

PROIZVODNO INŽENIRSTVO

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Proizvodno inženirstvo
Course title:	Production Engineering
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo - razvojno raziskovalni program, prva stopnja, univerzitetni (od študijskega leta 2026/2027 dalje)	Ni členitve (študijski program)	3. letnik	2. semester	izbirni

Univerzitetna koda predmeta/University course code:	0562778
Koda učne enote na članici/UL Member course code:	2038-U

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:	doc. dr. Tomaž Berlec, prof. dr. Niko Herakovič, izr. prof. dr. Marko Šimic
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Izvajalci predavanj:	
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	

Vrsta predmeta/Course type:	Splošni izbirni predmet /Elective general course
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Jeziki/Languages:	Predavanja/Lectures:	Slovenščina
	Vaje/Tutorial:	Slovenščina

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	Prerequisites:
Izpolnjevanje pogojev za vpis v Univerzitetni študijski program I. stopnje Strojništvo - Razvojno raziskovalni program.	Meeting the enrollment conditions for the Academic study programme of Mechanical Engineering - Research and Development program.

Vsebina:	Content (Syllabus outline):
Predavanja: Proizvodni procesi in sistemi - Opredelitev proizvodnih procesov in sistemov; - Proizvodna sredstva; - Vloga ročnega dela in avtomatizacije;	. Lecture: Production processes and systems - Defining of production processes and systems; - Production means; - The role of manual labor and automation;

- Povezava z življenjsko dobo izdelka. 2. Predavanje: Izdelek - Opredelitev izdelka in njegovih komponent; - Vloga in funkcija strukture izdelka; - Tipi posameznih struktur in njihove lastnosti; - Obvladovanje variantne kompleksnosti izdelka. 3. Predavanje: Proizvodni procesi - Vplivne veličine in vzroki za delitev na podprocese, delovne operacije – opredelitev in lastnosti; - Metode in modeli za določanje časa posameznih delovnih operacij; - Struktura proizvodnega procesa; - Vrste delovnih operacij. 4. Predavanje: Ročna delovna mesta - Značilnosti ročnih delovnih mest; - Pretočni sistemi s podajanjem v urejenem in neurejenem stanju; - Časovna in prostorska povezanost ter organiziranost. 5. Predavanje: Ergonomija delovnih mest - Metode za povečanje učinkovitosti dela; - Ergonomsko oblikovanje ročnega delovnega mesta; - Ukrepi za lažje delo; - Metode krajšanja časov delovnih operacij. 6. Predavanje: Avtomatizacija proizvodnih procesov - Togi sistemi; - Fleksibilni sistemi; - Hibridni sistemi. 7. Predavanje: Robotizirani sistemi - Anatomija robota in njegovi atributi; - Krmilni podsistem robota in načini programiranja; - Robotska prijemala; - Urejevalni sistemi. 8. Predavanje: Uvod v LEAN in Digitalni LEAN - Osnovni koncept LEANa; - Osnove Digitalnega LEANa; - Digitalne tehnologije I4.0 kot podpora LEANu. 9. Predavanje: Projekt in projektno vodenje - Mesto in vloga projektnega vodenja v industriji; - Definicija projekta in projektnega vodenja, primeri projektov; - Vrste projektov glede na različne kriterije delitve ter razlika med projektom in običajno nalogo. 10. Predavanje: Timsko delo - Razlika med timskim in skupinskim delom; - Načini oblikovanja timov; - Timske vloge, koraki rasti učinkovitega tima. 11. Predavanje: Cilji projekta - Namenski in objektni cilji projekta; - Strategije za doseganje projektnih ciljev; - Organiziranje projekta (strukturirana členitev vsebine dela, organizacijska struktura projekta, matrike odgovornosti udeležencev projekta do aktivnosti projekta). 