UČNI NAČRT PREDMETA / COURSE SYLLABUS	
Ime predmeta:	SKLADIŠČNI SISTEMI IN SKLADIŠČNO POSLOVANJE
Course title:	WAREHOUSE 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	5	10				

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). 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. Skladiščna in manipulativna tehnika: sistemi za skladiščenje, komisioniranje, sortiranje, združevanje, pakiranje. Skladiščne in komisionirne strategije.	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). 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.

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. Analitični in numerični modeli za določitev zmogljivosti transportno skladiščnih sistemov. Oblikovanje in optimiranje skladiščnih sistemov; načrtovanje, umestitev v prostor in optimiranje skladiščne opreme v skladišču. Načrtovanje in priprava dokumentacije izgradnje skladišča. Informacijska podpora skladiščnim procesom (WMS). Varovanje zaposlenih in tovora pri skladiščenju, notranjem transportu in manipulaciji blaga. Mobilni roboti (avtonomna oz. avtomatsko vodena vozila): uporaba mobilnih robotov v intralogistiki, osnovne konfiguracije, varnostni laserski skenerji, pregled komercialnih rešitev. Industrijski in kolaborativni roboti: uporaba robotov v intralogistiki, robotska prijemala, pregled komercialnih rešitev.	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. Analytical and numerical models for performance analysis of transport and warehouse systems. Design and optimization of warehouse systems; planning, placement and optimization of warehouse equipment in warehouse. Planning and preparation of documentation for building warehouse.. Warehouse management systems (WMS). Safety of employees and cargo in warehousing, internal transport and goods manipulation. Mobile robots (autonomous or automated-guided vehicles): application of mobile robots in intralogistics, basic configurations, safety laser scanners, review of commercial solutions. Industrial and collaborative robots: robots in intralogistics, robotic grippers, review of commercial solutions.

Temeljni literatura in viri / Reading materials:

- E-gradivo predmeta.
- Lerher, T. (2021). Skladiščno-komisionirni sistemi. Univerza v Mariboru, Fakulteta za strojništvo.
- Lerher, T. (2021). Avtomatsko vodeni in avtonomni vozički ter mobilni roboti v intralogistiki. Univerza v Mariboru, Fakulteta za strojništvo.
- 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.
- Ten Hompel, M., Sadowsky, V., Beck, M. (2011). Kommissionierung, Materialflusssysteme 2 - Planung und Berechnung der Kommissionierung in der Logistik, Springer-Verlag Berlin Heidelberg.
- Ten Hompel, M., Schmidt, T. (2010). Warehouse Management, Organisation und Steuerung von Lager- und Kommissioniersystemen, Springer-Verlag Berlin Heidelberg.
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Cilji in kompetence:	**Objectives and competences:**
Študenti bodo v okviru tega predmeta:	In the framework of this subject, the students will:

• spoznali skladiščne sisteme in skladiščno poslovanje s poudarkom na sodobnih skladiščnih sistemih, avtomatizaciji in robotizaciji skladiščnih procesov, • znali povezati znanja teoretičnih in numeričnih modelov načrtovanja in optimiranja skladiščnih sistemov, • znali samostojno in kreativno iskanje rešitev načrtovanja in optimiranja skladiščnih sistemov.	• know warehouse systems and warehouse activity with the emphasis on modern warehousing systems, automation and robotisation of warehouse process, • know to integrate knowledge of theoretical and numerical models for the design and optimization of warehouse systems, • know to independently and creatively find solutions in design and optimization of warehouse systems.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Študent je ob zaključku predmeta zmožen: • opredeliti pomen sodobnih skladiščnih sistemov v logistični verigi, • uporabiti sistemski pristop pri iskanju rešitev v skladiščnih sistemih v logistični verigi, • uporabiti sodobne algoritme upravljanja in optimiranja skladiščnih sistemov, • izbrati in uporabiti ustrezne modele ~~in~~ na podlagi znanstvene literature za snovanje, oblikovanje in optimiranje komisioniranja in sodobnih skladiščnih sistemov. • zasnovati, oblikovati in optimirati komisioniranje in sodobne skladiščne sisteme.	Upon passing the exam, students will be able to: • define the meaning of modern warehouse systems in logistics chain, • use a systems approach in finding solutions of warehouse systems in logistics chain, • use the modern algorithms for the management and optimization of warehouse systems, • select and use appropriate models based on scientific literature for planning, design and optimization of order-picking and warehouse systems, • plan, design and optimize the order-picking 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 laboratoriju, 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 seminar is in a laboratory while the rest is in the form of e-learning (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.	40%	• Written exam.
• Ustni izpit.	50%	• Oral exam.
• Poročilo o laboratorijskih vajah.	10 %	• Laboratory exercise report.

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.