POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Topology optimization in mechanical design [S2MiBM2-IWP>OTwP]

Course

Field of study
Mechanical Engineering

Year/Semester
1/2

Area of study (specialization)
Virtual Engineering Design

Profile of study
general academic

Level of study
second-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
0

Number of credit points

2,00

Coordinators

prof. dr hab. inż. Michał Nowak
michal.nowak@put.poznan.pl

Lecturers

Prerequisites

KNOWLEDGE: Knowledge of geometry modeling methods in CAD systems. Basic knowledge of the construction of computer systems. basic knowledge of structural analysis. SKILLS: Ability to use computer systems. Ability to use a basic CAD system. Ability to model geometry in the CAD system. Ability to use the finite element method in practice. SOCIAL COMPETENCES: Ability to work in a team. Understanding the need for learning and acquiring new knowledge.

Course objective

Transfer of knowledge about methods and processes related to advanced virtual design using topological optimization systems. Indication of the role of structural optimization in the design process. Practical familiarization of students with contemporary possibilities of optimizing cross-sectional dimensions, shape and the special role of topology optimization. Indication of factors stimulating the market need for the development of such design methods, which is the growing production potential of additive methods. With the mastery of the ability to produce additive products directly in metal, the demand for a design process that breaks with traditional technological limitations has increased dramatically. New quality in the design process is created by using topology optimization methods. To familiarize students with the available software for topology optimization.

Course-related learning outcomes

Knowledge:
1. The student has ordered, theoretically founded general knowledge covering structural optimization issues.
2. Student has basic knowledge about development trends in virtual design, especially in structural optimization procedures in CAD systems.

Skills:
1. The student should characterize the goal of topology optimization.
2. Student should characterize the limitations of topology optimization.
3. Student can practically apply topology optimization algorithms in the CAD environment.
4. Student is able to describe the available software in the field of topology optimization.
5. Student is able to describe how to use the topology optimization method in the design process.

Social competences:
1. The student is able to interact and work in a group.
2. The student is able to properly set priorities for the implementation of themselves and others set task.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Oral and written tests. Individual assessment of completed projects.
Verification test:
- the level of knowledge regarding elasticity theory,
- the level of knowledge concerning methods of structural analysis,
- level of knowledge regarding methods of structural optimization of structures,
- level of knowledge regarding industrial design methods and tools.
Questions with short answers (concerning the area of virtual design of structures) in the scope of the course material.
Verification test:
- ability to apply knowledge,
- practical skills of working with CAD/CAM systems .
Questions with short answers (concerning the area of virtual design of structures) in the scope of the course material.
Practical tasks.
Verification test:
- potential problem-solving skills.
Questions with short answers (concerning the area of virtual structural design) in the scope of the course material.
Grading criteria:
grade of very good (5.0) - the student's attendance in class and a very good pass on the final exam;
grade plus good (4.5) - student's attendance in class and good results of the final exam;
grade good (4.0) - student's attendance in class, satisfactory results of the final exam;
grade plus sufficient (3.5) - student's attendance in class and average level of passing the final exam;
grade sufficient (3.0) - student's attendance in class and low level of passing the final exam;
grade of insufficient (2.0) - the student's absence from 20% of classes or an insufficient level of passing the final exam.
Grades: very good - if the ratio of sums of achieved and total points is bigger than 90,1%; good plus - if the ratio of sums of achieved and total points is between 80,1-90%; good - if the ratio of sums of achieved and total points is between 70,1-80%; satisfactory plus - if the ratio of sums of achieved and total points is between 60,1-70%; satisfactory - if the ratio of sums of achieved and total points is between 50,1-60%; if the sum is smaller than 50% - unsatisfactory.

Programme content

Lecture topics:
1. The role of optimization in virtual design.
2. Introduction to the issue of structural optimization.
3. Topology optimization: the essence and theoretical foundations.

4. Limitations and problems in achieving a solution in the form of a continuous structure - checkerboard problem, problem of sensitivity to force values, problem of many load cases.
5. The issue of filtration.
6. Practical application of topology optimization methods.
7. Summary and review of software for topology optimization.
Practical classes (computer laboratory):
1. Parameterization of geometric models.
2. Finite element method and its specificity in the case of procedures
optimization.
3. Construction of the topology optimization task.
4. Problems related to the selection of the design domain.
5. Practical ways of solving problems resulting from the specifics of the algorithm during topology optimization.
6. Interpretation of topology optimization results.
7. Final test.

Course topics

none

Teaching methods

An interactive lecture using multimedia presentations.

Bibliography

Basic:
1. Bendsoe M.P., Sigmund O., Topology optimization, Theory, Methods and Applications, Springer-Verlag, Berlin Heidelberg, 2003
2. Bochenek B., Krużelecki J., Optymalizacja stateczności konstrukcji ? współczesne problemy, Wydawnictwo Politechniki Krakowskiej, Kraków, 2007
3. Brandt A. M., Kryteria i metody optymalizacji konstrukcji, P WN, Warszawa , 1977.
4. Brandt A. M., Podstawy optymalizacji elementów konstrukcji budowlanych, PWN, Warszawa 1977
5. Chlebus E., Techniki komputerowe CAx w inżynierii produkcji, WNT, 2000
6. Haftka, R., Gürdal, Z., Elements of structural optimization, 3rd edition, Kluwer, 1992
7. Kirsch U., Optimum Structural Design, McGraw-Hill, New York, 1981
8. Kleiber M. i inni, Mechanika techniczna, tom XI, Komputerowe metody mechaniki ciał stałych, Wydawnictwo Naukowe PWN, Warszawa, 1995
9. Kleiber M., Metoda elementów skończonych w nieliniowej mechanice, PW N, Warszawa, 1985
10. Kutyłowski R., Optymalizacja topologii kontinuum materialnego, Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław, 2004

Additional:
1. Dzieniszewski W., Zeszyt IPPT PAN, Optymalizacja wytrzymałościowa konstrukcji: Optymalizacja kształtów konstrukcji w założeniach teorii sprężystości, 114-137, Ossolineum, 1983
2. Krog L., Tucker A., Kemp M., Boyd R., Topology optimization of aircraft wing box ribs, AIAA-Paper 2004-4481, 2004
3. Nowak M., Gnarowski W. and Abratowski P., Structural Optimization of Helicopter AirLanding Rope Console with Multiple Loading Conditions, The 40th Solid Mechanics Confrence SolMech2016, 29.08-2.09 2016, Warsaw, 2016

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	2,00
Classes requiring direct contact with the teacher	30	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	20	1,00