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| **UČNI NAČRT PREDMETA / COURSE SYLLABUS** | | | | | | | | | | | | | | | | | |
| **Predmet:** | | | Računalniška simulacija | | | | | | | | | | | | | | |
| **Course title:** | | | Computer simulation | | | | | | | | | | | | | | |
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| **Študijski program in stopnja**  **Study programme and level** | | | | | **Študijska smer**  **Study field** | | | | | | | | **Letnik**  **Academic year** | | **Semester**  **Semester** | | |
| Univerzitetni študijski program prve stopnje Elektrotehnika | | | | | **Avtomatika** | | | | | | | | **3.** | | **letni** | | |
| 1st cycle academic study programme Electrical Engineering | | | | | **Control Systems** | | | | | | | | **3.** | | **summer** | | |
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| **Vrsta predmeta / Course type** | | | | | | | | | | | | obvezni – strokovni /  compulsory professional | | | | | |
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| **Univerzitetna koda predmeta / University course code:** | | | | | | | | | | | | 64133 | | | | | |
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| **Predavanja**  **Lectures** | **Seminar**  **Seminar** | | | **Vaje**  **Tutorial** | | | **Klinične vaje**  **work** | | | | **Druge oblike študija** | | | **Samost. delo**  **Individ. work** | |  | **ECTS** |
| **45** |  | | | **30** | | |  | | | |  | | | **75** | |  | **6** |
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| **Nosilec predmeta / Lecturer:** | | | | | Borut Zupančič | | | | | | | | | | | | |
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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. | | | | | | | | |  | Enrolment in the year of the course. | | | | | | | |
| **Vsebina:** | | | | | | | |  | | **Content (Syllabus outline):** | | | | | | | |
| Uvod: definicije, modeliranje in simulacija kot enovit ciklični postopek, uporabnost na področju vodenja sistemov.  Osnove modeliranja: ravnotežni zakoni, teoretično in eksperimentalno modeliranje, značilni primeri.  Vrste modelov in simulacij: zvezna, diskretna-dogodkovna, hibridna, simulacija v realnem času.  Metode za simulacijo: indirektna in implicitna metoda, simulacija prenosnih funkcij - vgnezdena in delitvena metoda, simulacija sistemov z velikimi zakasnitvami.  Orodja za simulacijo: osnovne lastnosti dobrih orodij.  Simulacija s pomočjo osnovnih funkcij okolja Matlab.  Simulacija v okolju Matlab-Simulink: osnovne zmožnosti, zahtevnejše zmožnosti: podsistemi in maskiranje, pogojno izvršljivi sistemi, analiza in optimizacija modelov podanih s Simulink shemo: izvajanje Simulink modela iz okolja Matlab, linearizacija, analiza ustaljenega stanja, optimizacija, S-funkcije.  Več- domensko, objektno-orientirano modeliranje: kavzalno in nekavzalno modeliranje, pomembne lastnosti OO okolij. Jezik Modelica, standardne knjižnice, okolja Modelica, okolje Dymola.  Kako deluje digitalna simulacija. Numerično integriranje, vrstni algoritem. Simulacija s pomočjo splošno namenskih programskih jezikov.  Numerični postopki in njih problematika: integracijske metode, numerična stabilnost, problem nezveznosti, problem algebrajske zanke.  Simulacija sistemov diskretnih dogodkov. Strategija proženja z dogodkovnimi grafi in procesnimi tokovi. Primeri v okoljih Matlab, SimEvents, Enterprise Dynamics, AnyLogic. Statistične značilnosti.  Inženirski pristop v eksperimentalnem modeliranju. Eksperimentalno modeliranje proporcionalnih in integrirnih procesov. Inženirsko razumevanje odzivov in poenostavljenih modelov. | | | | | | | |  | | Introduction: definitions, modelling and simulation as a unified cyclic procedure, applicability in the field of control systems.  Basics of modelling: balance equations, theoretical and experimental modelling, examples.  Types of models and simulations: continuous, discrete-event, hybrid, simulation in real time.  Simulation methods: indirect and implicit method, simulation of transfer functions - nested and partitioned method, simulation systems with large delays.  Simulation tools: the basic features.  Simulation using the basic functions of Matlab environment.  Simulation in Matlab - Simulink: basic capabilities, advanced capabilities: subsystems and masking, conditionally executable systems, analysis and optimization of Simulink models: execution of Simulink models from Matlab, linearization, steady state analysis, optimization, S- functions.  Multi-domain, object-oriented modelling: causal and non-causal models, important properties of OO environments. Language Modelica, a standard library, Modelica environments, Dymola environment.  How digital simulation works. Numerical integration, sorting algorithm, simulation using general purpose programming languages.  Numerical methods and problems: integration methods, numerical stability, the problem of discontinuities, the problem of algebraic loops.  Simulation of discrete-event systems. The strategy of the triggering with event graphs and process flows, examples with Matlab, SimEvents, Enterprise Dynamics, AnyLogic. Statistical features in discrete event modelling and simulation.  Engineering approach in experimental modelling. Experimental modelling of proportional and integral processes. Engineering understanding of the responses and simplified models. | | | | | | | |

