UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Predmet:	MODELIRANJE DINAMIČNIH PROCESOV V LOGISTIKI
Course title:	PRINCIPLES OF MODELLING DYNAMICS IN LOGISTICS

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
LOGISTIKA SISTEMOV 2.stopnja		2.	3.
SYSTEM LOGISTICS 2.degree		2.	3.

Vrsta predmeta / Course type: IZBIRNI

Univerzitetna koda predmeta / University course code: MAG 12

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje Laboratory work	Druge oblike študija Field work	Samost. delo Individ. work	ECTS
15 e-P 30 a-P		15 e-V 25 a-V			65	5

Nosilec predmeta / Lecturer: TONE LERHER

Jeziki / Languages:	
Predavanja / Lectures:	SLOVENSKI / SLOVENE
Vaje / Tutorial:	SLOVENSKI / SLOVENE

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	Prerequisits:
Znanja iz Matematike in Mehatronike v logistiki	Knowledge of Mathematics and Mechatronics in logistics

Vsebina:	Content (Syllabus outline):
Evolucijska enačba zveznih in diskretnih dinamičnih sistemov. Linearni in nelinearni dinamični sistemi. Avtonomno Duffingovo nihalo. Duffingovo nihalo s harmoničnim vzbujanjem, osnovna resonanca Duffingovega nihala. Zvezna logistična enačba in omejitve rasti. Modeliranje pojavov v dinamičnem sistemu plenilec – plen (predator-prey). Modeliranje tekmovalnih in kooperativnih procesov. Uporaba homotopsko perturbacijske metode v zveznih dinamičnih sistemih. Diskretna logistična enačba. Teorija stabilnosti. Globalna teorija bifurkacij. Teorija determinističnega kaosa. Konveksni optimizacijski problemi. Paretov optimizacijski problem. Teorija iger, Nashevo ravnotežje, čiste in mešane strategije. Uporaba teorije strateških iger v oskrbovalnih verigah in transportnih problemih. Modeliranje oskrbovalnih verig in transportnih problemov s pomočjo projiciranih dinamičnih sistemov z nezveznostmi. Učinek biča (bullwhip effect) v oskrbovalnih verigah. Nestacionarni procesi v čakajočih vrstah.	Evolution equation of continuous and discrete dynamical systems. Linear and nonlinear dynamical systems. Autonomous Duffing oscillator. Harmonically excited Duffing oscilator, fundamental resonance of Duffing oscillator. Continuous logistic equation and growth limitations. Modelling of phenomena in predator – prey dynamical system. Modelling of competitive and cooperative processes. The use of homotopic perturbation method in continuous dynamical systems. Discrete logistic equation. The theory of stability. Global theory of bifurcations. The theory of deterministic chaos. Convex optimization problems. Pareto optimization problem. The game theory, Nash equilibrium, pure and mixed strategies. The use of game theory in supply chains and transport problems. Modelling of supply chains and transport problems by using projected dynamical systems with discontinuities. The bullwhip effect in supply chains. Nonstationary processes in waiting queues. The theory of fuzzy sets. Neuronal networks and genetic

Teorija mehkih množic. Nevronske mreže in genetski algoritmi.	algorithms.

Temeljna literatura in viri / Readings:

1. J. Banks, J. S. Carson, B. L. Nelson, D. M. Nicol. Discrete-Event System Simulation, Pearson Education Limited, 2014.
2. A. M. Law, W. D. Kelton. Simulation modeling and analysis, McGraw-Hill, 2000.
3. D. S. Levi, X. Chen, J. Bramel. The Logic of Logistics: Theory, Algorithms, and Applications for Logistics Management, Springer-Verlag, 2013.
4. D. A. Coley. Introduction To Genetic Algorithms For Scientists And Engineers, World Scientific Publishing Co., 2003.

Cilji in kompetence:	Objectives and competences:
▪ Predmet je namenjen pridobitvi poglobljenih znanj iz modeliranja, simulacij in metod analize dinamičnih procesov v logistiki	• The subject is designed to gain the deep knowledge about modelling, simulation and analysis methods of dynamic process in logistics.

Predvideni študijski rezultati:	Intended learning outcomes:
Študent/študentka: • razume osnove dinamike zveznih in diskretnih sistemov in jih je sposoben matematično modelirati. Obvlada teoretične koncepte pri modeliranju nelinearnih sistemov na primeru Du-ffingovega nihala. Razume teoretične osnove zveznih in diskretnih modelov rasti populacij in njihove omejitve. Pozna dinamični sistem plenilec – plen, kooperativne sisteme in sisteme tekmovalnosti. Seznanjen je s problemom stabilnosti in bifurkacij v dinamičnih sistemih. Spozna konveksno optimiranje, Paretov optimizacijski problem, teorijo iger, uporabo projeciranih dinamičnih sistemov z nezveznostmi, nestacionarne procese v čakajočih vrstah, uporabo mehkih množic in nevronskih mrež. • osvoji poglobljena znanja na področjih analize in modeliranja, simulacij in analize dinamičnih procesov v logistiki, • usposobi se za reševanje zgoraj navedenih problemov stroke, • zna uporabljati računalniška orodja za modeliranje in simulacijo dinamičnih procesov v logistiki	*Students* • master the basic knowledge of continuous and discrete systems and can perform the mathematical modelling of such systems. Students master the concepts of modelling of nonlinear systems with case studies of Duffing oscillator. Students understand the basics of continuous and discrete population growth models as well as its limitations. Students know the predator – prey systems, cooperative and competitive dynamical systems. Students know the problem of stability and bifurcations in dynamical systems. Students understand convex optimization, Pareto optimization problem, the game theory, the use of projected dynamical system with discontinuities, nonstationary processes in waiting queues, the use of fuzzy sets and neuronal networks. • gain the deep knowledge about the analysis, modelling and simulation of dynamic processes in logistics, • qualify for solving problems in this field • know how to use computer tools for modelling and simulation of dynamical processes in logistics

