

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Numerično modeliranje fizikalnih pojavov v tehniki, biologiji in medicini
Course title:	Numerical Modelling of Physical Phenomena in Engineering, Biology and Medicine

Študijski programi in stopnja	Študijska smer	Letnik	Semestri
Elektrotehnika, druga stopnja, magistrski	Ni členitve (študijski program)	1. letnik	Zimski

Univerzitetna koda predmeta/University course code: 64252

Predavanja	Seminar	Vaje	Klinične vaje	Druge oblike študija	Samostojno delo	ECTS
30		45			75	6

Nosilec predmeta/Lecturer: Alenka Maček Lebar

Vrsta predmeta/Course type: Izbirni-splošni /elective general

Jeziki/Languages:	Predavanja/Lectures:	Slovenščina
	Vaje/Tutorial:	Slovenščina

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:

Vpis v letnik.
Pogoj za vključitev v študijski proces sta poznavanje višje matematike in osnov programiranja.

Prerequisites:

Enrolment in the year of the course.
The condition for inclusion in the study process is the knowledge of higher mathematics and the basics of programming.

Vsebina:

Predavanja:
Kratek pregled osnovnih postopkov modeliranja v tehniki in biologiji; določitev opazovanega sistema in njegove okolice, izbira ustreznih spremenljivk za opis sistema, časa opazovanja pojava ter matematični zapis le tega.
Numerične metode za reševanje sistemov linearnih algebrskih enačb in nelinearnih algebrskih enačb.
Optimizacijski postopki.
Numerične metode za reševanje navadnih diferencialnih enačb.
Formulacija parcialnih diferencialnih enačb z ustreznimi začetnimi in robnimi pogoji.
Numerično reševanje parcialnih diferencialnih enačb; osnove metode končnih diferenc in metode končnih elementov.
Osnove modeliranja s celičnimi avtomati.
Osnove metod tipa Monte Carlo.
Laboratorijske vaje:
Reševanje različnih primerov iz tehnike in biologije in medicine z uporabo programa Matlab in njegove zbirke orodij (Partial Differential Equation Toolbox) ter programa Comsol Multiphysics.

Content (Syllabus outline):

Lectures:
A brief overview of the basic procedures of modelling in engineering and biology; determination of the system and its surroundings, the selection and mathematical description of variables that describe the system and the observation time.
Numerical methods for solving systems of linear algebraic equations and nonlinear algebraic equations.
The optimization procedures.
Numerical methods for solving ordinary differential equations.
Formulation of partial differential equations with appropriate initial and boundary conditions.
Numerical solution of partial differential equations; basics of finite difference method and finite element method.
The basics of cellular automata and Monte Carlo methods.
Laboratory work:
Solving of various problems in biology and medicine using Matlab, its toolboxes (Partial Differential Equation Toolbox) and Comsol Multiphysics program.

Temeljna literatura in viri/Readings:

1. Dunn SM, Constantinides A, Moghe PV. Numerical methods in biomedical engineering, Elsevier 2006
2. Reddy J.N. Introduction to the Finite Element Method, McGraw-Hill 1993
3. Fagan MJ. Finite Element Analysis - Theory and Practice, Longman 1992
4. Kwon YW, Bang H. The finite element method using Matlab, CRC Press 2000
5. Comsol Multiphysics - User's Guidebook, Comsol AB., 2004
6. Schiff JL. Cellular Automata: A Discrete View of the World, Wiley-Interscience 2008

Cilji in kompetence:

V okviru predmeta bodo študenti pridobili znanja o modeliranju in uporabi numeričnih metod pri reševanju problemov iz tehnike, biologije in medicine. Seznanili se bodo z osnovnimi postopki zapisa modela opazovanega pojava na osnovi tipičnih a raznolikih primerov iz tehnike, medicine in biologije. Spoznali bodo osnove modeliranja s celičnimi avtomati, metodami tipa Monte Carlo ter osnovne optimizacijske postopke.

Večino snovi predmeta pokrivajo numerični postopki za reševanje parcialnih diferencialnih enačb. Študenti bodo osvojili teoretične osnove metode končnih diferenc in metode končnih elementov. Na osnovi reševanja sprva preprostih in nato zapletenejših problemov se bodo spoznali s prednostimi in omejitvami numeričnih metod. Pomemben del učnega procesa bo predstavljala analiza izračunanih vrednosti in njihova primerjava z eksperimentalno pridobljenimi vrednostmi, v primerih, kjer bodo rezultati ustreznih meritev na voljo. Raznolikost obravnavanih primerov bo študentom ponudila uporabno znanje na širšem področju tehnike in naravoslovja.

