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| **UČNI NAČRT PREDMETA / COURSE SYLLABUS** | | | | | | | | | | | | | | | | | |
| **Predmet:** | | | Avtomatsko vodenje sistemov | | | | | | | | | | | | | | |
| **Course title:** | | | Automatic Control Systems | | | | | | | | | | | | | | |
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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 | | | | |  | | | | | | | | **2.** | | **letni** | | |
| 1st cycle academic study programme Electrical Engineering | | | | | **/** | | | | | | | | **2.** | | **summer** | | |
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| **Vrsta predmeta / Course type** | | | | | | | | | | | | Izbirni – strokovni/  Elective - professional | | | | | |
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| **Univerzitetna koda predmeta / University course code:** | | | | | | | | | | | | 64119 | | | | | |
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| **Predavanja**  **Lectures** | **Seminar**  **Seminar** | | | **Vaje**  **Tutorial** | | | **Klinične vaje**  **work** | | | | **Druge oblike študija** | | | **Samost. delo**  **Individ. work** | |  | **ECTS** |
| **45** |  | | | **15** | | |  | | | |  | | | **65** | |  | **5** |
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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 v avtomatsko vodenje: vrste, učinki, celostni pristop, struktura računalniškega vodenja v podjetju, gradniki sistemov vodenja, sistemski pristop pri načrtovanju vodenja.  Sistemi in signali: primeri sistemov, povezava z modeliranjem, procesi, osnovni signali, uvod v spektralno analizo.  Modeliranje procesov: cilji, vrste modelov, načini modeliranja, primeri.  Zapisi matematičnih modelov: diferencialne enačbe, prenosne funkcije, bločni diagrami.  Analiza sistemov v časovnem prostoru: vpliv polov in ničel, obravnava proporcionalnih, integrirnih in diferencirnih sistemov, stabilnost.  Simulacija: simulacijska shema, indirektni način, simulacija prenosnih funkcij.  Vodenje sistemov: vpeljava z bločnimi diagrami in tehnološkimi shemami, krmiljenje, regulacija, sledenje, odpravljanje motenj, učinki povratne zanke na ustaljeni pogrešek, stabilnost, primeri, osnovni industrijski regulacijski algoritmi, proporcionalno-integrirno-diferencirni-regulator: vloga posameznih členov, uglaševanje z nastavitvenimi pravili in s simulacijo, primeri.  Orodja za računalniško podprto analizo in načrtovanje vodenja: Matlab, Control Toolbox, orodje za simulacijo Matlab- Simulink, okolje za večdomensko objektno orientirano modeliranje in simulacijo Dymola-Modelica.  Primeri z uporabo orodij za analizo, modeliranje, simulacijo in načrtovanje vodenja: ogrevanje stavbe, avtomobilsko vzmetenje, populacijska dinamika, električni sistemi, regulacija rotacijskih sistemov, robotski sistem, hidravlični sistem, … | | | | | | | |  | | Introduction to automatic control: types, effects, holistic approach, computer integrated manufacturing, the building blocks of control systems, system approach to the control system design.  Systems and signals: examples of systems, connection to modelling, processes, basic signals, an introduction to spectral analysis.  Process modelling: goals, types, approaches, examples.  Descriptions of mathematical models: differential equations, transfer functions, block diagrams.  Systems analysis in the time domain: influence of poles and zeros, proportional, integral and differential systems, systems stability.  Simulation: simulation scheme, indirect approach, simulation of transfer functions.  Control systems : presentation with block diagrams and technological schemes, feedforward and feedback control, reference tracking and disturbance elimination, the effects of feedback on steady state error, stability, examples, basic industrial control algorithms, PID control, the role of P, I, and D parts, tuning with rules and simulation, examples.  Tools for computer-aided analysis and control systems design: Matlab, Control Toolbox, tool for the simulation - Matlab-Simulink, environment for multi-domain object oriented modelling and simulation Dymola-Modelica.  Examples: heating in the building, car suspension system, population dynamics, electrical systems, control of rotation systems, robotic system, hydraulic system, ... | | | | | | | |

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| **Temeljni literatura in viri / Readings:** | | | | | |
| Osnovna/basic:   1. B. Zupančič, Avtomatsko vodenje sistemov, delovna verzija učbenika, Univerza v Ljubljani, Fakulteta za elektrotehniko, 2014. 2. 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, R. Karba, D. Matko, I. Škrjanc, Simulacija dinamičnih sistemov, Založba FE in FRI, Univerza v Ljubljani, Fakulteta za elektrotehniko , 2010. 3. R. Karba, Modeliranje procesov, Založba FE in FRI, Univerza v Ljubljani, Fakulteta za elektrotehniko, 1999. 4. 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. 5. 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. avtomatskega vodenja sistemov na zanimiv način preko številnih primerov in z uporabo računalniških orodij. Pridobljene kompetence: modeliranje in simulacija enostavnejših sistemov, razumevanje principov povratne zanke, načrtovanje avtomatskega vodenja enostavnejših procesov, poznavanje najnaprednejših računalniških orodij za analizo, modeliranje, simulacijo in načrtovanje sistemov avtomatskega vodenja. | |  | | The basic objective is to present the automatic control systems in an interesting way through a series of examples and using computer tools. Acquired skills: modeling and simulation of simple systems, an understanding of the principles of feedback loop, design of automatic control of simpler processes, familiarity of the most advanced computer tools for analysis, modeling, simulation and automatic control systems design. | |
| **Predvideni študijski rezultati:** | | |  | **Intended learning outcomes:** | |
| Študenti se bodo naučili: modelirati in simulirati enostavnejše sisteme, načrtati avtomatsko vodenje enostavnejših 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 simpler systems, to design automatic control of simple laboratory processes and to use the most advanced computer tools for analysis, modeling, simulation and automatic control systems design (Matlab, Control Systems Toolbox, Simulink, Dymola-Modelica). | |
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| **Metode poučevanja in učenja:** | | |  | **Learning and teaching methods:** | |
| Predavanja (s številnimi primeri), nekaj zanimivih tem zunanjih predavateljev, laboratorijske vaje | | |  | Lectures (with many examples), interesting topics from invited lecturers, 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 (the condition for oral exam is the positive grade of lab. exercises)  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. | | | | | |