COURSE DESCRIPTION CARD - SYLLABUS

Course name
FEM systems [S1ETI2>SMES]

Course

Field of study
Education in Technology and Informatics

Year/Semester
3/6

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
15

Other
0

Tutorials
0

Projects/seminars
15

Number of credit points

3,00

Coordinators

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Lecturers

Prerequisites

Studend starting the course should has the knowledge in the field of mathimatics, mechanics of materials, mechanical engineering design, engineering graphics and material science. Should be able to solve simple tasks related to mechanics of materials, understand general rules of the machine design, be able to model physical phenomena as well as simple machine elements. Should be able to use efficiently the software for 3D modelling of solids. Should know how to find and how to use a proper catalogs and standards related to engineering materilas and machine parts.

Course objective

Presenting the principles of operation and capabilities of modern computer systems allowing to perform numerical calculations based on the finite element method. Learning the proper use of the finite element method in order to solve, correctly and effectively, complex engineering problems. Description of basic types of numerical analyses.

Course-related learning outcomes

Knowledge:
1. Has basic knowledge how the FE systems works and how to use them (knows numerical methods).

2. Has knowledge related to numerical modelling of structural elements and simple assemblies of these elements (knows the principles of engineering graphics and technical drawing, has knowledge of optimization procedures in the design of machine structures and their practical engineering applications).
3. Knows the rules of preparation of numerical models of structural elements by simplification of the actual objects (has knowledge of optimization procedures in the design of machine structures and their practical engineering applications).
4. Has knowledge to select the type of analysis and properties of the numerical model adequate for the given engineering problem (knows numerical methods, has basic knowledge of technical mechanics, strength of materials and general principles of engineering structures, as well as technologies for producing and processing engineering materials).

Skills:
1. Is able to carry out the strength analysis of machine elements under simple cases of load using numerical methods (is able to perform strength calculations of engineering structure elements, is able to select analytical or numerical tools to solve technical problems, is able to design and carry out numerical simulations of physical phenomena and technical processes using standard software).
2. Is able to prepare a correct and effective numerical model of the structural elements and machine parts (is able to perform strength calculations of engineering structure elements, is able to select analytical or numerical tools to solve technical problems).
3. Is able to interpret the results of numerical analyses and to draw the conclusions allowing to make a design decision (is able to evaluate the results of numerical analysis and use computer programs supporting the design process (e.g. CAD)).
4. Is able to prepare a correct and comprehensible report from numerical investigation and present it to occupational environment using modern IT techniques (is able to use software enabling graphical presentation and analysis of experimental results).

Social competences:
1. Understands the importance of computer systems and the latest technical achievements in the engineering work (understands the need for continuous education in order to improve professional and social competences and the need to think and act in an entrepreneurial and innovative way).
2. Understand the necessity of cooperation of experts in many different fields of engineering during the design process (is able to work on a given task independently and cooperate in a team, assuming various roles, demonstrates professionalism and responsibility for decisions made).
3. Is aware of the influence of the design engineer's work on shaping the public space and the environment (is aware of the importance of engineering activities and their non-technical aspects, including the impact on the environment, and understands the need to provide information related to technology and IT in a generally understandable manner).

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture - exam, about 60 min., covering the knowledge presented in lectures; the condition to get credit is positive grade from the exam (at least 60 % of points).
Laboratory - one colloquium at the end of the semester; reports prepared at the end of each classes.
Project- - reports ending each of the exercises, projects using the known types of numerical tests

Programme content

LECTURE
Introduction, description and classification of finite elements, preparation of FE model, mesh preparation
Description of basic types of analyses
Examples of analyses of a selected structural elements; modelling of selected machine elements
Contact problems
Presenting of the results of FEM analyses - preparation of a report
LABORATORY
The use of the finite element methods to solve practical engineering problems; learning the proper modelling of supports and loads as well as the choice of a proper finite element.
PROJECT

The use of the finite element methods to solve engineering problems project

Course topics

LECTURE
Introduction: description of methods used in structural analysis; idea of the finite element method (FEM); FEM in design process; applications of FEM
Description and classification of finite elements
Preparation of FE model: transition from an actual structure to a discrete model; analysis of support and load conditions; simplifying models; errors in FEM analysis
Mesh preparation: choice of the finite element; determining the mesh density - solution convergency analysis; mesh quality analysis; improving the mesh quality
Description of basic types of analyses: analysis of stress and displacements (linear and non-linear analysis, sources of nonlinearity); stability analysis (determining buckling loads and buckling shapes, post-buckling analysis - equilibrim path); modal analysis (determining natural frequencies and corresponding modes of vibrations); thermal analysis (heat flow)
Examples of analyses of a selected structural elements; modelling of selected machine elements
Contact problems: self-contact; bonded connections
Presenting of the results of FEM analyses - preparation of a report
LABORATORY
Topics covered during classes: determining stresses and displacements in a cantilever beam, a stub pipe and a thin-walled tank; stability analysis in welded lattice structure; determining stresses in the plate caused by temperature changes; optimization of stress distribution in the press punch.
PROJECT
Use of the finite element method to solve design problems such as: FEA convergence for a notched structure, beam strength based on geometric simplifications, pin connections, shelf column strength and stability, Lame's problem, loss of stability of a welded I-beam

Teaching methods

Lecture:
- lecture with multimedia presentation containing figures and pictures supported with examples presented on the blackboard; real time presentation of the possibilities of the FE system
- application of theoretical knowledge presented on the lecture to solve simple ingeneering problems
- during the lecture the discussion with students is initiated
Laboratory and Project:
- solving exemplary engineering problems with the use of computer using FE system
- the presented examples and and solutions are discussedt with the students

Bibliography

Basic:
1. Rakowski G., Kacprzyk Z. Metoda elementów skończonych w mechanice konstrukcji, Oficyna Wydawnicza Politechniki Warszawskiej, 2005.
2. Kurowski P.M. Finite element analysis for design engineers (2nd ed.), SAE International, Warrendale, Pa., 2017.
3. Steele J.M. Applied finite element modeling, Marcel Dekker, Inc. New York, 1989.

Additional:
1. Łodygowski T., Kąkol W., Metoda elementów skończonych w wybranych zagadnieniach mechaniki konstrukcji inżynierskich. WPP, Poznań, 1991.
2. Bathe K.J. Finite element procedures, Prentice-Hall, Inc., New Jersey, 1996.
3. Zienkiewicz O.C., Taylor R.L., Zhu J.Z. The finite element method: its basics and fundamentals, Elsevier Butterworth-Heinemann, New York, 2005.
4. Singiresu S., The finite element method in engineering , Elsevier Butterworth-Heinemann, New York, 2014.

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,00
Classes requiring direct contact with the teacher	47	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	28	1,00