COURSE DESCRIPTION CARD - SYLLABUS

Course name
Structural optimization

Course

Field of study
Biomedical Engineering

Year/Semester
3/6

Area of study (specialization)
-

Profile of study
generally academic

Level of study
First-cycle studies

Course offered in
Polish

Form of study
full-time

Requirements
elective

Number of hours

Lecture
15

Laboratory classes
30

Other (e.g. online)
0

Tutorials
0

Projects/seminars
0

Number of credit points

3

Lecturers

Responsible for the course/lecturer:
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Wydział Inżynierii Mechanicznej

ul. Piotrowo 3, 60-965 Poznań

Responsible for the course/lecturer:

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

Provide knowledge about the methods and processes related to advanced virtual design with the use of CAD design systems. Developing practical skills in creating a virtual project. Indication of the role of structural optimization in the design process. Practical familiarization of students with the modern possibilities of optimizing the dimensions of the cross-section, shape and topological optimization. Indication of factors stimulating the market need for the development of such design methods as the increasing production potential of additive methods. As the possibilities of additive manufacturing of products directly in metal were mastered, the demand for a design process that breaks with traditional technological limitations grew rapidly.

Identification of the similarity between the structural optimization in mechanical applications and the processes of functional adaptation of living structures on the example of the phenomenon of adaptive reconstruction of the trabecular bone.

To acquaint students with the available software for structural optimization. Overview of the proprietary Cosmoprojector software (cosmoprojector.eu) - optimization according to the biological pattern.

Course-related learning outcomes

Knowledge

1. Student has basic knowledge of engineering design and engineering graphics, allowing to design objects and processes, systems in terms of systems, machine elements; formulate and analyze problems; look for solution concepts; apply engineering calculations, select and evaluate solution variants; use modeling, optimization and knowledge bases in engineering design, computer-aided design process, technical drawing; read drawings and diagrams of machines, devices and technical systems; describe their structure and principles of operation. K_W05

2. The student has detailed knowledge covering key issues in the field of tissue functioning and growth, communication between cells, the influence of external fields, in particular mechanical interactions and their role in self-organization and optimization of bone structures. K_W14

3. The student has a basic knowledge of the development trends of computer aided engineering design, knows selected numerical methods of optimization, and the development trends of Cax systems. K_W20

Skills

1. The student is able to obtain information from literature, databases and other properly selected sources; in particular, can describe the issues of biochemistry and biophysics and combine them with technical issues and engineering design, can integrate the obtained information, interpret it, and find similarities of the developed methods in the field of engineering and the achievements of Nature. K_U01

2. The student is able to use information and communication techniques appropriate to the implementation of tasks typical for engineering activities. K_U07 3.

The student is able to carry out computer simulations, interpret the obtained results and draw conclusions. He can use computer aided to solve technical tasks, in particular in the area of structural optimization. K_U08

4. The student can solve technical problems based on the laws of mechanics; apply knowledge of electrical engineering and electronics to design and analyze electrical and electronic systems; perform strength analyzes of machine elements and mechanical systems and use numerical tools for the purposes of structural optimization, also with the use of biomimetic methods. K_U15

Social competences

1. The student can interact and work in a group, assuming different roles in it. K_K03

2. The student is able to set priorities for the implementation of a task defined by himself or others, especially in the area of the problem of structural optimization. K_K04

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.

Test for:

- level of knowledge,

- application of knowledge,

- potential problem-solving skills.

Programme content

Lecture topics:

1. The role of optimization in virtual design.

2. Introduction to the problem of structural optimization.

3. Optimization of cross-section sizes and parametric shape optimization.

4. Practical application of the methods of optimization of cross-section sizes and parametric shape optimization.

5. Topological optimization: essence and theoretical basis.

6. Practical application of topological optimization methods.

7. Summary and software review for structural optimization. Overview of the proprietary Cosmoprojector software (cosmoprojector.eu) - structural optimization according to a biological pattern.

Practical classes (computer lab):

1. Parameterization of geometric models.

2. Finite element method and its specificity in the case of procedures optimization.

3. Construction of the parametric optimization problem of the shape and cross-section dimensions.

4. Construction of the topological optimization task.

5. Interpretation of topological optimization results.

6. Similarities and differences in the process of functional tissue adaptation and structural optimization.

7. Final test.

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. Huiskes R et al (2000) Effects of mechanical forces on maintenance and adaptation of form in trabecular bone. Nature 404:704–706, 2000

7. Nowak M, Structural optimization system based on trabecular bone surface adaptation. J Struct Multidiscip Optim 32(3):241– 251, 2006

8. Kleiber M. i inni, Mechanika techniczna, tom XI, Komputerowe metody mechaniki ciał stałych, Wydawnictwo Naukowe PWN, Warszawa, 1995

9. Michał Nowak, Optymalizacja strukturalna według wzorca biologicznego, Politechnika Poznańska, Rozprawy nr 402, Wydawnictwo Politechniki Poznańskiej, ISBN 83-7143-259-3, Poznań, 2006

10. Kutyłowski R., Optymalizacja topologii kontinuum materialnego, Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław, 2004

Additional
1. Nowak M., Projektowanie konstrukcji o wysokiej sztywności z zastosowaniem optymalizacji strukturalnej, "https://sin.put.poznan.pl/organizations/details/wydawnictwo-politechniki-poznanskiej"Wydawnictwo Politechniki Poznańskiej , ISBN 978-83-7775-460-3, 2017.

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	75	3,0
Classes requiring direct contact with the teacher	45	2,0
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation) [1]	30	1,0

1

[?] delete or add other activities as appropriate