UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	Osnove krmilnih sistemov
Course title:	Basics of Control Systems

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Tehnologije in sistemi – prva stopnja	/	drugi ali tretji	peti
Technologies and Systems – 1st cycle	/	third	fifth

Vrsta predmeta / Course type izbirni/elective

Univerzitetna koda predmeta / University course code: TS IP UN 7

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Laboratorijske vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
45		15	15		100	6

Nosilec predmeta / Lecturer: doc. dr. Tomaž Perme

Jeziki / Languages:	Predavanja / Lectures:	Slovenski/Slovenian
	Vaje / Tutorial:	Slovenski/Slovenian

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisits:**
• vpis v tretji letnik študija	• enrollment in the third year of study

Vsebina:	**Content (Syllabus outline):**
• *Uvod.* Definicije, zgodovinski razvoj tehnične kibernetike in vodenja sistemov, predstavitev in delitev krmilnih sistemov ter značilni primeri iz prakse. • *Osnove.* Sistemi, procesi, signali in sistemska teorije, načela in teorije vodenja ter načrtovanje in sistemsko inženirstvo. Predstavitev tehniških procesov in sistemov ter vrste procesov. • *Modeliranje sistemov z diferencialnimi enačbami.* Definicija in delitev diferencialnih enačb, linearizacija, značilni vstopni signali, reševanje navadnih	• *Introduction.* Definitions, historical development of technical cybernetics and system management, presentation and calssification of control systems and typical examples from practice. • *Basics.* Systems, processes, signals and systems theories, management principles and theories, and design and systems engineering. Presentation of technical processes and systems and types of processes. • *Modelling systems with differential equations.* Definition and division of

linearnih diferencialnih enačb s konstantnimi koeficienti, numerično reševanje v programskem okolju MATLAB.

- *Prenosna karakteristika.* Opredelitev prenosne karakteristike, prenosne karakteristike proporcionalnih, integriranih in diferencirnih gradnikov, prenosne karakteristike osnovnih sestavljenih mehanskih in električnih gradnikov, analogije osnovnih fizikalnih sistemov.
- *Blokovna algebra.* Blokovni diagram in poenostavljanje (redukcija zaporedne vezave, Masonovo pravilo, načelo superozicije), modeliranje sistemov z blokovnim diagramom, primeru uporabe blokovnega diagrama.
- *Laplaceova transformacija.* Namen, opredelitev in lastnosti Laplaceove transformacije, primeri tranfromacij nekaterih funkcij in razširitev na parcialne ulomke, prenosna funkcija.
- *Fourierova transformacija.* Fourierova vrsta in integral, lastnosti in slike nekaterih pomembnih funkcij ter frekvenčna karektiristika in frekvenčni diagram (Bodejev diagram, Nyquistov diagram).
- *Analiza sistemov.* Stabilnost sistemov (Routhov kriterij, Hurwitzow kriterij, uporaba frekvenčnih diagramov), odstopek v stacionarnem stanju (za enotno skočno funkcijo, za strmino in za parabolično funkcijo), analiza odstopkov glede na tip sistema, vpliv lege ničel na karakteristične enačbe in korenska krivulja.
- *Sinteza sistemov.* Sinteza v frekvenčni domeni, PID krmilniki, diskretni PID krmilniki, izvedba prenosnih karakteristik.
- *Digitalni krmilni sistemi.* Sistemi z vzorčenjem: z-transformacija, zaprtozančni sistemi, stabilnost v z-ravnini, značilnosti sistemov drugega reda, načrtovanje krmiljenja gibanja delovne mize.
- *Modeliranje in simulacija.* Vnos in simulacija linearnih dinamičnih sistemov. Simulacijska shema in prenosna funkcija. Osnovne lastnosti simulacijskih sistemov. Simulacijsko okolje MATLAB-Simulink,

differential equations, linearization, characteristic input signals, solution of ordinary linear differential equations with constant coefficients, numerical solution in MATLAB programming environment.

