

TEHNOLOGIJA MONTAŽE

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Tehnologija montaže
Course title:	Assembly technology
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo - projektno aplikativni program, prva stopnja, visokošolski strokovni	Proizvodne tehnologije (smer)	2. letnik	2. semester	obvezni

Univerzitetna koda predmeta/University course code: 0563507

Koda učne enote na članici/UL Member course code: 3058-V

Predavanja /Lectures	Seminar /Seminar	Vaje /Tutorials	Klinične vaje /Clinical tutorials	Druge oblike študija /Other forms of study	Samostojno delo /Individual student work	ECTS
30		30			40	4

Nosilec predmeta/Lecturer: Marko Šimic, Miha Pipan, Niko Herakovič

Izvajalci predavanj:

Izvajalci seminarjev:

Izvajalci vaj:

Izvajalci kliničnih vaj:

Izvajalci drugih oblik:

Izvajalci praktičnega usposabljanja:

Vrsta predmeta/Course type:

Izbirni strokovni predmet/Elective specialised course

Jeziki/Languages:

Predavanja/Lectures:

Slovenščina

Vaje/Tutorial:

Slovenščina

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:**Prerequisites:**

Izpolnjevanje pogojev za vpis v Visokošolski strokovni študijski program I. stopnje Strojništvo - Projektno aplikativni program.

Meeting the enrollment conditions for the MECHANICAL ENGINEERING - Project Oriented Applied Programme.

Vsebina:**Content (Syllabus outline):**

1. Montaža v proizvodnem sistemu
 - Opredelitev procesa montaže kot dela proizvodnega procesa
 - Montaža v življenjski dobi izdelka
 - Vpliv parametrov na izbiro montažnih metod
 - Povezovanje montaže z ostalimi procesi izdelave
2. Izdelki
 - Izdelki, končni izdelki, polizdelki, podsestavi, podsklopi, sestavni deli, bazni deli
 - Struktura izdelkov
 - Primeri strukture izdelkov
 - Obvladovanje variantnosti izdelkov
 - Skupine in družine izdelkov
3. Proces montaže in montažne operacije
 - Montažni proces, vplivne veličine, zveze in njihov vpliv na montažni proces
 - Predmontaža in končna montaža, montažne operacije, kriteriji delitve na predmontažo in končno montažo
 - Čas montažne operacije, entitetno-relacijski model
 - Metode določanja časa montažnih operacij
4. Struktura montažnega procesa
 - Struktura montaže in zaporednje montažnih operacij
 - Primeri strukture montažnega procesa
 - Skupni čas montaže, takt in delovni cikel, čas montažnega mesta

1. Assembly in the production system
 - Defining the assembly process as part of the production process
 - Assembly during product life cycle
 - The influence of parameters on the choice of assembly methods
 - Connecting assembly to other manufacturing processes
2. Products
 - Products, finished products, semi-finished products, subassemblies, subsystems, components, base parts
 - Product structure
 - Examples of product structure
 - Managing product variance
 - Groups and product families
3. The assembly process and assembly operations
 - The assembly process, the influential parameters, connections and their influence on the assembly process
 - Pre-assembly and final assembly, assembly operations, division criteria for pre-assembly and final assembly
 - Time of assembly operations, entity-relational model
 - Methods of determining the time of assembly operations
4. Structure of the assembly process
 - Assembly structure and sequence of assembly operations
 - Examples of the assembly process