Objectives and competences:

During this course students will gain knowledge about the modeling and the use of numerical methods for solving problems in engineering, biology and medicine. They will learn the basic procedures of mathematical model construction on the basis of typical examples from technique, medicine and biology. They will learn the basics of cellular automata modeling, Monte Carlo methods and optimization procedures.

Mostly, the course deals with numerical methods for solving partial differential equations. Students learn the theoretical basis of the finite difference and finite element method. On the basis of solving simple problems at the beginning and more complex problems during the course the students familiarize with the advantages and limitations of numerical methods. An important part of the learning process is an analysis of the calculated values and their comparison with the experimentally obtained values in cases where the results of the corresponding measurements are available.

The diversity of cases offers students an useful knowledge in the wider field of engineering and science.

Predvideni študijski rezultati:

- Po uspešno opravljenem predmetu naj bi bili študenti zmožni:
- opisati koncepte modeliranja v tehniki, biologiji in medicini
 - izbrati ustrezen način numeričnega reševanja zapisanih matematičnih formulacij
 - navesti teorijo metode končnih elementov kot poglobitve metode za numerično reševanje parcialnih diferencialnih enačb
 - aplicirati numerične metode na preproste in kompleksnejše primere
 - razložiti prednosti in slabosti numeričnih metod.

Intended learning outcomes:

- After successful completion of the course, students should be able to:
- describe the concepts of modelling in technology, biology in medicine
 - choose the appropriate method for numerical solving of mathematical formulations
 - state the theory of finite element method as the main method for numerical solving of partial differential equations
 - use numerical methods for solving simple and more complex cases
 - explain the advantages and disadvantages of numerical methods.

Metode poučevanja in učenja:

Predavanja; skupno reševanje tipičnih nalog za razumevanje snovi v okviru laboratorijskih vaj; reševanje kompleksnejših nalog v okviru laboratorijskih vaj in samostojnega dela doma.

Learning and teaching methods:

Lectures; solving typical problems in the context of laboratory work; solving complex tasks in the context of laboratory work and independent work at home.

Načini ocenjevanja:

Pisni izpit, ustno izpit, domače naloge, laboratorijske vaje Ocena 5 je negativna ocena,

Delež/Weight**Assessment:**

Written exam, oral exam, laboratory exercises, homework Negative grade is 5, positive grades:

ocene od vključno 6 do 10 so pozitivne. Pozitivna ocena laboratorijskih vaj je pogoj za opravljanje izpita. Prispevki k oceni: laboratorijske vaje in domače naloge pisni izpit in/ali ustni izpit		from 6 to 10. Positive evaluation of laboratory exercises is a prerequisite for the exam. Contributions to the final grade: laboratory exercises written exam and/or oral exam
laboratorijske vaje in domače naloge	50,00 %	laboratory exercises
pisni izpit in/ali ustni izpit	50,00 %	written exam and/or oral exam

Reference nosilca/Lecturer's references:

1. Maček Lebar A, Damjanić F, Antolič V, Iglič A, Srakar F, Brajnik D. Nepravilnosti v cementnem plašču : analiza z metodo končnih elementov = Cement filling defects : a finite element analysis. Farmacevtski vestnik 47(3): 311-314, 1996. 2. Iglič A, Kralj-Iglič V, Daniel M..., Maček Lebar A. Computer determination of contact stress distribution and size of weight bearing area in the human hip joint. Computer methods in biomechanics and biomedical engineering 5(2): 185-192, 200 3. Šel D, Maček Lebar A, Miklavčič D. Feasibility of employing model-based optimization of pulse amplitude and electrode distance for effective tumor electropermeabilization. IEEE T. Biomed. Eng. 54: 773-781, 2007. 4. Jelenc J, Jelenc J, Miklavčič D, Maček Lebar A. Low-frequency sonoporation in vitro: experimental system evaluation. Stroj. Vestn. 58: 319-326, 2012. 5. Maček Lebar A, Velikonja A, Kramar P, Iglič A: Internal configuration and electric potential in planar negatively charged lipid head group region in contact with ionic solution, Bioelectrochemistry, 111: 49–56, 2016.
