POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name
FEM analysis in biomedical problems [S1IBio1E>AMES]

Course

Field of study
Biomedical Engineering

Year/Semester
2/4

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
english

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
30

Other (e.g. online)
0

Tutorials
0

Projects/seminars
0

Number of credit points

3,00

Coordinators

Lecturers

Prerequisites

Knowledge of mathematics, mechanics, fluid mechanics, strength of materials, heat transfer and differential equations, numerical methods. Skills of logical thinking, the use of information obtained from the library and the Internet. Social competencies of understanding the need for learning and acquiring new knowledge.

Course objective

The student should obtain knowledge of theoretical and computational fundamentals for solution of basic linear and non-linear partial differential equation problems modeling and governing technical, engineering and nature problems. Theoretical and practical knowledge of computing using finite element method/analysis to solve the basic problems of linear and nonlinear scientific and technical issues described by partial differential equations (stationary and non-stationary problems).

Course-related learning outcomes

Knowledge:
Has basic knowledge of development trends in computer-aided engineering design, finite element methods (FEM), the use of FEM in computer-aided design, the use of computer graphics in the process of creating technical documentation.
Has basic knowledge of engineering design and engineering graphics, enabling the design of 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; apply modeling, optimization and knowledge bases in engineering design, computer aided design process, technical devices and systems; describe their structure and operating principles.

Skills:
Is able to obtain information from literature, databases and other properly selected sources (also in English or other foreign language) in the field of biomedical engineering; is able to integrate obtained information, interpret and critically evaluate information, as well as draw conclusions and formulate and fully justify opinions.
He is able to plan and carry out experiments, has the ability to computer modeling and simulation in biomedical engineering.

Social competences:
Understands the need for lifelong learning; can inspire and organize the learning process of others.
Can interact and work in a group, taking on various roles.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture: Credit in writing on the basis of general questions or scores (credit in the case of obtaining 51% of points:> 50% - 3.0,> 60% - 3.5,> 70% - 4.0,> 80% - 4.5,> 90 % of points - 5.0) carried out at the end of the semester. In the case of remote work, it may be implemented in the form of a technical problem developed and solved (using FEM) described in the selected scientific publication.
Laboratory / project: Assessment on the basis of the project of the developed problem / issues in the field of content of issues performed in the laboratory exercises. The form and quality of prepared materials is assessed (description of issues, theory, method, results, analysis and literature). The prepared data will allow calculations and graphical representation of the calculations.

Programme content

Lecture: Mathematical foundations of the finite element method. The essence of FEM. Calculation stages: "preprocessing-solving-postprocessing"; model analysis, solution and analysis of results. Generalized concept of finite elements method. Boundary issues for partial differential equations. Types of boundary conditions. Solving basic initial-boundary problems. Fundamentals of heat exchange. Basic mechanisms of heat exchange. Thermo-mechanical properties of materials. Modeling and simulation of heat transfer issues. Constitutive relationships of solids for 3D and 2D models. Modeling and simulation of the problem of solid state mechanics. Modeling and simulation of natural vibration forms. Modeling and simulation of thermal deformation issues. Modeling and simulation of fluid mechanics issues.
Laboratory: Solving engineering problems in the content of the lecture in a computer program (Comsol Multiphysics or another in the case of remote work). Computer and mathematical models (equations with initial-boundary conditions) will be prepared for the contents of the lecture presented in the laboratory. The prepared data will allow calculations and graphical representation of the calculations.
Examples will relate to simple models used in biomedical engineering (e.g. simple foot prosthesis).

Teaching methods

Lecture: lecture / problem lecture / lecture with multimedia presentation.
The content of the lecture is presented in the form of a multimedia presentation in combination with a classic blackboard lecture enriched with shows related to the issues presented.
Computer laboratory: project method (research, implementation, practical project) / group work / task solving.

Bibliography

Basic:
O.C. Zienkiewicz , R.L. Taylor , The Finite Element Method, Volume 1-3, 5th edition, Butterworth-Heinemann, Oxford, 2000. (7th edition - 2013: https://www.elsevier.com/books/the-finite-element-method-its-basis-and-fundamentals/zienkiewicz/978-1-85617-633-0)
William B. J. Zimmerman, Multiphysics Modeling With Finite Element Methods, Series on Stability Vibration and Control of Systems, Series A - Vol. 18, 2006.
Andriy Milenin, Podstawy metody elementów skończonych. Zagadnienia termomechaniczne,

Wydawnictwo AGH, 2010.
Stefan Wiśniewski, Tomasz S. Wiśniewski, Wymiana ciepła (wyd 6), PWN, Warszawa, 2017.
Adrian Bejan, Allan D. Kraus, Heat Transfer Handbook, John Wiley & Sons, Inc., Hoboken, New Jersey, 2003.
Allan F. Bower, Applied Mechanics of Solids, http://solidmechanics.org/index.html
Introduction to Structural Mechanics: https://www.comsol.com/multiphysics/introduction-to-structural-mechanics
Ryszard Tadeusiewicz, Inżynieria biomedyczna - księga wspólczesnej wiedzy tajemnej w wersji przystępnej i przyjemnej, Wydawnictwo AGH, 2008.
Henryk Leda, Materiały inżynierskie w zastosowaniach biomedycznych, Wydawnictwo Politechniki Poznańskiej, Poznań, 2011.
Irving P. Herman, Physics of Human Body, Springer, Berlin, 2007.

Additional:
Taler J., Duda P.: Rozwiązywanie prostych i odwrotnych zagadnień przewodzenia ciepła, WNT, Warszawa 2003.
A.J.H. Frijns, G.M.J. van Leeuwen, A.A. van Steenhoven, Modelling Heat Transfer in Humans, Ercoftac Bulletin, nr 68(2006), str. 43 – 47.
Yu.I. Luchakov, A.D. Nozdrachev, Mechanism of Heat Transfer in Different Regions of Human Body, Biology Bulletin, nr 36(2009), str. 53 – 57.
V. Mitvalsky, Heat Transfer in the Laminar Flow of Human Blood through Tube and Annulus, Nature 206(1965).
Marek Paruch, Zastosowanie metod identyfikacji w wybranych zagadnieniach przepływu biociepła, Gliwice, 2005.

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,00
Classes requiring direct contact with the teacher	45	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	30	1,00