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| **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 | | | | | | | | | | | | | |
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| **Študijski program in stopnja**  **Study programme and level** | | | | | **Študijska smer**  **Study field** | | | | | | | **Letnik**  **Academic year** | | **Semester**  **Semester** | | |
| Podiplomski magistrski študijski program druge stopnje Elektrotehnika | | | | | Vse smeri | | | | | | | 1 | | 1 | | |
| 2nd cycle masters study programme in Electrical Engineering | | | | | All study fields | | | | | | | 1 | | 1 | | |
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| **Vrsta predmeta / Course type** | | | | | | | | | | | Izbirni-splošni /elective general | | | | | |
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| **Univerzitetna koda predmeta / University course code:** | | | | | | | | | | | 64252 | | | | | |
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| **Predavanja**  **Lectures** | **Seminar**  **Seminar** | | | **Vaje**  **Tutorial** | | | **Klinične vaje**  **work** | | | **Druge oblike študija** | | | **Samost. delo**  **Individ. work** | |  | **ECTS** |
| **30** |  | | | **45** | | |  | | |  | | | **75** | |  | **6** |
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| **Nosilec predmeta / Lecturer:** | | | | | Alenka Maček Lebar | | | | | | | | | | | |
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| **Jeziki /**  **Languages:** | | **Predavanja / Lectures:** | | | | slovenski / slovenian | | | | | | | | | | |
| **Vaje / Tutorial:** | | | | slovenski / slovenian | | | | | | | | | | |
| **Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:** | | | | | | | |  | **Prerequisits:** | | | | | | | |
| Vpis v letnik.  Pogoj za vključitev v študijski proces sta poznavanje višje matematike in osnov programiranja. | | | | | | | |  | 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. | | | | | | | |

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| **Vsebina:** |  | **Content (Syllabus outline):** |
| 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 algebrajskih enačb in nelinearnih algebrajskih enačb.  Optimizacijski postopki.  Numerične metode za reševanje navadnih diferncialnih 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. |  | 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. |

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| **Temeljni 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:** | |  | | **Objectives and competences:** | |
| 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. | |  | | 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:** | | |  | **Intended learning outcomes:** | |
| Znanje in razumevanje:  Razumevanje konceptov modeliranja naravnih pojavov in osnov numeričnega reševanja matematičnih formulacij, ki pri tem nastanejo. Poznavanje teorije metode končnih diferenc in metode končnih elementov kot poglavitnih metod za numerično reševanje parcialnih diferencialnih enačb. Zmožnost uporabe teh metod na preprostih in kompleksnejših primerih; pravilna določitev robnih pogojev, izbira tipa in števila elementov, analiza rezultatov. Razumevanje prednosti in slabosti numeričnih metod. Dopolnitev poznavanja programskega paketa Matlab ter seznanitev s programskim orodjem Comsol Multiphysics.  Usposobljenost za samostojno zasnovo modela izbranega pojava, izbiro ustrezne metode reševanja in analizo rezultatov.  Reševanje problemov iz različnih področij tehnike, biologije in medicine omogoča široko uporabo pridobljenega znanja.  Poznavanje numeričnega reševanja sistemov  algebrajskih enačb, navadnih diferencialnih enačb in parcialnih diferencialnih enačb z različnih področij. Poznavanje ustreznih programskih orodij. | | |  | Knowledge and understanding:  Understanding the concepts of modelling and the basics of solving mathematical formulations by numerical methods. Knowledge of the theory of finite difference and finite element methods as the main methods for the numerical solution of partial differential equations. The ability to use these methods on simple and complex cases; correct determination of the boundary conditions, the choice of the type and number of elements, analysis of the results. Understanding the strengths and weaknesses of numerical methods. Supplementing the knowledge of Matlab and familiarization with the software Comsol Multiphysics. Ability to independently design the model of selected phenomenon, to select an appropriate method for solving the problem and to analyse the results.  Solving the problems from different areas of engineering, biology and medicine offers the students use of the knowledge at many scientific fields. Knowledge of the methods for numerical solving the systems of algebraic equations, ordinary differential equations and partial differential equations in various fields. Knowledge of appropriate software tools. | |
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| **Metode poučevanja in učenja:** | | |  | **Learning and teaching methods:** | |
| Predavanja; skupno reševanje tipičnih nalog za razumevanje snovi v okviru laboratorijskih vaj; reševanje kompleksnejših nalog v okviru laboratorijskih vaj in samostojnega dela doma. | | |  | 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:** | Delež (v %) /  Weight (in %) | | | | **Assessment:** |
| Pisni izpit, ustno izpit, domače naloge, laboratorijske vaje  Ocene od 1 do vključno 5 so negativne, 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 | 50%  50% | | | | Written exam, oral exam, laboratory exercises, homework  Negative grades: from 1 to 5.  Positive grades: 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 |
| **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, 2002. 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. Strojn. 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. | | | | | |