

POGONI

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Pogoni
Course title:	DRIVES
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo - razvojno raziskovalni program, prva stopnja, univerzitetni	Ni členitve (študijski program)	3. letnik	1. semester	obvezni

Univerzitetna koda predmeta/University course code:	0577605
Koda učne enote na članici/UL Member course code:	2031-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:	Mitjan Kalin, Tomaž Katrašnik
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Izvajalci predavanj:	
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	
Izvajalci praktičnega usposabljanja:	

Vrsta predmeta/Course	Obvezni splošni predmet /Compulsory general course
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type:

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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.
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Vsebina:

Content (Syllabus outline):

<p>1. Predavanje:</p> <ul style="list-style-type: none">- Primeri pogonov v transportu in industriji ter identifikacija komponent pogonov- Razvrstitev komponent pogonov, (prenosniki moči, pretvorniki energije, naprave za shranjevanje energije),- Raba energije in neposredni ter posredni izpusti onesnažil pogonov. <p>2. Predavanje:</p> <ul style="list-style-type: none">- Tehnološke smernice in zahteve razvoja pogonov in komponent pogonov,- Energijski tokovi v pogonih in izkoristki komponent pogonov,- Ragonov diagram. <p>3. Predavanje: Električni stroji:</p> <ul style="list-style-type: none">- Osnove delovanja električnih strojev,- Izvedbe električnih strojev in njihove značilnosti ter zmogljivosti. <p>4. Predavanje: Baterije in gorivne celice:</p> <ul style="list-style-type: none">- Osnove delovanja baterij in gorivnih celic,- Izvedbe baterij in njihove značilnosti ter zmogljivosti,- Izvedbe gorivnih celic in njihove značilnosti ter zmogljivosti,- Mehanizmi staranja baterij in gorivnih celic. <p>5. Predavanje: Toplotni motorji:</p> <ul style="list-style-type: none">- Izvedbe in zasnove toplotnih motorjev,- Značilnosti in zmogljivosti toplotnih motorjev.	<p>1. Lecture:</p> <ul style="list-style-type: none">- Examples of drives and powertrains in transport & industry and identification of their components,- Classification of powertrains components, (power transmissions, energy converters, energy storage devices),- Use of energy and direct and indirect emissions of drives and powertrains. <p>2. Lecture:</p> <ul style="list-style-type: none">- Technology guidelines and R&D requirements of drives and powertrains and their components,- Energy flows in powertrains and efficiencies of components,- Ragone plot. <p>3. Lecture: Electrical machines:</p> <ul style="list-style-type: none">- Basics principles of electrical machines,- Classification of electrical machines and their characteristics and performances. <p>4. Lecture: Batteries and fuel cells:</p> <ul style="list-style-type: none">- Basics principles of batteries and fuel cells,- Classification of batteries, their characteristics and performances,- Classification of fuel cells, their characteristics and performances,- Degradation mechanisms of batteries and fuel cells. <p>5. Lecture: Heat engines:</p> <ul style="list-style-type: none">- Types and designs of heat engines,
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<p>6. Predavanje:</p> <ul style="list-style-type: none"> - Topologije pogonov vozil (električni pogoni, toplotni motorji, hidravlični pogoni, hibridni pogoni, kombinirani pogoni), - Izbira ustreznih pogonov z ozirom na predviden način uporabe vozila. <p>7. Predavanje:</p> <ul style="list-style-type: none"> - Topologije pogonov v industriji (električni pogoni, toplotni motorji, hidravlični in pnevmatski pogoni), - Izbira ustreznih pogonov z ozirom na predviden način uporabe pogona. <p>8. Predavanje:</p> <ul style="list-style-type: none"> - Vrste in izbira mehanskih pogonskih sklopov (Pogonski stroj, delovni stroj, sklopka, gonilo. Kriteriji za izbiro, izkoristki, prilagoditev komponent sklopa - funkcijska, geometrijska). <p>9. Predavanje: Predležna in planetna gonila:</p> <ul style="list-style-type: none"> - Predležna: Vrste - zobniško, torni, jermensko, verižno, prednsoti, slabosti. Prestave, hitrosti, pretok moči, izkoristki. - Planetna: Enostavna, sestavljena. Prestave (notranje, zunanje), hitrosti, pretok moči, izkoristki, prednosti, slabosti. <p>10. Predavanje:</p> <ul style="list-style-type: none"> - Zobniška gonila iz polimernih materialov (Prednosti in slabosti glede na kovinske, aplikacije, izvedbe, izbor, modeliranje in preizkušanje). <p>11. Predavanje:</p> <ul style="list-style-type: none"> - Poškodbe zobniških gonil (Vrste poškodb, vzroki, posledice, mazanje, termična obdelava in površine). <p>12. Predavanje:</p> <ul style="list-style-type: none"> - Ročni avtomobilski menjalniki (Določitev prestav, sestavni deli, struktura gonila, delovanje, sinhroni, sklopka). <p>13. Predavanje:</p> <ul style="list-style-type: none"> - Avtomatski avtomobilski menjalniki (Vrste avtomatskih menjalnikov, sestavni deli in struktura gonila, delovanje, hidrodinamična sklopka, posebnosti). <p>14. Predavanje:</p> <ul style="list-style-type: none"> - Industrijska gonila in diagnostika (Vrste industrijskih gonil, posebnosti, 	<ul style="list-style-type: none"> - Characteristics and performances of heat engines. <p>6. Lecture:</p> <ul style="list-style-type: none"> - Topologies of vehicle propulsion systems (battery electric powertrains, internal combustion powertrains, hydraulic drives, hybrid powertrains, combined powertrains), - Selection of appropriate powertrains with respect to the intended use of the vehicle. <p>7. Lecture:</p> <ul style="list-style-type: none"> - Topologies of industrial drives (electric drives, heat engines, hydraulic and pneumatic drives), - Selection of suitable drives according to the intended use of drives. <p>8. Lecture:</p> <ul style="list-style-type: none"> - Types and selection of mechanical drive assemblies (drive machine, work machine, clutch, gearbox. Criteria for selection, efficiency, adjustment of the assembly components - functional, geometric). <p>9. Lecture: Gearboxes and planetary gears:</p> <ul style="list-style-type: none"> - Gearboxes: Types - gear, friction, belt, chain, strengths, weaknesses. Gear ratios, speeds, power flow, efficiency. - Planetary: Simple, complex. Gear ratios (internal, external), speeds, power flow, efficiency, advantages, disadvantages. <p>10. Lecture:</p> <ul style="list-style-type: none"> - Gear transmissions made of polymer materials (Advantages and disadvantages with respect to metal, applications, types, selection, modelling and testing). <p>11. Lecture:</p> <ul style="list-style-type: none"> - Gear transmission damage (Types of damage, causes, consequences, lubrication, heat treatment and surfaces). <p>12. Lecture:</p> <ul style="list-style-type: none"> - Manual vehicle gearboxes (Gear ratio definition, components, gearbox structure, operation, synchons, clutch). <p>13. Lecture:</p> <ul style="list-style-type: none"> - Automatic vehicle transmissions (Types, components and transmission
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<p>napake, nadzor stanja, odkrivanje napak, ukrepi).</p> <p>15. Predavanje: Pogoni prihodnosti:</p> <ul style="list-style-type: none"> - Refleksija in povezovanje vsebin, - Analiza najustrežnejših izvedenk pogonov, - Viharjenje na temo učinkovitejših pogonov prihodnosti. 	<p>structure, operation, hydrodynamic clutch, special features).</p> <p>14. Lecture:</p> <ul style="list-style-type: none"> - Industrial drives and diagnostics (Types of industrial drives, specialties, faults, condition monitoring, fault detection, measures). <p>15. Lecture: Drives in the future:</p> <ul style="list-style-type: none"> - Reflection and integration of content, - Analysis of the most suitable drive versions, - Brainstorming on the subject of more efficient drives of the future.
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Temeljna literatura in viri/Readings:

<ol style="list-style-type: none"> 1. Guzzella L, Sciarretta A.: Vehicle Propulsion Systems - Introduction to Modeling and Optimization, 2nd ed., Springer, 2007, ISBN 978-3-540-74691-1 [COBISS.SI-ID 11212571] 2. Ehsani M, Gao Y, Emadi A: Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design, Second Edition, CRC, 2009, ISBN 978-1420053982 [COBISS.SI-ID 6798110] 3. J. Vižintin: Gonila in pogonski sklopi, Slovensko društvo za tribologijo, 2012 [COBISS.SI-ID 260126976] 4. G. Niemann, H. Winter, B.R. Hohn: Maschinenelemente, Band 1, Springer Verlag, 2005 [COBISS.SI-ID 8511003] 	
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Cilji in kompetence:

