of the knowledge and skills to apply computational procedures according to SLS. |
| **P03** | The assessment of the familiarize with the knowledge in the context of the calculation procedures. |

## III.WORKLOAD OF STUDENT

| O.n. | Activity | Average number of hours/ECTS to complete the activity [hours] |
|---|---|---|
| **1. Contact hours with the teacher:** | | |
| **1.1** | Hours of classes organized by the universities – **lecture** | 15 |
| **1.2** | Hours of classes organized by the universities – **exercise** | 15 |
| **1.3** | Hours of classes organized by the universities – **laboratory** | 0 |
| **1.4** | Hours of classes organized by the universities – **project** | 30 |
| **1.5** | Consultations | 15 |
| **1.6** | Exam | 0 |
| | **Total contact hours with the teacher:** | **75** |
| **2. Student's own work** | | |
| **2.1** | Preparing for the practices and for the final assignment | 20 |
| **2.2** | Preparation for the laboratory, execution of individual test reports | 0 |
| **2.3** | Preparing own project | 15 |
| **2.4** | Preparation for the final test from the lecture | 5 |
| **2.5** | Preparation for the exam | 0 |
| **2.6** | Get acquainted with the indicated literature | 5 |
| | **Total hours of student work:** | **45** |
| | **General workload of the student:** | **120** |
| **TOTAL NUMBER OF ECTS FOR SUBJECT:** | | |
| The number of **ECTS** which the student receives in a course requiring direct teacher involvement: | | **3.75** |
| The number of **ECTS** which the student receives in a practical course, including laboratory and project classes: | | **2.25** |

## IV.LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA


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|---|---|
| **Literatura podstawowa:** | |
| **1.** | Zienkiewicz O. C.: Metoda elementów skończonych, Arkady, Warszawa 1972. |
| **2.** | Klaus-Jürgen Bathe: Finite element procedures Prentice Hall, 1996. |
| **3.** | Rakowski G., Kacprzyk Z.: Metoda elementów skończonych w mechanice konstrukcji, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2005. |
| **4.** | Grzegorz Dzierżanowski, Marta Sitek: Samouczek Metody Elementów Skończonych dla studentów Budownictwa. Oficyna Wydawnicza Politechniki Warszawskiej Warszawa 2012. |
| **5.** | Szmelter J., Dacko M., Dobrociński S., Wieczorek M.: Metoda elementów skończonych w statyce konstrukcji, Arkady, Warszawa 1979 |
| **6.** | Sieczkowski J.M.: Podstawy komputerowego modelowania konstrukcji budowlanych, Oficyna wydawnicza Politechniki Wrocławskiej, Wrocław 2001 |
| **7.** | Starosolski W.: Wybrane zagadnienia z komputerowego modelowania konstrukcji inżynierskich, Wydawnictwo Politechniki Śląskiej, Gliwice 2001 |
| **Literatura uzupełniająca:** | |
| **1.** | Bogucki W., Żyburtowicz M.: Tablice do projektowania konstrukcji metalowych, Arkady, Warszawa 2008 |
| **2.** | PN-EN 1993-1-1:2006 Eurokod 3. Projektowanie konstrukcji stalowych. Część 1-1: Reguły ogólne i reguły dotyczące budynków. |
| **3.** | PN-EN 1993-1-5:2008 Eurokod 3. Projektowanie konstrukcji stalowych. Część 1-5: Blachownice. |

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| **4.** | PN-EN 1993-1-3:2008 Eurokod 3. Projektowanie konstrukcji stalowych. Część 1-3: Reguły ogólne - reguły uzupełniające dla konstrukcji z kształtowników i blach profilowanych na zimno. |

## V.MATRIX OF IMPLEMENTATION EFFECTS OF EDUCATION FOR DIRECTION

| The effect of learning | The reference to the effect of learning defined for the entire program | Reference of the effect to characteristics of I and II PRK | | Objectives of the course | Program content | Tools of teaching | Method for assessing |
|---|---|---|---|---|---|---|---|
| | | universal | In technical sciences and leading to engineering competencies | | | | |
| **EK1** | K1_W08<br>K1_W10 | P6U_W | P6S_WG | C01<br>C02<br>C03 | W1-W12<br>C1-C14 | 1, 2, 3, 4 | F01, P03 |
| **EK2** | K1_U05<br>K1_U16 | P6U_U | P6S_UW | C01<br>C02<br>C03 | W1-W14<br>C2-C14 | 1, 2, 3, 4 | F01, P01,<br>P03, P03 |
| **EK3** | K1_K01<br>K1_K02<br>K1_K03 | P6U_K | P6S_KK | C01<br>C02<br>C03 | W1<br>W14<br>C1-C14 | 1, 2, 3, 4 | P03 |

## VI.METHODS ASSESSMENT - DETAILS

| MARKS | LEARNING OUTCOME |
|---|---|
| | **EK1** |
| **2,0** | The graduate does not know and does not understand how to conduct the analysis using MES. |
| **3,0** | The graduate knows the basic concepts related to FEM modeling. He can solve a simple issue using FEM. |
| **4,0** | The graduate knows the concepts related to FEM modeling. He can solve a problem using FEM, and apply complex boundary conditions and loads. Moreover, the student is able to analyse the results of calculations during the design process. |
| **5,0** | The graduate knows and understands the method of conducting the analysis using FEM. He can solve a complex issue using FEM. Moreover, the student completed the information given in the standards of knowledge given in the books. |
| | **EK2** |
| **2,0** | The graduate can not explain the workflow using the finite element method |
| **3,0** | The graduate can draw up a flow chart for the FEM model. He can build a simple numerical FEM model |
| **4,0** | The graduate can draw up a flow chart for the FEM model. He can build a numerical FEM model and interpret the results of calculations accordingly.. |
| **5,0** | The graduate is able to draw up a scheme of procedure for modeling using the finite element method, build a numerical model of FEM, and interpret the results of calculations accordingly. He can optimize the numerical model of FEM |
| | **EK3** |
| **2,0** | The student performs the tasks assigned to him carelessly. |
| **3,0** | The student performs the tasks carefully, but he does not subject their results to discussion.<br>Moreover, the student notes the need to discuss the result, but he cannot formulate the problem properly. |
| **4,0** | The student formulates the problem correctly, but he cannot perform the discussions about the result.<br>The student can discuss the result using the appropriate criteria. |
| **5,0** | Moreover, the student is able to assess the impact of changes of particular criteria on the final result. |

**Half score 3.5 is given in the case of a full assessment of the learning outcomes for grade 3.0, but the student has not fully absorbed the learning outcomes for grade 4.0.**
**Half-score 4.5 is given in the case of a full assessment of the learning outcomes for grade 4.0, but the student has not fully absorbed the learning outcomes for grade 5.0**

## VII.OTHER USEFUL INFORMATIONS ABOUT THE COURSE

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|---|---|
| **1.** | Information where the student can see the presentations to classes, support materials and literature: |

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| | *According to the type of materials - in the classes didactic, in the room of teacher, in the library of the university and faculty.* |
| **2.** | Information on the place of event classes: |
| | *Showcased at the Faculty of Civil Engineering, Faculty of Civil Engineering website.* |
| **3.** | Information on the date of the course (day of week / time): |
| | *Showcased at the Faculty of Civil Engineering, Faculty of Civil Engineering website.* |
| **4.** | Information on the consultation (hours + location): |
| | *Schedule of consultation on the website of Faculty of Civil Engineering and on the door of the worker's room.* |