12. Predavanje: Tehnike prikazovanja poteka dela	- Connection to the product life-cycle. 2. Lecture: Product - Definition of the product and its components; - The role and function of the product structure; - Types of individual structures and their properties; - Managing the variant complexity of the product. 3. Lecture: Production processes - Influential parameters and causes of division into sub-processes, work operations - definition and properties; - Methods and models for determining the timing of individual work operations; - Structure of the production process; - Types of work operations. 4. Lecture: Manual workplaces - Characteristics of manual workplaces; - Flow systems with arranged or unarranged feeding; - Temporal and spatial connections and organization. 5. Lecture: Ergonomics of workplaces - Methods for increasing work efficiency; - Ergonomic design of manual workplaces; - Measures for easier work; - Methods of shortening the duration of work operations. 6. Lecture: Automation of Production Processes - Rigid systems; - Flexible systems; - Hybrid systems. 7. Lecture: Robotic systems - Anatomy of a robot and its attributes; - Robot control subsystem and programming modes; - Robotic grippers; - Feeding and arrangement systems. 8. Lecture: Introduction to LEAN and Digital LEAN - The basic concept of LEAN; - Basics of Digital LEAN; - Digital I4.0 technologies as a support to LEAN. 9. Lecture: A project and project management - The place and role of project management in industry; - Definition of a project and project management, examples of projects; - Types of projects according to different division criteria and the difference between the project and a usual task. 10. Lecture: Teamwork - The difference between teamwork and group work; - Ways to form teams; - Team roles, steps to build an efficient team. 11. Lecture: Project goals - Purposive and objective goals of a project; - Strategies for achieving project goals; - Organizing a project (work breakdown structure, organizational structure of the project, responsibility
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na projektu in analiza časa projekta - Mrežne tehnike; - Vrste in pomen različnih odvisnosti med aktivnostmi projekta; - CPM in PERT metoda; - Gantovi diagram. 13. Predavanje: Metode za analiziranje virov projekta - Razpoložljivost virov; - Obremenitveni profili virov; - Izravnavanje virov. 14. Predavanje: Stroški projekta - Stroški posameznega vira; - Direktni strošek aktivnosti; - Skupni stroški projekta. 15. Predavanje: Spremljanje realizacije projekta - Lansiranje aktivnosti izvajalcem; - Aktualizacija projekta; - Sprejemanje ukrepov, kaj-če analiza.	matrix of project participants in relation to project activities). 12. Lecture: Techniques for presenting the progress of work on the project and project time analysis - Network techniques; - Types and meaning of different dependencies between project activities; - CPM and PERT method; - Gantt chart. 13. Lecture: Methods for analyzing project resources - Availability of resources; - Allocation profiles of resources; - Leveling up resources. 14. Lecture: Project costs - Costs of individual source; - Direct activity cost; - Total project costs. 15. Lecture: Monitoring the realization of the project - Launching activities to executors; - Project actualization; - Determination of measures, what-if analysis.
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Temeljna literatura in viri/Readings:

1. Kuzman, K. idr. Moderno proizvodno inženirstvo, Izbrana poglavja. Grafis Trade, Grosuplje, 2010, [COBISS.SI-ID [244690944](#)].
2. Groover, M. P. Automation, Production Systems, and Computer-Integrated Manufacturing. 2019, [COBISS.SI-ID [146606595](#)].
3. Boothroyd, G. Assembly Automation and Product Design, Second edition, CRC Press, 2005, [COBISS.SI-ID [26842117](#)].
4. A Guide to the Project Management Body of Knowledge, 6th ed., PMI Standards Committee, Project Management Institute, Upper Darby, USA, 2017, [COBISS.SI-ID [31665191](#)].
5. Stare, Aljaž: Agilno!? : projekti, zaposleni, podjetja , 2021, [COBISS.SI-ID [41366019](#)].
6. Saunders, Ken, Basic manufacturing, Oxford [etc.] : Butterworth-Heinemann, cop. 1999, [COBISS.SI-ID [3410971](#)].

Cilji in kompetence:

Cilji:

1. Usvojiti koncepte, strukturo in ključne tehnologije proizvodnih procesov in sistemov
2. Usvojiti metode in načine optimiranja proizvodnih podprocesov in podsistemov ter medsebojnih povezav izdelkov, proizvodnih procesov in sistemov
3. Usvojiti moderne koncepte vodenja projektov
4. Spoznati metode in načine izdelave načrta projekta

Kompetence:

S1-RRP: Sposobnost razumevanja in strukturiranja ključnih tehnologij proizvodnih procesov in sistemov
S2-RRP: Sposobnost holističnega pogleda na proizvodne procese in sisteme ter načrtovanja in oblikovanja posameznih ključnih procesov in sistemov ter oblikovanje izdelkov, ki bodo omogočili učinkovito izvajanje proizvodnih procesov

Objectives and competences:

Objectives:

1. To acquire the concepts, structure and key technologies of production processes and systems
2. To acquire methods and ways for optimizing production sub-processes and sub-systems, and interconnections of products, production processes and systems
3. To acquire modern project management concepts
4. To learn the methods and means of project planning

Competencies:

S1-RRP: The ability to understand and structure key technologies of production processes and systems
S2-RRP: The ability to take a holistic view of production processes and systems, to plan and design individual key processes and systems, and to design products that will enable the efficient execution of production processes

S6-RRP: Sposobnost uporabe pridobljenih znanj pri izdelavi načrta projekta P3-RRP: Temeljna usposobljenost na področju strojništva, ki omogoča nadaljevanje na magistrskem študiju P6-RRP: Sposobnost razčlenitve lažjih strokovnih nalog	S6-RRP: The ability to use the acquired knowledge in the project planning P3-RRP: Having basic engineering competence, which allows him/her to carry on studying on Level 2. P6-RRP: The ability to analyse easier professional tasks
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Predvideni študijski rezultati:

Znanja: Z1: Pridobljena znanja uporabi študent za holistično obravnavanje osnovnih proizvodnih procesov in sistemov, za njihovo načrtovanje in oblikovanje v smeri doseganja čim večje učinkovitosti procesov in izkoriščenosti proizvodnih sredstev. Pri tem izhaja iz izdelka. Obenem pridobi študent poglobljeno strokovno teoretično in praktično znanje na področju vodenja projektov, podprto s širšo teoretično in metodološko osnovo. Spretnosti: S1.1 Optimizacija obstoječih ali načrtovanje novih, bolj učinkovitih proizvodnih procesov in sistemov S1.2 Oblikovanje ergonomsko oblikovanih delovnih mest S1.3 Načrtovanje avtomatiziranih in robotiziranih proizvodnih procesov in sistemov S1.4 Izvajanje kompleksnih operativno-strokovnih opravil na področju vodenja projektov, ki vključujejo tudi uporabo metodoloških orodij S1.5 Obvladovanje zahtevnih, kompleksnih delovnih procesov ob samostojni uporabi znanja v novih situacijah. S1.6 Diagnosticiranje in reševanje problemov v različnih specifičnih delovnih okoljih, povezanih s področjem izobraževanja in usposabljanja S1.7 Osnova za izvirna dognanja/stvaritve in kritično refleksijo	Intended learning outcomes: Knowledge: Z1: The student uses the acquired knowledge to holistically address the basic production processes and systems, to plan and design them in order to maximize the efficiency of processes and the utilization of production means. In doing so, he stems from the product. At the same time the student acquires in-depth professional theoretical and practical knowledge in the field of project management, supported by a broader theoretical and methodological basis. Skills: S1.1 Optimization of existing or design of new, more efficient production processes and systems S1.2 Designing ergonomically designed work places S1.3 Planning of automated and robotic manufacturing processes and systems S1.4 Performing complex operational and professional tasks in the field of project management, including the use of methodological tools S1.5 Mastering difficult, complex work processes while independently using knowledge in new situations. S1.6 Diagnosing and problem solving in various specific work environments related to education and training S1.7 Basis for original findings / creations and critical reflection
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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	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
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Načini ocenjevanja:

Delež/Weight

Assessment:

Teoretične vsebine (predavanja): kolokviji, pisni in/ali ustni izpit.	60,00 %	Theoretical contents (lectures): partial exams, written and/or oral exam.
Samostojno delo na avditornih in laboratorijskih vajah (vključno s poročili).	40,00 %	Individual laboratory work in exercises, individual laboratory work (including reports).