<p>Cilji:</p> <ol style="list-style-type: none"> 1. Spoznati in razumeti delovanje komponent pogonov 2. Spoznati in razumeti značilnosti in zmogljivosti komponent pogonov 3. Razumeti dejavnike staranja komponent pogonov 4. Znati določiti najustrežnejšo topologijo pogona in značilnosti komponent pogona z ozirom na namen uporabe <p>Kompetence:</p> <ol style="list-style-type: none"> 1. P1-RRP: Obvladovanje temeljnih teoretičnih znanj na področju pogonov in njihovih component. 2. S6-RRP in P3-RRP: Sinteza ustreznih komponent v pogone za različne namene uporabe. 3. P1-RRP: Sposobnost razumevanja interakcije različnih komponent 	<p>Objectives:</p> <ol style="list-style-type: none"> 1. To know and understand the operation of drive components 2. To know and understand the characteristics and capabilities of the drive components 3. To understand the aging factors of drive components 4. Be able to determine the most appropriate drive topology and characteristics of the drive components with respect to their intended use <p>Competencies:</p> <ol style="list-style-type: none"> 1. P1-RRP: Mastering the fundamental theoretical knowledge of drives and their components. 2. S6-RRP and P3-RRP: Synthesis of suitable components into drives for various applications.
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<p>pogonov.</p> <p>4. S7-RRP in P4-RRP: Sposobnost analize, vrednotenja in kritične presoje različnih zasnov pogonov in njihovih component.</p>	<p>3. P1-RRP: Ability to discuss the interaction of different drive components.</p> <p>4. S7-RRP and P4-RRP: Ability to analyze, evaluate and critically evaluate different drive designs and their components.</p>
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Predvideni študijski rezultati:

<p>Znanja:</p> <p>Poglobljeno strokovno teoretično in praktično znanje na področju pogonov in komponent pogonov, podprto s širšo teoretično in metodološko osnovo.</p> <p>Spretnosti:</p> <p>S1.1 Sposobnost vrednotenja pogonov in njihovih komponent z oziroma na zasnov, izkoristek in trajnost komponent</p> <p>S1.2 Samostojna uporaba pridobljenega znanja pri analizi in snovanju pogonov in njihovih komponent.</p> <p>S1.3 Sposobnost snovanja okolju prijaznejših pogonov.</p> <p>S1.4 Sposobnost nadaljnjega, samostojnega študija.</p>
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Intended learning outcomes:

<p>Knowledge:</p> <p>In-depth professional theoretical and practical knowledge in the field of drives and drive components, supported by a broader theoretical and methodological basis.</p> <p>Skills:</p> <p>S1.1 Ability to evaluate drives and their components with or on the design, performance and durability of components</p> <p>S1.2 Independent use of acquired knowledge in the analysis and design of drives and their component.</p> <p>S1.3 Ability to design greener drives.</p> <p>S1.4 Ability to further independently study.</p>

Metode poučevanja in učenja:

<p>P1: Avditorna predavanja z reševanjem izbranih - za področje značilnih - teoretičnih in praktično uporabnih primerov.</p> <p>P2: Obravnava snovi po urejeni in vnaprej razloženi sistematiki.</p> <p>P3: Avditorne vaje, kjer se teoretično znanje s predavanj podkrepi z računskimi primeri.</p> <p>P4: Laboratorijske vaje.</p> <p>P5: Uporaba študijskega gradiva v obliki (e-verzija predstavitve predavanj).</p> <p>P8: Izdelava in predstavitev aplikativnih seminarskih nalog</p> <p>P10: Uporaba anket v realnem času</p>
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Learning and teaching methods:

<p>P1: Classroom lectures by solving selected - typical - theoretical and practical examples.</p> <p>P2: Treatment of the substance according to an orderly and pre-interpreted systematics.</p> <p>P3: Tutorials where theoretical knowledge of lectures is supported by computational examples.</p> <p>P4: Laboratory work.</p> <p>P5: Use of study materials in format (e-version of lecture presentation).</p> <p>P8: Design and presentation of applied seminar work</p> <p>P10: Use real-time surveys</p>

