TRANSMISIJE IN POGONI V INDUSTRIJI

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Transmisije in pogoni v industriji
Course title:	Industrial Power-Trains
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo - projektno aplikativni program, prva stopnja, visokošolski strokovni (od študijskega leta 2026/2027 dalje)	Konstruiranje industrijskih sistemov (smer)	3. letnik	1. semester	obvezni

Univerzitetna koda predmeta/University course code:	0563471
Koda učne enote na članici/UL Member course code:	3054-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:	prof. dr. Jernej Klemenc, izr. prof. dr. Simon Oman

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. Predavalnje: Bilanca sil in moči v industrijskih pogonih: - Upori in bremena kot ponori moči; - Pogonski stroj kot izvor moči;	1. Lecture: Force and power balance in industrial power-trains: - Resistors and loads as power consumers; - Driving engine as power source;

- Transmisija kot sestav komponent od izvora do ponora moči. 2. Predavanje: Vrste prenosa moči in možnosti za rekuperacijo energije: - Mehanski prenos moči; - Hidravlični prenos moči; - Električni prenos moči. 3. Predavanje: Vrste pogonskih strojev in njihove značilnosti: - Karakteristika idealnega pogonskega stroja; - Elektromotorji; - Motorji z notranjim zgorevanjem. 4. Predavanje: Gonila za mehanski prenos moči: - Kdaj potrebujemo različna prestavna razmerja v gonilih; - Diskretna prestavna razmerja; - Zvezno nastavljiva prestavna razmerja. 5. Predavanje: Gonila za mehanski prenos moči: - Značilnosti gonil z oblikovnim prenosom moči; - Izgube in samozapornost gonila; - Značilnosti gonil s tornim prenosom moči. 6. Predavanje: Pogonski sistemi z več izvori ali ponori moči: - Princip delitve moči iz enega izvora; - Princip sumacije moči iz več izvorov; - Distribuirani pogoni; - Problem sinhronizacije tokov moči. 7. Predavanje: Osnove planetnih gonil kot mehanskih sumatorjev ali delilnikov moči: - Vrste in oznake planetnih gonil; - Grafična določitev notranjih prestav enostavnega planetnega gonila; - Navori na gredeh planetnega gonila. 8. Predavanje: Osnove planetnih gonil kot mehanskih sumatorjev ali delilnikov moči: - Wolfova shema; - Zunanje prestave planetnega gonila; - Kotalna in sklopna moč planetnega gonila. 9. Predavanje: Osnove planetnih gonil kot mehanskih sumatorjev ali delilnikov moči: - Kombinirana planetna gonila. 10. Predavanje: Primeri mehanskih menjalnikov: - Ročni sekvenči menjalnik; - Ročni menjalnik s predležno gredjo; - Avtomatski menjalnik z dvojno sklopko. 11. Predavanje: Avtomatski menjalnik s pretvornikom navora: - Ravigneaux planetno gonilo; - Hidravlični pretvornik navora; - Izgube pri prenosu moči. 12. Predavanje: Usmerjanje navora v transmisiji z razvejišči: - Diferencialna gonila v transmisiji z razvejišči; - Uporaba visko-sklopke v transmisiji z razvejišči; - Vektoriranje navora. 13. Predavanje: Električni hibridni prenosniki moči: - Zaporedni hibridni pogon; - Vzporedni hibridni pogon;	- Transmission as an assembly of components between power source and power consumption. 2. Lecture: Power-transmisson types and possibilities for energy recovery: - Mechanical transmissions; - Hydraulic transmissions; - Electric transmissions. 3. Lecture: Driving engine types and their output characteristics: - Characteristics of an ideal power source; - Electric motors; - Internal combustion engines. 4. Lecture: Mechanical transmission systems: - When different transmission ratios are needed in gearboxes; - Discreete transmission ratios; - Continously variable transmissions. 5. Lecture: Mechanical transmission systems: - Characteristics of transmissions with geometric power transmission; - Power losses and self-locking; - Characteristics of transmissions with frictional power transmission. 6. Lecture: Transmission systems with multiple power sources and outputs: - Principle of power splitting from one source; - Principle of power summation from multiple sources; - Distributed transmissions; - Problem of power-flow synchronisation. 7. Lecture: Introduction to planetary gears as mechanical power summators or splitters: - Types and designations of planetary gears; - Graphical determination of internal (stable) gear ratios for a simple planetary gear; - Torques in shafts of the planetary gear. 8. Lecture: Introduction to planetary gears as mechanical power summators or splitters: - Wolf's scheme; - Outer gear ratios of the planetary gear; - Rolling and swirching power in the planetary gear. 9. Lecture: Introduction to planetary gears as mechanical power summators or splitters: - Combined planetary gears. 10. Lecture: Examples of mechanical gearboxes: - Manual sequential gearbox; - Manual conventional gearbox; - Automatic dual-clutch gearbos. 11. Lecture: Automatic gearbox with torque converter: - Ravigneaux planetary gear; - Hydraulic torque converter; - Power losses during power transmission. 12. Lecture: Torque vectoring in transmission with multiple branches: - Differential gear in transmission with multiple branches; - Application of visco-clutch in transmission with

