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| **UČNI NAČRT PREDMETA / COURSE SYLLABUS** | | | | | | | | | | | | | | | | | |
| **Predmet:** | | | Vodenje sistemov | | | | | | | | | | | | | | |
| **Course title:** | | | Control systems | | | | | | | | | | | | | | |
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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 | | | | | Elektronika | | | | | | | | 1 | | 2 | | |
| 2nd cycle masters study programme in Electrical Engineering | | | | | Electronics | | | | | | | | 1 | | 2 | | |
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| **Vrsta predmeta / Course type** | | | | | | | | | | | | Obvezni-strokovni met/ Compulsory professional | | | | | |
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| **Univerzitetna koda predmeta / University course code:** | | | | | | | | | | | | 64227 | | | | | |
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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 / Slovene** | | | | | | | | | | | |
| **Vaje / Tutorial:** | | | | **slovenski / Slovene** | | | | | | | | | | | |
| **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 v vodenje sistemov: splošno, vrste, učinki, gradniki, celostni in sistemski pristop.  Modeliranje: cilji, sistem, proces, model, simulacija, teoretično, eksperimentalno in kombinirano modeliranje, ciklični postopek modeliranja in simulacije, primeri: avtomobilsko vzmetenje, ogrevanje prostora, ekološki model žrtev in roparjev. Prikazi modelov v okolju Dymola-Modelica.  Zapisi modelov: diferencialne enačbe, prenosne funkcije, bločni diagrami.  Simulacija: osnovne metode (indirektni način, sim. prenosnih funkcij), vpeljava okolja Matlab-Simulink .  Računalniško podprta analiza, modeliranje in simulacija.  Analiza sistemov v časovnem prostoru: vpliv polov in ničel, proporcionalni, integrirni in diferencirni sistemi, stabilnost.  Vodenje sistemov: odprtozančni sistem, zaprtozančni sistem, sledilno delovanje, regulacijsko delovanje, pokazatelji kvalitete reg. sistema, obravnava v delovni točki, ustaljeno stanje reg. sistemov, stabilnost.  Regulacijski algoritmi: PID regulator, določevanje parametrov z nastavitvenimi pravili, optimiranje parametrov s pomočjo okolja Matlab, primerne cenilke, računalniška izvedba PID algoritma.  Analiza in načrtovanje regulacijskih sistemov z diagramom lege korenov.  Analiza in načrtovanje regulacijskih sistemov v frekvenčnem prostoru.  Analiza in načrtovanje regulacijskih sistemov v prostoru stanj. | | | | | | | |  | | Introduction to control systems: general, types, effects, building elements, holistic and systemic approach.  Modelling: objectives, system, process, simulation, theoretical, experimental and combined modelling, cyclic approach in modelling and simulation, examples: car suspension, room heating, pray and predator system. Presentation of models in Dymola-Modelica environment.  Model descriptions: differential equations, transfer functions, block diagrams.  Simulation: basic methods (indirect approach, transfer functions), description of Matlab-Simulink environment.  Computer-aided analysis, modelling and simulation.  Analysis of systems in the time domain: influence of poles and zeros, proportional, integral and differential systems, stability.  Control systems: open-loop, closed loop system, tracking and regulating performance, control quality indicators, working point treatment, steady state analysis, stability.  Control algorithms: PID algorithm, the determination of the parameters with setting rules, optimization of parameters by using the Matlab environment, suitable functions, computer implementation of the PID algorithm.  Analysis and design of control systems with root locus diagram.  Analysis and design of control systems in the frequency domain.  Analysis and design of control systems in state space. | | | | | | | |

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| **Temeljni literatura in viri / Readings:** | | | | | |