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| **Temeljni literatura in viri / Readings:** | | | | | |
| Osnovna/basic   1. B. Zupančič, Računalniška simulacija, učbenik v delovni verziji, Univerza v Ljubljani, Fakulteta za elektrotehniko. 2. B. Zupančič, R. Karba, D. Matko, I. Škrjanc, Simulacija dinamičnih sistemov, Založba FE in FRI, Univerza v Ljubljani, Fakulteta za elektrotehniko , 2010. 3. J.B. Dabney, T.L. Harman , Mastering SIMULINK , Prentice Hall, Upper Saddle River, N.J., USA, 2004. 4. S. Oblak, I. Škrjanc, Matlab s Simulinkom : priročnik za laboratorijske vaje, 1. izdaja, Založba FE in FRI, Univerza v Ljubljani, Fakulteta za elektrotehniko, 2005.   Dodatna/additional   1. D. Matko, B. Zupančič, R. Karba , Simulation and Modelling of Continuous Systems - A Case Study Approach, Prentice Hall, 1992. 2. Dymola, Dynamic Modeling Laboratory, Users manual, ver 2014 FD01. Dessault Systems, Dynasim AB, Sweden, Lund, 2013. 3. R. Karba, Modeliranje procesov, 1. izdaja, Univerza v Ljubljani, Fakulteta za elektrotehniko, 1999. 4. F.E. Cellier, Continuous System Modeling, Springer - Verlag, NY, USA, 1991. 5. F.E. Cellier, E. Kofman, Continuous System Simulation, Springer Science+Business Media, Inc., NY, USA, 2006 6. P. Fritzson, Principles of Object Oriented Modeling and Simulation with Modelica 2.1, IEEE Press, John Wiley&Sons, Inc., Publication, USA, 2004 7. S. Raczynski, Modeling and Simulation, John Wiley & Sons, Ltd., England, 2006 | | | | | |
| **Cilji in kompetence:** | |  | | **Objectives and competences:** | |
| Računalniška simulacija je najpomembnejši, najsplošnejši pa tudi relativno enostaven pristop pri analizi in načrtovanju sistemov in tudi sistemov vodenja. Osnovni cilj je predstavitev področja na zanimiv način preko številnih primerov in z uporabo računalniških orodij. Študenti bodo spoznali osnovne pristope pri modeliranju predvsem zveznih, pa tudi dogodkovnih sistemov, osnovne pristope pri simulaciji, spoznali bodo osnovne in naprednejše zmožnosti računalniških orodij, seznanili pa se bodo tudi z numerično problematiko pri simulaciji. | |  | | Computer simulation is the most important, the most common but also relatively simple approach for the analysis and design of systems, also control systems. The basic objective is to present areas in an interesting way through a series of examples and using computer tools. Students will learn the basic approaches to modelling of continuous systems as well as discrete event systems, the basic approaches to simulation, they learn the basic and advanced capabilities of computer tools and become familiar with numerical problems in digital simulation. | |
| **Predvideni študijski rezultati:** | | |  | **Intended learning outcomes:** | |
| Poglobljeno znanje modelerskih in simulacijskih metod, poglobljeno znanje iz rabe naprednih računalniških orodij: Matlab, Simulink, Dymola-Modelica. | | |  | Profound knowledge of modelling and simulation methods, profound knowledge of the use of advanced computer tools: Matlab, Simulink, Dymola-Modelica. | |
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| **Metode poučevanja in učenja:** | | |  | **Learning and teaching methods:** | |
| Predavanja in laboratorijske vaje. | | |  | Lectures and laboratory exercises. | |
| **Načini ocenjevanja:** | Delež (v %) /  Weight (in %) | | | | **Assessment:** |
| Preverjanje znanja med predavanji  Laboratorijske vaje  Ustni izpit (pogoj za ustni izpit so pozitivno ocenjene lab. vaje).  Ocenjuje se z 1-5 (negativno), 6-10 (pozitivno). | 10%  40%  50% | | | | Examination during lectures  Laboratory exercises  Oral exam  Grades are 1-5 (fail), 6-10 (pass). |
| **Reference nosilca / Lecturer's references:** | | | | | |
| 1. ZUPANČIČ, Borut, SODJA, Anton. Computer-aided physical multi-domain modelling : some experiences from education and industrial applications. V: ALEXÍK, Mikuláš (ur.), ŠNOREK, Miroslav (ur.), CEPEK, Miroslav (ur.). EUROSIM 2010 : special issue, Simulation modelling practice and theory, Elsevier, ISSN 1569-190X, 2013, vol. 33, str. 45-67.  2. ZUPANČIČ, Borut, SODJA, Anton. Analysis and control design of thermal flows in buildings : efficient experimentation with a room model in Matlab-Modelica environment. V: 8th EUROSIM Congress on Modelling and Simulation, Cardiff, Wales. AL-BEGAIN, Khalid (ur.). *Eurosim 2013*. [et al.]: IEEE = Institute of Electrical and Electronics Engineers, 2013, str. 155-160.  3. KARER, Gorazd, MUŠIČ, Gašper, ŠKRJANC, Igor, ZUPANČIČ, Borut. Feedforward control of a class of hybrid systems using an inverse model. V: 6th Vienna International Conference on Mathematical Modelling, February 11-13, 2009, Vienna, Austria. TROCH, Inge (ur.), BREITENECKER, Felix (ur.). *Transactions of IMACS*, (Mathematics and computers in simulation, ISSN 0378-4754, vol. 82, no. 3 (Nov. 2011)). Amsterdam [etc.]: Elsevier, 2011, str. 414-427.  4. SODJA, Anton, ZUPANČIČ, Borut. Modelling thermal processes in buildings using an object-oriented approach and Modelica. Simulation modelling practice and theory, ISSN 1569-190X, Jul. 2009, vol. 17, no. 6, str. 1143-1159.  5. TROBEC LAH, Mateja, ZUPANČIČ, Borut, KRAINER, Aleš. Fuzzy control for the illumination and temperature comfort in a test chamber. Building and environment, ISSN 0360-1323, 2005, letn. 40, št. 12, str. 1626-1637. | | | | | |