- Kombinirani hibridni pogon. 14. Predavanje: Hidravlični prenosniki moči: - Hidrostatični prenosnik moči; - Hidrodinamični prenosnik moči. 15. Predavanje: Kombinirani mehansko-hidravlični prenosnik moči: - Razcep in združenje tokov moči; - Zveznost prestavnega razmerja; - Inverzija smeri vrtenja in blokada hidravličnega toka moči; - Izkoristek transmisije.	multiple branches; - Torque vectoring. 13. Lecture: Electric hybrid power-trains: - Serial hybrid drive; - Parallel hybrid drive; - Combined hybrid drive. 14. Lecture: Hydraulic power-trains: - Hydrostatic hydraulic transmission; - Hydrodynamic hydraulic transmission. 15. Lecture: Combined hydro-mechanical transmission systems: - Power splitting and summation; - Continously variable transmission; - Inverter of angular velocity and locking of hydraulic power flow; - Power efficiency.

Temeljna literatura in viri/Readings:

1. Klemenc J. Dinamika vozil – učbenik. Ljubljana: UL, Fakulteta za strojništvo, 2019. [COBISS.SI-ID 300788992]
2. Wittel H., Jannasch D., Vossiek J., Spura C. Roloff/Matek Maschinenelemente – 23. Auflage. Springer Vieweg, 2017. [COBISS.SI-ID 15706907]
3. Flašker J., Pehan S. Prenosniki moči : učbenik. UM, Fakulteta za strojništvo, 2005. [COBISS.SI-ID 55774209]

Cilji in kompetence:	**Objectives and competences:**
Cilji: Spoznati osnovne principe uravnoteženja moči pri industrijskih pogonih. Spoznati različne variante transmisij in pogonov v industriji. Spoznati kriterije za izbiro posameznih tipov industrijskih pogonov. Spoznati delovne principe, koncipiranje in oblikovanje osnovnih mehanskih industrijskih pogonov. Spoznati delovne principe naprednih industrijskih pogonov v smislu njihove uporabe. Kompetence: S1-PAP: Sposobnost uporabe pridobljenega znanja s področja industrijskih pogonov v praksi. S10-PAP: Sposobnost strokovnega sporazumevanja in pisnega izražanja z obravnavanega področja. S13-PAP: Sposobnost iskanja virov znanja, selekcija najdenih virov in uporaba tako pridobljenega znanja pri svojem delu. P1-PAP: Razume fizikalne zakone in pojave, na katerih temelji funkcija mehanskih, hidravličnih in električnih pogonov. P8-PAP: Obvlada osnovna in potrebna specifična znanja v izbrani študijski smeri (analiza in sinteza industrijskih pogonov).	Objectives: To learn basic principles of power balancing in industrial power-trains. To learn different types of transmission systems in the industry. To train usage of the relevant criteria for selecting different types of industrial power-trains. To learn work principles, conceptualisation and design of basic mechanical industrial power-trains. To learn working principles of complex industrial power-trains from the viewpoint of ther application. Competences: S1-PAP: The ability to use the attained knowledge of industrial power-trains in the practice. S10-PAP: The ability to communicate professionally and express oneself in writing. S13-PAP: The ability to find sources of knowledge, select among the available resources and use the knowledge acquired for one's work. P1-PAP: Understanding the laws of physics and the phenomena behind the operating principles of mechanical, hydraulic and electric power-trains. P8-PAP: Mastering the basic and required specific knowledge from the selected study (analysis and synthesis of industrial power-trains).

