POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Biomimetics in mechanical design [S1IBio1E>BwP]

Course

Field of study
Biomedical Engineering

Year/Semester
3/6

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
English

Form of study
full-time

Requirements
elective

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

empty

Course-related learning outcomes

Knowledge:
1. The 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 the key issues of the functioning and growth of tissues, has ordered, theoretically founded general knowledge covering the issues of the functioning of living organisms and the use of biomimetic design methods. K_W14
3. The student has a basic knowledge of development trends in the issues of modeling and numerical simulation of processes occurring in living organisms. 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 following the achievements of Nature. K_U08
4. The student can solve technical problems based on the laws of mechanics; should understand the essence of biological evolution, be able to use numerical tools for modeling and designing according to the methods known from Nature. K_U15

Social competences:
1. 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 the tasks set by himself or others, especially in the area of modeling changes in living organisms. 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.
The condition for receiving a positive evaluation is obtaining at least 50% of the possible points. This applies to all forms of classes.

Programme content

Lecture topics:
1. Introduction to the use of biomimetics in mechanical engineering.
2. Optimization of cross-section sizes and parametric optimization of the shape as well as topological optimization based on the evolution of the density of artificial material, the essence, theoretical basis and specificity of use in design.
3. Structural optimization and the way of its implementation by living organisms.
4. The essence of the process of adaptive reconstruction of the trabecular bone - biological process and its characteristics from the point of view of mechanical engineering.
5. The process of adaptive reconstruction of the trabecular bone as a structural optimization - simultaneous optimization of shape and topology.
6. Optimization with the use of genetic algorithms.
7. Summary and discussion of the directions of development of biomimetic methods in mechanical design.
Practical classes:
1. Parameterization of geometric models.
2. Finite element method and its specificity in the case of procedures optimization.
3. The problem of structural optimization of the living world - software examples, genetic algorithms, adaptive reconstruction. 4
. Methods of obtaining information and a geometric description of the growth and remodeling of biological tissues - available software.
5. Practical application of biomimetic structural optimization algorithms, based on the phenomenon of

adaptive reconstruction of the trabecular bone - the Cosmoprojector system.
6. Similarities and differences in the practical implementation of the biomimetic algorithm of structural optimization and topological optimization based on the evolution of the density of artificial material.
7. Final test.

Course topics

none

Teaching methods

An interactive lecture using multimedia presentations.

Bibliography

Basic:
1. Iniewski, K., Introduction to bionics. In S. Carrara & K. Iniewski (Eds.), Handbook of Bioelectronics: Directly Interfacing Electronics and Biological Systems (pp. 277-280). Cambridge: Cambridge University Press. doi:10.1017/CBO9781139629539.027, 2015
2. Tkacz E., Borys P., Bionika, ISBN: 9788320434040, WNT, 2015
3. Samek A., Bionika w kształceniu, Wydawnictwa AGH, 2013
4. Gwiazda T.D., Algorytmy genetyczne. Kompendium, Wydawnictwo Naukowe PWN, ISBN-13, 978-83-01-15168-3, 2009
5. Huiskes R et al (2000) Effects of mechanical forces on maintenance and adaptation of form in trabecular bone. Nature 404:704-706, 2000
6. Klarbring A, Torstenfelt B, Lazy zone bone remodelling theory and its relation to topology optimization. Ann Solid Struct Mech 4(1):25-32, 2012
7. Nowak M, Structural optimization system based on trabecular bone surface adaptation. J Struct Multidiscip Optim 32(3):241- 251, 2006
8. Nowak M, On some properties of bone functional adaptation phenomenon useful in mechanical design. Acta Bioeng Biomech 12(2):49-54, 2010
9. Sigmund O, On the optimality of bone microstructure. Synthesis in Bio Solid Mechanics, Kluwer 221-234, 1999
10. Nowak M., Projektowanie konstrukcji o wysokiej sztywności z zastosowaniem optymalizacji strukturalnej, HYPERLINK "https://sin.put.poznan.pl/organizations/details/wydawnictwo-politechniki-poznanskiej"Wydawnictwo Politechniki Poznańskiej , ISBN 978-83-7775-460-3, 2017.

Additional:
-

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