Ocenjevalna lestvica:	Grading system:
5 - 10, pri čemer velja, da je pozitivna ocena od 6 - 10	5 - 10, a student passes the exam if he is graded from 6 to 10

Reference nosilca/Lecturer's references:

Niko Herakovič:

1. VUZEM, Filip Jure, PIPAN, Miha, ZUPAN, Hugo, ŠIMIC, Marko, **HERAKOVIČ, Niko**. Automated generation of simulation models and a digital twin framework for modular production. *Systems*. 2025, vol. 13, iss. 9, [article no.] 800, 32 str., ilustr. ISSN 2079-8954. <https://www.mdpi.com/2079-8954/13/9/800>, DOI: 10.3390/systems13090800. [COBISS.SI-ID [249817347](#)].
2. JANKOVIČ, Denis, ŠIMIC, Marko, **HERAKOVIČ, Niko**. A comparative study of machine learning regression models for production systems condition monitoring. *Advances in production engineering & management*. Mar. 2024, vol. 19, nr. 1, str. 78–92, ilustr. ISSN 1854-6250. https://apem-journal.org/Archives/2024/Abstract-APEM19-1_078-092.html, DOI: 10.14743/apem2024.1.494. [COBISS.SI-ID [201874947](#)].
3. JANKOVIČ, Denis, PIPAN, Miha, ŠIMIC, Marko, **HERAKOVIČ, Niko**. Polynomial regression-based predictive expert system for enhancing hydraulic press performance over a 5g network. *Applied sciences*. 2024, vol. 14, iss. 24, [art. no.] 12016, 24 str., ilustr. ISSN 2076-3417. <https://www.mdpi.com/2076-3417/14/24/12016>, DOI: 10.3390/app142412016. [COBISS.SI-ID [220374019](#)].
4. ZUPAN, Hugo, ŽEROVNIK, Janez, **HERAKOVIČ, Niko**. A hybrid metaheuristics for layout optimization in production cell. V: VALENTINČIČ, Joško (ur.), LEVY, Paul R. (ur.), SABOTIN, Izidor (ur.). MIT 2016 : proceedings of the 14th International Conference on Management and Innovative Technologies, Fiesa, Slovenia, 5th-7th September 2016. 14th International Conference on Management and Innovative Technologies, Fiesa, Slovenia, 5th-7th September 2016. Ljubljana: LAT - Laboratory for Alternative Technologies, Faculty of Mechanical Engineering, 2016. F. 81-87, ilustr. ISBN 978-961-6980-17-3. <https://mitconference.files.wordpress.com/2016/09/mit2016-conference-proceedings.pdf>. [COBISS.SI-ID [14925595](#)].
5. JOVANOVIĆ, Vukica, DEBEVEC, Mihael, **HERAKOVIČ, Niko**, VERMA, Alok, TOMOVIC, Mileta M. Applications of digital manufacturing in manufacturing process support. *The technology interface*. 2016, vol. 16, nr. 2, f. 41-46, ilustr. ISSN 1523-9926. http://tijj.org/issues/issues/spring2016/Z__TIIJ%20spring%202016%20v16%20n2.pdf. [COBISS.SI-ID [14795291](#)].

Tomaž Berlec:

1. MARC, Ivan, KUŠAR, Janez, **BERLEC, Tomaž**. Decision-making techniques of the consumer behaviour optimisation of the product own price. *Applied sciences*. 2022, vol. 12, iss. 4, str. 1-14, ilustr. ISSN 2076-3417. <https://www.mdpi.com/2076-3417/12/4/2176>, [Repozitorij Univerze v Ljubljani – RUL](#), DOI: [10.3390/app12042176](#). [COBISS.SI-ID [99620867](#)].
2. JORDAN, Eva, **BERLEC, Tomaž**, RIHAR, Lidija, KUŠAR, Janez. Simulation of cost driven value stream mapping. *International journal of simulation modelling*. Sep. 2020, vol. 19, no. 3, str. 458-469, ilustr. ISSN 1726-4529. http://www.ijssimm.com/Full_Papers/Fulltext2020/text19-3_527.pdf, [Repozitorij Univerze v Ljubljani – RUL](#), DOI: [10.2507/IJSIMM19-3-527](#). [COBISS.SI-ID [27881731](#)].
3. ŽUŽEK, Tena, RIHAR, Lidija, **BERLEC, Tomaž**, KUŠAR, Janez. Standard project risk analysis approach. *Business systems research journal : international journal of the Society for Promotion of Business Information Technology (BIT)*. 2020, vol. 11, no. 2, str. 149-158, ilustr. ISSN 1847-8344. <http://www.bsrijournal.org/vol-11-no-2.html>, DOI: [10.2478/bsrij-2020-0021](#). [COBISS.SI-ID [32720643](#)].
4. ŽUŽEK, Tena, KUŠAR, Janez, **BERLEC, Tomaž**. Guidelines for agile concurrent product development in SMEs. V: DROBNE, Samo (ur.), et al. *SOR '21 proceedings: the 16th International Symposium on Operational Research in Slovenia: September 22 - 24, 2021, online*. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2021. Str. 233-238, ilustr. ISBN 978-961-6165-57-0. [Repozitorij Univerze v Ljubljani – RUL](#). [COBISS.SI-ID [83774467](#)].
5. VIDMAR, Matej, KUŠAR, Janez, **BERLEC, Tomaž**. Prenova projektnega informacijskega sistema podjetja. V: BERLEC, Tomaž (ur.), BROJAN, Miha (ur.), DROBNIČ, Boštjan (ur.). *Zbornik del : Študentska tehniška konferenca ŠTeKam, Ljubljana, 13. 9. 2018*. Ljubljana: Fakulteta za strojništvo, 2018. F. 174-181, ilustr. ISBN 978-961-6980-48-7. [COBISS.SI-ID [16232731](#)].

Marko Šimic:

1. JANKOVIČ, Denis, **ŠIMIC, Marko**, HERAKOVIČ, Niko. A comparative study of machine learning regression models for production systems condition monitoring. *Advances in production engineering & management*. Mar. 2024, vol. 19, nr. 1, str. 78–92, ilustr. ISSN 1854-6250. https://apem-journal.org/Archives/2024/Abstract-APEM19-1_078-092.html, DOI: 10.14743/apem2024.1.494. [COBISS.SI-ID [201874947](#)]
2. **ŠIMIC, Marko**, HERAKOVIČ, Niko. Investigation of innovative high-response piezoelectric actuator used as smart actuator–sensor system. *Applied sciences*. 2024, vol. 14, iss. 18, art. 8523, str. 1-17, ilustr. ISSN 2076-3417. <https://www.mdpi.com/2076-3417/14/18/8523>, DOI: 10.3390/app14188523. [COBISS.SI-ID [208705027](#)]
3. PIPAN, Miha, **ŠIMIC, Marko**, VONČINA, Leon, HERAKOVIČ, Niko. Use of 5G technology in manufacturing processes and systems. *Ventil : revija za fluidno tehniko in avtomatizacijo*. jun. 2024, letn. 30, št. 3, str. 144-150, ilustr. ISSN 1318-7279. [COBISS.SI-ID [200884739](#)]
4. **ŠIMIC, Marko**, JANKOVIČ, Denis, MATOŠA, Klemen, HERAKOVIČ, Niko. Simulation analysis of influential parameters effecting the hydraulic press behaviour. V: LOVREC, Darko (ur.), TIČ, Vito (ur.). *International conference Fluid Power 2023 : conference proceedings* : [Maribor, Slovenia, 20th - 21st September 2023]. 1st ed. Maribor: University of Maribor, University Press, 2023. Str. [219]-233, ilustr. ISBN 978-961-286-782-9. <https://press.um.si/index.php/ump/catalog/book/811>. [COBISS.SI-ID [165508867](#)]
5. TURK, Maja, **ŠIMIC, Marko**, KOS, Andrej, DEBEVEC, Mihael, ADROVIČ, Edo, HERAKOVIČ, Niko, ZUPAN, Hugo, RESMAN, Matevž. Časovna analiza preprostih gibov v programu SIEMENS Jack : zaključno poročilo o rezultatih raziskovalno razvojnega dela. Ljubljana: Fakulteta za strojništvo, Laboratorij za strego, montažo in pnevmatiko, 2017. 56 str., graf. prikazi. [COBISS.SI-ID [15594523](#)]