UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Ime predmeta:	SKLADIŠČNI SISTEMI IN SKLADIŠČNO POSLOVANJE
Course title:	WAREHOSE SYSTEMS AND WAREHOUSE OPERATION

Študijski program in stopnja **Study programme and cycle**	**Študijska smer** **Study option**	**Letnik** **Year of study**	**Semester** **Semester**
LOGISTIKA SISTEMOV 1. stopnja		2.	4.
SYSTEM LOGISTICS 1st degree		2.	4.

Vrsta predmeta (obvezni ali izbirni) / **Course type (compulsory or elective)**	OBVEZNI COMPULSORY
Univerzitetna koda predmeta / University course code:	UN

Predavanja **Lectures**	**Seminar** **Seminar**	**Vaje** **Tutorial**			**Klinične vaje** **Clinical training**	**Druge oblike študija** **Other forms of study**	**Samost. delo** **Individual work**	**ECTS**
15 e-P 30 a-P		**a-V**	**e-V**	**LV**			105	6
		15	9	6				

Nosilec predmeta / Course coordinator:	**TONE LERHER**
Jeziki /Languages: **Predavanja / Lectures:**	SLOVENSKI/SLOVENE
Vaje / Tutorial:	SLOVENSKI/SLOVENE

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites for enrolling in the course or for performing study obligations:**
Ni pogojev.	None.

Vsebina (kratek pregled učnega načrta):	**Content (syllabus outline):**
Razvoj in pomen skladišč v oskrbovalni verigi. Materialni tok; skladišče kot sistem čakalne vrste. Osnovni procesi skladiščenja (sprejem, skladiščenje, komisioniranje, sortiranje, združevanje in pakiranje, odprema). Transportno skladiščne enote; palete, zaboji, kontejnerji. Sistemi cikličnega in kontinuiranega transporta v skladišču. Vrste transporterjev glede na izvedbo, principe delovanja, zmogljivosti, nosilnosti, pogone. Vrste viličarjev in dvigal glede na principe delovanja, pogone, zmogljivosti, nosilnosti. Transportni vozički; klasični, induktivno vodeni, avtonomni.	Development and importance of warehouses in supply chain. Material flow; warehouse as a queue system. Basic warehouse process (receiving, storage, order-picking, sorting, unitizing, packaging, shipping). Transport unit loads; pallet, totes, containers. Systems of discrete and continuous transport in warehouse. Types of conveyors depending on implementation, working principle, performance, bearing strength, drives. Types of industrial trucks and cranes depending on implementation, working principle, performance, bearing strength, drives. Transport vehicles; classical, inductive guided, autonomous.

Skladiščna in manipulativna tehnika: sistemi za skladiščenje, komisioniranje, sortiranje, združevanje, pakiranje. Skladiščne in komisionirne strategije. Sistem komisioniranja "Blago-h-komisionarju" in "Komisionar-k-blagu". Specialne oblike komisionirnih sistemov (VDI združenje). Avtomatizirani sladiščno-komisionirni sistemi (AVS/RS, SBS/RS, VLM). Planiranje in izbira sistema komisioniranja ter optimiranje poti komisionarja. Obvladovanje naročil in optimiranje velikosti zalog v skladišču. Analitični in numerični modeli za določitev zmogljivosti transportno skladiščnih sistemov. Oblikovanje in optimiranje skladiščnih sistemov; načrtovanje, umestitev in optimiranje transportno-skladiščne opreme v skladišču. Načrtovanje in priprava dokumentacije izgradnje skladišča. Informacijska podpora skladiščnim procesom (WMS). Standard GS1 v skladiščnem poslovanju. Varovanje zaposlenih in tovora pri skladiščenju, notranjem transportu in manipulaciji blaga. Mobilni roboti (avtonomna oz. avtomatsko vodena vozila): uporaba mobilnih robotov v logistiki, osnovne konfiguracije, varnostni laserski skenerji, pregled komercialnih rešitev. Industrijski in kolaborativni roboti: uporaba robotov v logistiki, osnovne komponente in konfiguracije, prijemala, programiranje robotov.	Warehouse and material handling equipment: systems for storage, order-picking, sorting unitizing, packaging. Storage and order-picking strategies. Order-picking system "Picker-to-Parts" and "Parts-to-Picker". Special designs of order-picking systems (VDI association). Automated storage and order-picking systems (AVS/RS, SBS/RS, VLM). Planning and selection and of the order-picking system and route optimization. Managing orders and inventory size optimization in warehouse. Analytical and numerical models for performance analysis of transport and warehouse systems. Design and optimization of warehouse systems; planning, placement and optimization of warehouse and transport equipment in warehouse. Planning and preparation of documentation for warehouse construction. Warehouse management systems (WMS). GS1 standard in warehouse operation. Safety of employees and cargo in warehousing, internal transport and goods manipulation. Mobile robots (autonomous or automated-guided vehicles): mobile robots in logistics, basic configurations, safety laser scanners, commercial solutions. Industrial and collaborative robots: robots in logistics, basic components and configurations, grippers, robot programming.