| Osnovna/basic:   1. B. Zupančič, Vodenje sistemov, delovna verzija učbenika, Univerza v Ljubljani, Fakulteta za elektrotehniko, 2015. 2. Gregor Klančar,Vodenje sistemov, Praktikum, delovna verzija gradiva za laboratorijske vaje, Univerza v Ljubljani, Fakulteta za elektrotehniko, 2014. 3. 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. B. Zupančič, Zvezni regulacijski sistemi 1. del, Založba FE in FRI, Univerza v Ljubljani, Fakulteta za elektrotehniko, 2010. 2. B. Zupančič, Zvezni regulacijski sistemi 2. del, Založba FE in FRI, Univerza v Ljubljani, Fakulteta za elektrotehniko, 2010. 3. B. Zupančič, Računalniška simulacija, delovna verzija učbenika za predmet Računalniška simulacija, Univerza v Ljubljani, Fakulteta za elektrotehniko , 2015. 4. B. Zupančič, Modelica, delovna verzija učbenika za predmet Računalniška simulacija, Univerza v Ljubljani, Fakulteta za elektrotehniko , 2015. 5. R. Karba, Modeliranje procesov, Založba FE in FRI, Univerza v Ljubljani, Fakulteta za elektrotehniko, 1999. 6. S. Strmčnik, R.Hanus, Đ. Juričić, R. Karba, Z. Marinšek, D.Murray-Smith, H. Verbruggen, B. Zupančič, Celostni pristop k računalniškemu vodenju procesov, 1. izdaja, Založba FE in FRI, Univerza v Ljubljani, Fakulteta za elektrotehniko, 1998. 7. R. C. Dorf, H. Bishop: Modern Control Systems, Pearson Education, Inc., Publishing As Pearson Prentice Hall, Tenth Edition, 2004. | | | | | |
| **Cilji in kompetence:** | |  | | **Objectives and competences:** | |
| Osnovni cilj je predstavitev avtomatike oz. vodenja sistemov na zanimiv način preko številnih primerov, z uporabo računalniških orodij in s praktičnim delom v dobro opremljenem laboratoriju. Pridobljene kompetence so naslednje: modeliranje in simulacija sistemov, ki se pojavljajo v avtomatiki, razumevanje principov povratne zanke, načrtovanje enostavnejšega PID vodenja in zahtevnejšega vodenja (kompenzacijske metode, regulator stanj, …), poznavanje najnaprednejših računalniških orodij za analizo sistemov, modeliranje, simulacijo in načrtovanje vodenja. | |  | | The basic objective is to present the control system’s area in an interesting way through a number of cases, the use of computer tools and practical work in a well-equipped laboratory. Acquired skills are as follows: modelling and simulation of systems that occur in automation, understanding the principles of feedback loop, PID control and more advanced control approaches: compensation methods, the state space control , ...), presentation and usage of advanced software tools for system analysis, modelling, simulation and control design. | |
| **Predvideni študijski rezultati:** | | |  | **Intended learning outcomes:** | |
| Študenti se bodo naučili: modelirati in simulirati sisteme, ki se pojavljajo pri vodenju, načrtati vodenje realnih in laboratorijskih procesov in uporabljati najnaprednejša računalniška orodja za analizo, modeliranje, simulacijo in načrtovanje sistemov avtomatskega vodenja (Matlab, Control Systems Toolbox, Simulink, Dymola-Modelica). | | |  | Students will learn: to model and simulate systems that arise in the control area, control design of real and laboratory processes and application of the most advanced computer tools for analysis, modelling, simulation and design of control systems (Matlab, Control Systems Toolbox, Simulink, Dymola-Modelica). | |
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| **Metode poučevanja in učenja:** | | |  | **Learning and teaching methods:** | |
| Predavanja, laboratorijske vaje | | |  | Lectures, laboratory exercises | |
| **Načini ocenjevanja:** | Delež (v %) /  Weight (in %) | | | | **Assessment:** |
| Laboratorijske vaje  Pisni izpit (pogoj za pisni izpit so pozitivno opravljene lab. vaje)  Ustni izpit (pogoj za ustni izpit je opravljen pisni izpit)  Ocenjevanje: 1-5 (negativno), 6-10 (pozitivno). | 40%  30%  30% | | | | Laboratory work  Written exam (successful completion of laboratory exercises required)  Oral exam (positive grade of written exam required)  Grading scale: 1-5 (negative), 6-10 (positive). |
| **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. | | | | | |