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanja: Z1: Poglobljeno strokovno teoretično in praktično	Knowledge: Z1: Thorough professional theoretical and practical

znanje na določenem področju, podprto s širšo teoretično in metodološko osnovo: - Razumevanje zveze med potrebami in viri moči v industrijskih pogonih. - Razumevanje teoretičnih in praktičnih osnov za izbiro, koncipiranje in oblikovanje nezahtevnih industrijskih pogonov. - Razumevanje delovanja naprednih industrijskih pogonov na nivoju njihove aplikacije. Spretnosti: S1.1 Izvajanje kompleksnih operativno-strokovnih opravil, ki vključujejo tudi uporabo metodoloških orodij: - Preračun zunanjih karakteristik mehanskih gonil. - Izdelava projektne ali nabavne dokumentacije za sestavne elemente industrijskih gonil. S1.2 Obvladovanje zahtevnih, kompleksnih delovnih procesov ob samostojni uporabi znanja v novih delovnih situacijah: - Vodenje vzdrževalnih posegov različne pogonske sisteme v industriji.	knowledge in a selected field of expertise that is supported with a broad theoretical and methodological basis: - Understanding relationship power sources and needs in industrial power-trains. - Understanding theoretical and practical basis for selection, conceptualisation and design of simple industrial power-trains. - Functional understanding of complex industrial power-trains at usage level. Skills: S1.1 Executing complex operationa-professional tasks that incorporate usage of methodological tools: - Calculating output characteristics of mechanical power-trains. - Preparation of project or procurement documentation for components of industrial power-trains. S1.2 Mastering demanding and complex work processes by independent usage of knowledge in new working situations: - Managing maintenance activities for different industrial power-trains.

Metode poučevanja in učenja:	**Learning and teaching methods:**
P1: Avditorna predavanja z reševanjem izbranih - za področje značilnih - teoretičnih in praktično uporabnih primerov. P3: Avditorne vaje, kjer se teoretično znanje s predavanj podkrepi z računskimi primeri. P4: Laboratorijske vaje z namenskimi didaktičnimi pripomočki (prirejeni zobniški menjalniki in diferencialna gonila). P8: Izdelava in predstavitev aplikativnih seminarskih nalog. P15: Uporaba video vsebin kot priprava na predavanja in vaje.	P1: Auditorial lectures with solving selected field-specific theoretical and applied use cases. P3: Auditorial exrecises, in which theoretical content from the lectures is supplemented with practical examples. P4: Laboratory exercises with special-purpose didactic devices (modified gearboxes and differential gears). P8: Making and presenting applied seminar exercises. P15: Application of videos for preparations to the lectures and exercises.

Načini ocenjevanja:	**Delež/Weight**	**Assessment:**
Teoretična znanja (pisni kolokviji in izpit z ustnim zagovorom).	50,00 %	Theoretical knowledge (written colloquia and exam with an oral examination).
Aplikativne seminarske naloge (poročila s predstavitvami).	20,00 %	Applied seminar exercises (reports with presentations).
Laboratorijske vaje (poročila).	10,00 %	Laboratory exercises (reports).
Pisni preskus praktičnega znanja, osvojenega na vajah.	20,00 %	Written examination of practical knowledge that was acquired in exercises.

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:

Jernej Klemenc:

1. TOMAŽINČIČ, Dejan, PANIĆ, Branislav, NAGODE, Marko, **KLEMENC, Jernej**. The fatigue life estimation of the porous AlSi9Cu3 alloy based on the classification of porate probability distribution density. Journal of materials research and technology. [Spletna izd.]. 2025, vol. 36, no. , [article no.], str.