- *Transferability characteristics.* Definition of transfer characteristics, transfer characteristics of proportional, integrated and differentiating building blocks, transfer characteristics of basic composite mechanical and electrical building blocks, analogies of basic physical systems.
- *Block algebra.* Block diagram and simplification (reduction of serial binding, Mason's rule, superposition principle), modelling of systems with block diagram, example of application of block diagrams.
- *Laplace transformation.* Purpose, definition and properties of Laplace transform, examples of transformations of some functions and extensions to partial fractions, transfer function.
- *Fourier transformation.* Fourier type and integral, properties and images of some important functions and frequency characteristics and frequency diagram (Bode diagram, Nyquist diagram).
- *Systems analysis.* Stability of systems (Routh criterion, Hurwitzow criterion, use of frequency diagrams), deviation in the stationary state (for a uniform step function, for a slope and for a parabolic function), analysis of deviations depending on the type of system, influence of the location of zeros on the characteristic equations and the root curve.
- *Synthesis of systems.* Synthesis in the frequency domain, PID controllers, discrete PID controllers, implementation of transfer characteristics.
- *Digital control systems.* Sampling systems: z-transform, closed-loop systems, stability in the z-plane, properties of second-order systems, design of workbench motion control.
- *Modelling and simulation.* Input and simulation of linear dynamic systems.

osnovna uporaba in analiza modelov s simulacijskim programom Simulink.	Simulation scheme and transfer function. Basic properties of simulation systems. MATLAB-Simulink simulation environment, basic use and analysis of models with Simulink simulation program.

Temeljni literatura in viri / Readings:

Temeljna literatura/Basic literature

- Podržaj, P. (2015) *Linearna teorija krmiljenja sistemov*. Ljubljana: Fakulteta za strojništvo.
- Podržaj, P. (2014) *Zbirka rešenih nalog s področja linearne teorije krmiljenja sistemov*. Ljubljana: Fakulteta za strojništvo.

Priporočljiva literatura/Recommended literature

- Strmčnik, S. in drugi (1998). *Celostni pristop k računalniškemu vodenju procesov*. Ljubljana: Založba FE in FRI
- Ogata, K. (2008) *Modern control engineering, 5th Int. Ed.* Pearson.
- Dorf, R. C., Bishop, R. H. (2010) *Modern control systems, 15th. International Ed*. Pearson.

Cilji in kompetence:

Učna enota prispeva predvsem k razvoju naslednjih splošnih in specifičnih kompetenc:

- sposobnost evidentiranja problema in njegove analize ter predvidevanja operativnih rešitev v tehnološkem smislu ali v procesu organizacije in vodenja,
- sposobnost obvladovanja standardnih razvojnih metod, postopkov in procesov,
- sposobnost uporabe pridobljenega teoretičnega znanja v praksi,
- sposobnost obvladovanja razvoja in napredka,
- avtonomnost v strokovnem delu s področja tehnologij in sistemov,
- sposobnost razumevanja in uporabe sodobnih teorij s področja tehniških, tehnoloških in naravoslovnih ved,
- sposobnost matematičnega razumevanja tehničnih problemov in uporaba matematike pri reševanju le-teh,
- sposobnost interdisciplinarnega povezovanja znanja,
- sposobnost reševanja konkretnih delovnih problemov na področju tehnologij in sistemov z uporabo standardnih strokovnih metod in postopkov,

Objectives and competences:

The learning unit mainly contributes to the development of the following general and specific competences:

- the ability to identify a problem and analyze it, as well as foresee operational solutions in a technological sense or in the process of organization and management,
- the ability to master standard development methods, procedures and processes,
- the ability to use acquired theoretical knowledge in practice,
- the ability to manage development and progress,
- autonomy in professional work in the field of technologies and systems,
- the ability to understand and apply modern theories in the field of technical, technological and natural sciences,
- the ability to mathematically understand technical problems and use mathematics to solve them,
- the ability to integrate knowledge in an interdisciplinary manner,
- the ability to solve specific work problems in the field of technologies and systems using standard professional methods and procedures,

• poznavanje, načrtovanje, vpeljevanje in upravljanje avtomatizacije in robotizacije, • sposobnost stalne uporabe informacijske in komunikacijske tehnologije na svojem strokovnem področju.	• knowledge, planning, implementation and management of automation and robotics, • the ability to continuously use information and communication technology in one's professional field.