• predavanja z aktivno udeležbo študentov, ki vsebujejo razprave, diskusije, odgovore na vprašanja in reševanje nalog, • avditorne vaje s poglabljanjem teoretičnih znanj	• Lectures including discussions, answers on questions and solving examples • Tutorials with deepening of theoretical knowledge

Metode poučevanja in učenja:	Learning and teaching methods:
• Predavanja: pri predavanjih študent spozna teoretične vsebine predmeta. Del predavanj se izvaja na klasični način v predavalnici, del pa v obliki e-predavanj (e-predavanja se lahko izvajajo na videokonferenčni način ali s pomočjo posebej v ta namen didaktično pripravljenih e-gradiv v virtualnem elektronskem učnem okolju). • Vaje: pri vajah študent utrdi teoretično znanje in spozna aplikativne možnosti. Del vaj se izvaja na klasični način v predavalnici, del pa v obliki e-predavanj (e-vaje se lahko izvajajo na videokonferenčni način ali s pomočjo posebej v ta namen didaktično pripravljenih e-gradiv v virtualnem elektronskem učnem okolju).	• Lectures: Students understand the theoretical frameworks of the course. Part of the lecture course is in a classroom while the rest is in the form of e-learning (e-lectures may be given via video-conferencing or with the help of specially designed e-material in a virtual electronic learning environment) • Tutorials: Students enhance their theoretical knowledge and are able to apply it. Part of the seminar is in a classroom while the rest is in the form of e-learning (e-seminars may be given via video-conferencing or with the help of specially designed e-material in a virtual electronic learning environment)

Načini ocenjevanja:	Delež (v %) / Weight (in %)	Assessment:
• domače naloge • ustni izpit končna ocena izpita je utežna vsota obeh ocen (domačih nalog in ustnega dela izpita).	40 60	• homeworks • oral exam the final grade of the exam is the weighted sum of the homeworks grade and the grade of the oral exam

Reference nosilca / Lecturer's references:

1. LERHER, Tone, ŠRAML, Matjaž, BOROVINŠEK, Matej, POTRČ, Iztok. Multi-objective optimization of automated storage and retrieval systems. *Annals of the Faculty of Engineering Hunedoara*, ISSN 1584-2665, 2013, tome 11, fasc. 1, str. 187-194. http://annals.fih.upt.ro/pdf-full/2013/ANNALS-2013-1-26.pdf. [COBISS.SI-ID 16732438].
2. LERHER, Tone, ŠRAML, Matjaž, POTRČ, Iztok. Simulation analysis of mini-load multi-shuttle automated storage and retrieval systems. *The international journal of advanced manufacturing technology*, ISSN 0268-3768, 2011, vol. 54, no. 1/4, str. 337-348, doi: 10.1007/s00170-010-2916-8. [COBISS.SI-ID 14398998].
3. LERHER, Tone, POTRČ, Iztok. The design and optimization of automated storage and retrieval systems. *Strojniški vestnik*, ISSN 0039-2480, 2006, letn. 52, št. 5, str. 268-291. [COBISS.SI-ID 10601750].
4. LERHER, Tone, POTRČ, Iztok, KRAMBERGER, Janez, ŠRAML, Matjaž, BOROVINŠEK, Matej. *Program za računalniško podprto načrtovanje regalnih skladiščnih sistemov*. Maribor: Fakulteta za strojništvo, 2005. 1 CD-ROM. [COBISS.SI-ID 9594902].
5. POTRČ, Iztok, LERHER, Tone, KRAMBERGER, Janez, ŠRAML, Matjaž. Simulation model of multi-shuttle automated storage and retrieval systems. *Journal of materials processing technology*, ISSN 0924-0136. [Print ed.], Dec. 2004, vol. 157/158, str. 236-244. http://dx.doi.org/10.1016/j.jmatprotec.2004.09.036. [COBISS.SI-ID 9224470].
6. POTRČ, Iztok, LERHER, Tone, KRAMBERGER, Janez, ŠRAML, Matjaž. Analytical and simulation approach for design of automated storage and retrieval systems. *International journal of simulation modelling*, ISSN 1726-4529, 2003, vol. 2, no. 3, str. 70-77. [COBISS.SI-ID 8256790].

Opomba:
Navedene sestavine so obvezna sestavina učnega načrta predmeta kot ga določajo Merila za akreditacijo visokošolskih zavodov in študijskih programov v 7. členu (Ur. l. RS, št. 101/2004).