10039-10054, ilustr. ISSN 2214-0697. https://www.sciencedirect.com/science/article/pii/S2238785425012311?via%3Dihub, DOI: 10.1016/j.jmrt.2025.05.076. [COBISS.SI-ID 238058499]
2. CERAR, Jan, JAN, Petra, KALIN, Mitjan, **KLEMENC, Jernej**, TUŠEK, Jaka. Towards reliable Ni-Ti components : tribological insights and fatigue behaviour under cyclic compressive loads. Engineering failure analysis. 2025, vol. 179, [article no.] 109766, 21 str., ilustr. ISSN 1873-1961. https://www.sciencedirect.com/science/article/pii/S1350630725005072?via%3Dihub, DOI: 10.1016/j.engfailanal.2025.109766. [COBISS.SI-ID 240662275]
3. NIKONOV, Anatolij, NAGODE, Marko, **KLEMENC, Jernej**. A methodology for characterizing lithium-ion batteries under constant-current charging based on spectral analysis. World electric vehicle journal. 2025, vol. 16, iss. 6, [art.] 308, str. 1-14, ilustr. ISSN 2032-6653. https://www.mdpi.com/2032-6653/16/6/308, Repozitorij Univerze v Ljubljani – RUL, DOI: 10.3390/wevj16060308. [COBISS.SI-ID 238016515]
4. **KLEMENC, Jernej**, KAJBIČ, Jure. Application of nonlinear damage accumulation rules for predicting fatigue life of additivelly manufactured composites. V: ESDERTS, A. (ur.), WERDIN, S. (ur.), BLEICHER, Christoph (ur.). VAL5 : Fifth International Conference on Material and Component Performance under Variable Amplitude Loading : 11 to 13 June 2024, Dresden, Germany. Berlin: DVM, 2024. Str. 325-336, ilustr. ISBN 978-3-9820591-3-6. https://dvm-wissen.de/de/val-5/413-VAL5-2024-011.html?sp=undefined&q=Kategorien-Variable+Amplitude+Loading/Publikationsart-Tagungsmanuskript+(PDF), DOI: 10.48447/VAL5-2024-011. [COBISS.SI-ID 200805379]
5. OKORN, Ivan, NAGODE, Marko, **KLEMENC, Jernej**, OMAN, Simon. On the influence of additional axial and bending loads on fatigue life of preloaded bolts. V: IQBAL KHAN, M. (ur.). Prime archives in material science. 3rd ed. Hyderabad (Telangana): Vide Leaf, cop. 2021. Str. 1-36, ilustr. ISBN 978-81-953047-9-0. https://videleaf.com/wp-content/uploads/2021/10/On-the-Influence-of-Additional-Axial-and-Bending-Loads-on-Fatigue-Life-of-Preloaded-Bolts.pdf. [COBISS.SI-ID 82670595]

Simon Oman:

1. **OMAN, Simon**, NAGODE, Marko. Bolted connection of an end-plate cantilever beam : the distribution of operating force. Strojniški vestnik. Nov. 2017, vol. 63, no. 11, str. 617-627, ilustr. ISSN 0039-2480. http://www.dlib.si/details/URN:NBN:SI:doc-5KLWXIYM, https://repozitorij.uni-lj.si/IzpisGradiva.php?id=105269, DOI: 10.5545/sv-jme.2017.4638. [COBISS.SI-ID 15744795]
2. OKORN, Ivan, NAGODE, Marko, KLEMENC, Jernej, **OMAN, Simon**. Analysis of additional load and fatigue life of preloaded bolts in a flange joint considering a bolt bending load. Metals. Mar. 2021, vol. 11, iss. 3, str. 1-20, ilustr. ISSN 2075-4701. https://www.mdpi.com/2075-4701/11/3/449, https://repozitorij.uni-lj.si/IzpisGradiva.php?id=126175, DOI: 10.3390/met11030449. [COBISS.SI-ID 59147523]
3. **OMAN, Simon**, NAGODE, Marko, KLEMENC, Jernej. Rubber-fibre composite modelling and its influence on fatigue damage assessment. Fatigue & fracture of engineering materials & structures. Feb. 2021, vol. 44, iss. 2, str. 521-532, ilustr. ISSN 8756-758X. https://onlinelibrary.wiley.com/doi/10.1111/ffe.13377, DOI: 10.1111/ffe.13377. [COBISS.SI-ID 37853699]
4. NAGODE, Marko, KLEMENC, Jernej, **OMAN, Simon**, ŠERUGA, Domen. A closed-form solution for temperature-dependent elastoplastic problems using the Prandtl operator approach. Communications in Nonlinear Science and Numerical Simulation. Aug. 2021, vol. 99, str. 1-24, ilustr. ISSN 1007-570 https://www.sciencedirect.com/science/article/pii/S1007570421001519?via%3Dihub, https://repozitorij.uni-lj.si/IzpisGradiva.php?id=126176, https://repozitorij.uni-lj.si/IzpisGradiva.php?id=126176, DOI: 10.1016/j.cnsns.2021.105839. [COBISS.SI-ID 59481091]
5. **OMAN, Simon**, NAGODE, Marko, KLEMENC, Jernej, MAJDIČ, Franc, HOČEVAR, Marko, GOSAR, Aleš, ŠKRLEC, Andrej, OLAH, Laslo. Submersible pump assembly and method for use of same : United States patent US 10,883,488 B1, 2021-01-05. Alexandria: United States Patent and Trademark Office, 2021. 10 f., ilustr. [COBISS.SI-ID 46897667], patentna družina: US202016883719 (A), 2020-05-26