Predvideni študijski rezultati: | **Intended learning outcomes:**

Znanje in razumevanje: *Študent/študentka:* • spozna temelje avtomatskega krmiljenja, • spozna pomen avtomatskega krmiljenja v sodobni tehnologiji, izdelkih in tovarnah, • usvoji temeljne gradnike krmilnih sistemov, • aplicira usvojeno matematično znanje na krmilnih problemih in spozna nekatere nove matematične metode, • seznani se z različnimi fizičnimi gradniki krmilnih sistemov in usvoji njihovo analogijo, • seznani se s koncepti prehodnega pojava in stacionarnega stanja, • usvoji koncept stabilnosti sistema, • spozna različne metode analize krmilnih sistemov v časovni in frekvenčni domeni, • seznani se s potrebo po načrtovanju krmilnih sistemov in z nekaterimi pomembnimi metodami, • spozna različne modele prikazovanja krmilnih sistemov, • razlikuje zvezne in diskretne krmilne sisteme, • pozna osnove dela s programsko opremo za modeliranje in simulacijo krmilnih sistemov.	Knowledge and understanding: *Student:* • learns the basics of automatic control, • learns the importance of automatic control in modern technology, products and factories, • learns the basic building blocks of control systems, • applies the acquired mathematical knowledge to control problems and learns some new mathematical methods, • gets acquainted with different physical components of control systems and learn their analogy, • becomes familiar with the concepts of transient phenomenon and stationary state, • gets acquainted with the concept of system stability, • gets acquainted with various methods of analysis of control systems in the time and frequency domain, • becomes familiar with the necessity of designing control systems and some important methods, • gets to know different display models of control systems, • distinguishes between federated and discrete control systems, • knows the basics of working with software for modeling and simulation of control systems.

Metode poučevanja in učenja: | **Learning and teaching methods:**

• *predavanja* z aktivno udeležbo študentov (razlaga, primeri iz prakse, vprašanja in diskusija, razvijanje ustvarjalnosti), • *vaje* s čim bolj ilustrativnimi in realnimi primeri s poudarkom na delu v	• *lectures with* active participation of students (explanation, examples from practice, questions and discussion, development of creativity),

programskem okolju MATLAB-Simulink in LabVIEW, • *laboratorijsko delo* za praktično utrjevanje teoretičnih spoznanj ter ugotavljanje lastnosti krmilnih sistemov v praksi, • *uporaba spletnih virov* in seznanjanje s široko strokovno literaturo in praktično uporabo dosegljive dokumentacije (knjig, revij, arhivov itd.), • *strokovne ekskurzije in ogledi.*	• *tutorials* with as illustrative and realistic examples as possible, with an emphasis on work in the MATLAB-Simulink and LabVIEW programming environment, • *laboratory work* for practical consolidation of theoretical knowledge and determining the properties of control systems in practice, • *use of online resources* and familiarization with a wide range of professional literature and practical use of available documentation (books, magazines, archives, etc.), • *professional excursions and tours*.

Načini ocenjevanja:	Delež (v %) / Weight (in %)	Assessment:
Način (pisni izpit, ustno izpraševanje, naloge, projekt): • pisni izpit iz nalog • pisni (ustni) izpit iz teorije Ocenjevalna lestvica: ECTS.	 50 % ocene 50 % ocene	Type (examination, oral, coursework, project): • written exam based on assignments • written (oral) exam in theory Grading scale: ECTS.