<ul style="list-style-type: none"> □ Balansiranje montažnega procesa □ Skupine in družine izdelkov <p>5. Montažni sistemi (MS)</p> <ul style="list-style-type: none"> □ Opredelitev in načini gradnje MS, montažni podsistemi □ Tipi avtomatizacije MS, hibridni MS □ Montažni sistemi in fleksibilnost □ Organiziranost in povezanost MS ter koncepti □ Vplivne veličine na izbiro koncepta montažnega sistema <p>6. Ročni montažni sistemi</p> <ul style="list-style-type: none"> □ Ergonomsko oblikovanje delovnega mesta □ Ukrepi za lažje delo □ Skrajšanje časov montažni operacij □ Metode virtualnega oblikovanja ročnih montažnih mest in modeliranje človeka □ Primeri ergonomsko oblikovanih ročnih montažnih mest □ Ročna montaža v virtualnem okolju, uporaba modeliranja in simulacije <p>7. Organiziranost ročnih montažnih sistemov</p> <ul style="list-style-type: none"> □ Posamična montažna mesta □ Ročna montaža na več mestih – pretočna montaža z ročnim podajanjem □ Pretočna montaža z mehanskim podajanjem izdelkov v urejenem stanju □ Paletni sistemi, postavitve ročnih montažnih mest ob paletni sistem <p>8. Cenena inteligenta ročna montaža</p> <ul style="list-style-type: none"> □ Načini za povečanje učinkovitosti ročnih montažnih sistemov □ U-celice □ Implementacija cenjenih konceptov Poka-yoke in enostavnih, inteligentnih ter učinkovitih montažnih pripomočkov <p>9. Ročna montaža in Industrija 5.0</p> <ul style="list-style-type: none"> □ Metodologija Industrije 5.0 za povečanje učinkovitosti ročnih montažnih mest □ Tehnologije 5.0 in povezanost z delavcem □ Virtualno usposabljanje in trening delavcev, VR in AR □ Uporaba simulacije in tehnologije digitalnih dvojčkov montažnega procesa <p>10. Avtomatizirani montažni sistemi</p>	<p>structure</p> <ul style="list-style-type: none"> □ Total assembly time, tact and duty cycle, assembly station time □ Balancing the assembly process □ Groups and product families <p>5. Assembly systems (AS)</p> <ul style="list-style-type: none"> □ Definition and construction methods of AS, assembly subsystems □ Types of AS automation, hybrid AS □ Assembly systems and flexibility □ Organization and connection of AS and concepts □ Effective parameters for the selection of the concept of the assembly system <p>6. Manual assembly systems</p> <ul style="list-style-type: none"> □ Ergonomic workplace design □ Measures for easier work □ Reducing the assembly operations times □ Methods of virtual design of manual assembly workplaces and human modelling □ Examples of ergonomically designed manual assembly workplaces □ Manual assembly in virtual environment, use of modelling and simulation <p>7. Organization of manual assembly systems</p> <ul style="list-style-type: none"> □ Individual assembly workplaces □ Multiple assembly workplaces - Flow assembly with manual feeding □ Flow assembly with mechanical feeding of the products in an ordered condition □ Pallet systems, setting of manual assembly workplaces next to the pallet system <p>8. Low-cost intelligent manual assembly</p> <ul style="list-style-type: none"> □ Ways to increase the efficiency of manual assembly systems □ U-cells □ Implementation of low-cost Poka-yoke concepts and simple, intelligent and efficient assembly accessories <p>9. Manual assembly and the Industry 5.0</p> <ul style="list-style-type: none"> □ Industry 5.0 methodology for the increase of the efficiency of manual assembly workplaces
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<p>□ Opredelitev, tehnično ekonomski in sociološki razlogi za avtomatizacijo montaže</p> <p>□ Pogoji za uspešno uvajanje avtomatizirane montaže</p> <p>□ Diagram uvajanja novega avtomatiziranega montažnega sistema</p> <p>□ Vrste avtomatiziranih montažnih sistemov</p> <p>11. Togi avtomatizirani montažni sistemi</p> <p>□ Značilnosti, pogoji in kriteriji implementacije</p> <p>□ Enopostajni avtomati</p> <p>□ Krožni avtomati</p> <p>□ Linijski avtomati</p> <p>□ Povezovanje togih avtomatov med seboj</p> <p>□ Možnosti vključitve ročnih montažnih mest v toge avtomatizirane sisteme</p> <p>12. Fleksibilni avtomatizirani montažni sistemi</p> <p>□ Opredelitev fleksibilnosti, produktivnosti in cene, vrste fleksibilnosti, sposobnost prilagajanja obsegu proizvodnje</p> <p>□ Modularna