Temeljni literatura in viri / Reading materials:

- E-gradivo predmeta.
- Glock, Christoph & Grosse, Eric. (2017). Warehousing 4.0: Technische Lösungen und Managementkonzepte für die Lagerlogistik der Zukunft, B + G Wissenschaftsverlag.
- Lerher, T., Potrč, I. (2017) Transportni sistemi v intralogistiki. Univerza v Mariboru, Fakulteta za logistiko.
- Bartholdi, John J. & Hackman, Steven T. (2017). Warehouse and distribution science, Release 0.98. The Supply Chain & Logistics Institute, H. Milton Stewart School of Industrial and Systems Engineering, Georgia Institute of Technology Atlanta, USA.
- Kay B.M. (2016) Lecture Notes for Production system design, North Carolina State University, USA.
- Gudehus, T. (2012) Logistik 1: Grundlagen, Verfahren und Strategien, Springer Verlag, Berlin.
- Arnold, D. (2002) Handbuch Logistik, Berlin, Springer Verlag, ISBN: 3-540-41996-9, COBISS.SI-ID: 24234757.

Cilji in kompetence: | **Objectives and competences:**

Študenti bodo v okviru tega predmeta: • spoznali skladiščne sisteme in skladiščno poslovanje s poudarkom na sodobnih transportno-skladiščnih sistemih, avtomatizaciji in robotizaciji skladiščnih procesov, • znali povezati znanja teoretičnih in numeričnih modelov načrtovanja in optimiranja transportno-skladiščnih sistemov, • znali samostojno in kreativno iskanje rešitev načrtovanja in optimiranja skladiščnih sistemov.	In the framework of this subject, the students will: • know warehouse systems and warehouse activity with the emphasis on modern transport-warehousing systems, automation and robotisation of warehouse process, • know to integrate knowledge of theoretical and numerical models for the design and optimization of transport andwarehouse systems, • know to independently and creatively find solutions in design and optimization of warehouse systems.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Po opravljenem izpitu bodo študentje znali: • opredeliti pomen sodobnih skladiščnih sistemov v logistični verigi, • sistemsko pristopiti pri iskanju rešitev skladiščnih sistemov v logistični verigi, • uporabiti sodobne algoritme upravljanja in optimiranja transportno-skladiščnih sistemov, • pridobljeno znanje uporabiti pri snovanju, oblikovanju in optimiranju sodobnih transportno-skladiščnih sistemov, • uporabiti modele in znanstveno literaturo pri snovanju, oblikovanju in optimiranju sodobnih transportno - skladiščnih sistemov.	Upon passing the exam, students will be able to: • define the meaning of modern warehouse systems in logistics chain, • approach systematically for finding solutions of warehouse systems in logistics chain, • use the modern algorithms for the management and optimization of transport and warehouse systems, • use the acquired knowledge for planning, design and optimization of order-picking, transport and warehouse systems, • use of models and scientific literature for planning, design and optimization of order-picking, transport and warehouse systems.

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-vaj (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 tutorial is in a classroom while the rest is in the form of e-tutorials (e-tutorials 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 %) / Share (in %)	**Assessment methods:**
• Opravljene obveznosti e-predavanj in e-vaj so pogoj za pristop k izpitu .		• Successful completion of e-lectures and e-tutorials is a prerequisite for entering the exam.

• Pisni izpit. • Ustni izpit.	50% 50%	• Written exam. • Oral exam.

Reference nosilca / Course coordinator's references:

1. KÜÇÜKYAŞAR, Melis, EKREN, Banu Y., LERHER, Tone. (2020). Cost and performance comparison for tier-captive and tier-to-tier SBS/RS warehouse configurations. International transactions in operational research. [Online ed.]. ISSN 1475-3995. https://doi-org.ezproxy.lib.ukm.si/10.1111/itor.12864, DOI: 10.1111/itor.12864.
2. Rajković, Miloš; Zrnić, N. Đ.; Kosanić, N; Borovinšek, M.; Lerher, T. (2019). A multi-objective optimization model for minimizing investment expenses, cycle times and CO2 footprint of an automated storage and retrieval systems. Transport, Vol. 34, iss. 2, 275-286, doi: 10.3846/transport.2019.9686.
3. Lerher, T. (2018). Aisle changing shuttle carriers in autonomous vehicle storage and retrieval systems. International Journal of Production Research, Vol. 56, Iss. 11, 3859-3879, doi: 10.1080/00207543.2018.1467060.
4. Ekren, B.Y., Akpunar, A., Sari, Z., Lerher, T. (2018). A tool for time, variance and energy related performance estimations in a shuttle-based storage and retrieval system. Applied mathematical modelling, Vol. 63, 109-127, https://doi.org/10.1016/j.apm.2018.06.037.
5. Lerher, T. (2018). Warehousing 4.0 by using shuttle-based storage and retrieval systems. FME Transactions, Vol. 46, Iss. 3, 381-385 doi: 10.5937/fmet1803381L.
6. Lerher, T., Borovinšek, M., Ficko, M., Palčič, I. (2017). Parametric study of throughput performance in SBS/RS based on simulation. International journal of simulation modelling, Vol. 16, No. 1, 96-107, doi: 10.2507/IJSIMM16(1)8.372.
7. Lerher, T., Ekren, B. Y., Sari, Z., Rosi. B. (2016). Method for evaluating the throughput performance of shuttle based storage and retrieval systems. Technical Gazette, Vol. 23, No. 3, 715-723.
8. Lerher, T., Ekren, B. Y., Sari, Z., Rosi. B. (2015). Simulation Analysis of Shuttle Based Storage and Retrieval Systems. International Journal of Simulation Modelling, Vol. 14, No. 1, 48-59. doi: 10.2507/IJSIMM14(1)5.281.
9. Lerher, T., EDL, M., Rosi, B. (2013) Energy efficiency model for the mini-load automated storage and retrieval systems. The international journal of advanced manufacturing technology, Vol. 70, No. 1/4, 97-115, doi: 10.1007/s00170-013-5253-x.