gradnja fleksibilnih montažnih sistemov ter ponovna uporaba (Re-use)</p> <p>□ Vrste fleksibilnih avtomatiziranih montažnih sistemov in njihove značilnosti</p> <p>□ Vključevanje ročnih montažnih mest v fleksibilne avtomatizirane montažne sisteme</p> <p>□ Fleksibilni montažni sistemi s paletnim prenosom in avtomatsko vodenimi vozički</p> <p>13. Avtomatizacija operacij sestavljanja in urejanje ter urejevalne naprave</p> <p>□ Vrste zvez in postopkov sestavljanja</p> <p>□ Vijačenje, značilnosti, kriteriji avtomatizacije vijačenja, napake</p> <p>□ Kovičenje, značilnosti, kriteriji avtomatizacije kovičenja, napake</p> <p>□ Toge in fleksibilne urejevalne naprave</p> <p>□ Povezovanje urejevalnih naprav z montažnimi mesti in sistemi</p> <p>□ Veličine, ki vplivajo na izbiro urejevalnih naprav</p> <p>14. Oblikovanje izdelkov za montažo</p>	<p>□ Technologies 5.0 and connections with the employee</p> <p>□ Virtual training and employee training, VR and AR</p> <p>□ The use of simulation and digital twin technology of assembly process</p> <p>10. Automated assembly systems</p> <p>□ Definition, technical, economic and sociological reasons for assembly automation</p> <p>□ Conditions for successful introduction of automated assembly</p> <p>□ Diagram of the introduction of a new automated assembly system</p> <p>□ Types of automated assembly systems</p> <p>11. Rigid automated assembly systems</p> <p>□ Characteristics, conditions and criteria of implementation</p> <p>□ One-station automated machines</p> <p>□ Circular automated machines</p> <p>□ Automated line machines</p> <p>□ Connecting rigid automated machines to each other</p> <p>□ Possibilities of including manual assembly workplaces in rigid automated systems</p> <p>12. Flexible automated assembly systems</p> <p>□ Defining flexibility, productivity and price, types of flexibility, ability to adapt to production volume</p> <p>□ Modular design of flexible assembly systems and re-use</p> <p>□ Types of flexible automated assembly systems and their characteristics</p> <p>□ Inclusion of manual assembly workplaces in flexible automated assembly systems</p> <p>□ Flexible assembly systems with pallet transport and automatic guided vehicles</p> <p>13. Automation of assembly operations, arrangement and arrangement devices</p> <p>□ Types of joining techniques and assembly procedures</p> <p>□ Screwing, characteristics, criteria for screwing automation, errors</p> <p>□ Riveting, characteristics, criteria for automation of riveting, errors</p> <p>□ Rigid and flexible arrangement devices</p> <p>□ Connecting handling devices to</p>
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<ul style="list-style-type: none"> □ Oblikovanje izdelkov za ročno montažo in smernice □ Oblikovanje izdelkov za avtomatizirano montažo in smernice □ Izboljšanje organiziranosti montaže □ Virtualna montaža in oblikovanje izdelkov <p>15. Planiranje montažnih procesov in sistemov</p> <ul style="list-style-type: none"> □ Opredelitev, izhodišča, vplivni parametri □ Metodologija planiranja montažnih sistemov in procesov, osem korakov, časovni vidik aktivnosti □ Cilji in metode načrtovanja montažnih procesov in sistemov □ Računalniško podprte metode načrtovanja montažnih in strežnih procesov in sistemov □ Koraki pri izdelavi koncepta, integralni model načrtovanja 	<p>assembly workplaces and systems</p> <ul style="list-style-type: none"> □ Parameters that influence the choice of handling devices <p>14. Design of products for assembly</p> <ul style="list-style-type: none"> □ Designing products for manual assembly and guidelines □ Designing products for automated assembly and guidelines □ Improving the organization of assembly □ Virtual assembly and product design <p>15. Planning of assembly processes and systems</p> <ul style="list-style-type: none"> □ Definition, starting points, impact parameters □ Methodology of planning of assembly systems and processes, eight steps, time aspect of activities □ Objectives and design methods for assembly processes and systems □ Computer aided design methods for assembly and handling processes and systems □ Concept design steps, integral design model
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Temeljna literatura in viri/Readings:

Boothroyd, G.: Assembly Automation and Product Design, Second edition, CRC Press, 2005

Herakovič, N.: Tehnologija montaže, Učno gradivo, UL FS, 2019

Groover, Mikell P.: Automation, Production Systems, and Computer-Integrated Manufacturing, 2007

Takeda, H.: LCIA - Low Cost Intelligent Automation, 2. Auflage, SPS, 2006

Nof, S. Y., Wilhelm W.I., Warnecke H.-J.: Industrial Assembly, Chapman & Hall, London, 1997

Kopač., J., Noe, D.: Strega in montaža, UL FS, 1989

Cilji in kompetence:

Cilji:

Usvojiti osnovna znanja in tehnike strukturiranja izdelkov in montažnih procesov

Usvojiti osnovna znanja in tehnologije ergonomskega oblikovanja ročnih delovnih mest in oblikovanja izdelkov za

Objectives and competences:

Objectives:

To gain basic knowledge and techniques of product structuring and assembly processes

To acquire basic knowledge and technologies of ergonomic design of manual workplaces and design of

<p>montažo</p> <p>Usvojiti osnove avtomatizacije montaže in osnovne tehnologije montažnih procesov</p> <p>Spoznati osnovna znanja in tehnike za optimizacijo montažnih procesov in sistemov</p> <p>Spoznati načine in tehnike načrtovanja montažnih procesov in sistemov</p> <p>Kompetence:</p> <p>Izdelava montažno orientirane strukture izdelka in procesa, ki omogoča načrtovanje učinkovitih montažnih procesov in sistemov</p> <p>Načrtovanje ergonomsko oblikovanih ročnih in hibridnih montanih mest ter oblikovanje izdelkov za enostavno in učinkovito montažo</p> <p>Sprejemanje odločitev o stopnji, načinu in tipu avtomatizacije montažnih procesov</p> <p>Sposobnost analize in optimiranja montažnih procesov in sistemov</p> <p>Sposobnost načrtovanja učinkovitih in cenenih ter naprednih montažnih procesov in sistemov</p>	<p>products for assembly</p> <p>To gain the basics of assembly automation and basic technologies of assembly processes</p> <p>To gain basic knowledge and techniques for optimizing assembly processes and systems</p> <p>To learn the ways and techniques of designing assembly processes and systems</p> <p>Competencies:</p> <p>Creation of assembly-oriented product and process structure that enables the design of efficient assembly processes and systems</p> <p>Design of ergonomic manual and hybrid assembly workplaces and design of products for simple and efficient assembly</p> <p>Making decisions about the degree, manner and type of automation of assembly processes</p> <p>Ability to analyze and optimize assembly processes and systems</p> <p>Ability to design efficient and inexpensive and advanced assembly processes and systems</p>
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Predvideni študijski rezultati:

<p>Znanja:</p> <p>Poznavanje in razumevanje osnov ročnih in avtomatiziranih ter robotiziranih montažnih procesov in sistemov, oblikovanja izdelkov za montažo (DFA), ter osnov strukturiranja izdelka in montažnega procesa na način, da bo montažni proces najbolj učinkovit.</p> <p>Spretnosti:</p> <p>Izdelava strukture izdelka in procesa na način, da bo možno razviti učinkovit in sledljiv ter transparenten montažni proces in sistem</p> <p>Uporaba računalniško podprtih programskih orodij za razvoj in analizo</p>	<p>Knowledge:</p> <p>Knowledge and understanding of the basics of manual and automated and robotic assembly processes and systems, product design for assembly (DFA), and the basics of structuring of product and assembly process in such a way that the assembly process will be most effective.</p> <p>Skills:</p> <p>Designing the product and process structure in such a way that it is possible to develop an efficient, traceable and transparent assembly process and system</p> <p>Using computer-aided software tools for</p>
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montažnih procesov in sistemov Programiranje robotov in izvajanje simulacij gibanj robotske roke Izbira montažnemu procesu ustreznih in učinkovitih tehnologij avtomatizacije in robotizacije	the development and analysis of assembly processes and systems Programming robots and performing simulations of robot arm movements Choosing efficient automation and robotization technologies that are appropriate for the assembly process
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Metode poučevanja in učenja:

P1, P2 Avditorna predavanja podprta z interaktivnim prikazom praktičnih primerov P3 Avditorne vaje z reševanjem praktičnih primerov P4 Laboratorijske vaje s timskim reševanjem aplikativnih problemov in uporabo programske opreme ter njihova predstavitev z razpravo. P5 Uporaba študijskega gradiva v e-obliki, skripta in e-verzija predavanj. P6 Interaktivna predavanja
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Learning and teaching methods:

P1, P2 Lectures supported by interactive presentation of practical examples P3 Tutorials solving practical examples P4 Laboratory exercises with team solving of application problems, using software and presenting them with discussion. P5 Use of study material in e-form, lecture notes and e-version of lectures. P6 Interactive lectures

Načini ocenjevanja:

Delež/ Weight

Assessment:

Teoretične vsebine (predavanja): Kolokviji, pisni in/ali ustni izpit	50,00 %	Theoretical contents (lectures): Cllloquium, writing and/or oral exam
Samostojno delo na avditornih in laboratorijskih vajah (vključno s poročili):	50,00 %	Individual work in exercises, individual laboratory work (including reports):

Reference nosilca/Lecturer's references:

Niko Herakovič:

1. PIPAN, Miha, KOS, Andrej, HERAKOVIČ, Niko. Adaptive algorithm for the quality control of braided sleeving : Miha Pipan, Andrej Kos, and Niko Herakovic. *Advances in mechanical engineering*, ISSN 1687-8132. [Printed ed.], 2014, str. 1-8, ilustr., doi: [10.1155/2014/812060](https://doi.org/10.1155/2014/812060). [COBISS.SI-ID [13667611](#)], [JCR, SNIP, WoS, Scopus]
2. GACEVA, Gordana Bogoeva, HERAKOVIČ, Niko, DIMESKI, Dimko, STEFOV, Viktor. Ultrasound assisted process for enhanced interlaminar shear strength of carbon fiber/epoxy resin composites. *Macedonian journal of chemistry and chemical engineering*, ISSN 1857-5552, 2010, vol. 29, no. 2, str. 149-155. [COBISS.SI-ID [11851291](#)], [JCR, SNIP, WoS, Scopus]
3. HERAKOVIČ, Niko. Flow-force analysis in a hydraulic sliding-spool valve.

Strojarstvo : časopis za teoriju i praksu u strojarstvu, ISSN 0562-1887, 2009, vol. 51, no. 6, str. 555-564. http://hrcak.srce.hr/index.php?show=clanak&id_clanak_jezik=77620. [COBISS.SI-ID [11989787](#)], [JCR, SNIP]

4. HERAKOVIČ, Niko, NOE, Dragica. Experimental analysis of conditions for machine vision control in EM stator assembly process. V: *IFAC Workshop on Intelligent Assembly and Disassembly, IAD'07, Alicante, Spain, May 23-25, 2007*. [Alicante]: [Universidad de Alicante]. 2007, str. 110-115. [COBISS.SI-ID [10336795](#)], [Scopus]
5. HERAKOVIČ, Niko, ZUPAN, Hugo, DEBEVEC, Mihael. *FMS simulation model and analysis of the factory : report of the project (done in year 2017)*. Ljubljana: Fakulteta za strojništvo, Laboratorij LASIM, 2017. 12 f., ilustr. [COBISS.SI-ID [16025883](#)]

Marko Šimic:

1. TURK, Maja, **ŠIMIC, Marko**, PIPAN, Miha, HERAKOVIČ, Niko. Multi-criterial algorithm for the efficient and ergonomic manual assembly process. *International journal of environmental research and public health*. [Online ed.]. Mar. 2022, vol. 19, iss. 6, str. 1-17, ilustr. ISSN 1660-4601. <https://www.mdpi.com/1660-4601/19/6/3496>, DOI: [10.3390/ijerph19063496](#). [COBISS.SI-ID [101798659](#)], [JCR, SNIP, WoS do 25. 2. 2023: št. citatov (TC): 4, čistih citatov (CI): 4, čistih citatov na avtorja (CIAu): 1,00, Scopus do 22. 1. 2023: št. citatov (TC): 4, čistih citatov (CI): 4, čistih citatov na avtorja (CIAu): 1,00]
2. TURK, Maja, PIPAN, Miha, **ŠIMIC, Marko**, HERAKOVIČ, Niko. Simulation-based time evaluation of basic manual assembly tasks. *Advances in production engineering & management*. Sep. 2020, vol. 15, no. 3, str. 331-344, ilustr. ISSN 1854-6250. http://www.apem-journal.org/Archives/2020/Abstract-APEM15-3_331-344.html, DOI: [10.14743/apem2020.3.369](#). [COBISS.SI-ID [40044035](#)], [JCR, SNIP, WoS do 3. 11. 2022: št. citatov (TC): 6, čistih citatov (CI): 6, čistih citatov na avtorja (CIAu): 1,50, Scopus do 12. 11. 2022: št. citatov (TC): 8, čistih citatov (CI): 8, čistih citatov na avtorja (CIAu): 2,00]
3. TURK, Maja, PIPAN, Miha, **ŠIMIC, Marko**, HERAKOVIČ, Niko. A smart algorithm for personalizing the workstation in the assembly process. *Applied sciences*. Dec. 2020, vol. 10, iss. 23, f. 1-19, ilustr. ISSN 2076-3417. <https://www.mdpi.com/2076-3417/10/23/8624/htm>, DOI: [10.3390/app10238624](#). [COBISS.SI-ID [40663299](#)], [JCR, SNIP, WoS do 12. 1. 2023: št. citatov (TC): 5, čistih citatov (CI): 4, čistih citatov na avtorja (CIAu): 1,00, Scopus do 14. 2. 2023: št. citatov (TC): 5, čistih citatov (CI): 4, čistih citatov na avtorja (CIAu): 1,00]
4. **ŠIMIC, Marko**, HERAKOVIČ, Niko. Advanced spool materials for friction reduction in pneumatic valves. V: LOVREC, Darko (ur.), TIČ, Vito (ur.). *Conference proceedings. International Conference Fluid Power 2019*. 1st ed. Maribor: University of Maribor Press, Faculty of Mechanical Engineering, 2019. Str. [75]-87, ilustr. ISBN 978-961-286-301-2. [COBISS.SI-ID [16798491](#)]
5. JANKOVIČ, Denis, NOVAK, Rok, **ŠIMIC, Marko**, HERAKOVIČ, Niko. The concept of automatic generation of hydraulic press cycle. V: LOVREC, Darko (ur.), TIČ, Vito (ur.). *International Conference Fluid Power 2021 : conference proceedings : Maribor, Slovenia, 16. - 17. September 2021*. 1st ed. Maribor: University of Maribor, University Press, 2021. Str. 285-300, ilustr. ISBN 978-961-286-513-9. DOI: [10.18690/978-961-286-513-9.24](#). [COBISS.SI-ID [77602051](#)]

Miha Pipan:

1. TURK, Maja, ŠIMIC, Marko, **PIPAN, Miha**, HERAKOVIČ, Niko. Multi-criterial algorithm for the efficient and ergonomic manual assembly process. *International journal of environmental research and public health*. [Online ed.]. Mar. 2022, vol. 19, iss. 6, str. 1-17, ilustr. ISSN 1660-4601. <https://www.mdpi.com/1660-4601/19/6/3496>, DOI: [10.3390/ijerph19063496](https://doi.org/10.3390/ijerph19063496). [COBISS.SI-ID [101798659](#)], [JCR, SNIP, WoS do 25. 2. 2023: št. citatov (TC): 4, čistih citatov (CI): 4, čistih citatov na avtorja (CIAu): 1,00, Scopus do 22. 1. 2023: št. citatov (TC): 4, čistih citatov (CI): 4, čistih citatov na avtorja (CIAu): 1,00]
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