P14: Virtualni eksperimenti	P14: Virtual experiments
P15: Uporaba video vsebin kot priprava na predavanja in vaje	P15: Using video content to prepare for lectures and tutorials

Načini ocenjevanja:
**Delež/
Weight**
Assessment:

Teoretična snov (predavanja).	50,00 %	Theoretical knowledge (lecture).
Samostojno delo na vajah.	20,00 %	Independent tutorial work.
Laboratorijsko delo na vajah (vključno s poročili).	20,00 %	Lab tutorial work (with reports).
Seminar.	10,00 %	Seminar: 10%

Ocenjevalna lestvica:
Grading system:

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Reference nosilca/Lecturer's references:
Mitjan Kalin:

1. **KALIN, Mitjan**, KUPEC, Alja. The dominant effect of temperature on the fatigue behaviour of polymer gears. *Wear*. Apr. 2017, vol. 376/377, part b, str. 1339-1346, ilustr. ISSN 0043-1648. [COBISS.SI-ID [15897115](#)]
2. POLAJNAR, Marko, **KALIN, Mitjan**, THORBJORNSSON, Ingólfur, THORGRIMSSON, Jon Thor, VALLE, Nathalie, BOTOR-PROBIERZ, Agnieszka. Friction and wear performance of functionally graded ductile iron for brake pads. *Wear*. 2017, vol. 382-383, str. 85-94, ilustr. ISSN 0043-1648. . [COBISS.SI-ID [15500059](#)]
3. BARTOLOMÉ, Luis, OBLAK, Eva, **KALIN, Mitjan**. Sliding evolution of the mechanical behaviour of zinc dialkyldithiophosphate tribofilms on diamond-like carbon coatings. *Tribology letters*. May 2016, vol. 62, iss. 2, str. 1-9, ilustr. ISSN 1023-8883. <http://link.springer.com/article/10.1007%2Fs11249-016-0666-y>, <https://repozitorij.uni-lj.si/IzpisGradiva.php?id=106739>, DOI: [10.1007/s11249-016-0666-y](#). [COBISS.SI-ID [14585883](#)]
4. ZALAZNIK, Maša, **KALIN, Mitjan**, NOVAK, Saša, JAKŠA, Gregor. Effect of the type, size and concentration of solid lubricants on the tribological properties of the polymer PEEK. *Wear*. [Print ed.]. Oct. 2016, vol. 364-365, str. 31-39, ilustr. ISSN 0043-1648. <http://www.sciencedirect.com/science/article/pii/S0043164816301272>, DOI: [10.1016/j.wear.2016.06.013](#). [COBISS.SI-ID [14846235](#)]
5. OBLAK, Eva, **KALIN, Mitjan**. Relationship between the nanoscale topographical and mechanical properties of tribochemical films on DLC coatings and their macroscopic friction behavior. *Tribology letters*. Sep. 2015, vol. 59, iss. 3, str. 1-16, ilustr. ISSN 1023-8883. DOI: [10.1007/s11249-015-0575-5](#). [COBISS.SI-ID [14196763](#)]

Tomaž Kutrašnik:

1. RAŠIĆ, Davor, RODMAN OPREŠNIK, Samuel, SELJAK, Tine, VIHAR, Rok, ŽVAR BAŠKOVIČ, Urban, WECHTERS BACH, Tomaž, **KATRAŠNIK, Tomaž**. RDE-based assessment of a factory bi-fuel CNG/gasoline light-duty vehicle. *Atmospheric environment*, ISSN 1352-2310. [Print ed.], Oct. 2017, vol. 167, str. 523-54 [COBISS.SI-ID [15650587](#)]
2. RODMAN OPREŠNIK, Samuel, VIHAR, Rok, SELJAK, Tine, VIHAR, Rok, GERBEC, Marko, **KATRAŠNIK, Tomaž**. Real-World fuel consumption, fuel cost and exhaust emissions of different bus powertrain technologies. *Energies*, ISSN 1996-1073, 2018, vol. 11, iss. 8, f. 1-20. [COBISS.SI-ID [16192027](#)]
3. ŽNIDARČIČ, Anton, **KATRAŠNIK, Tomaž**. A 3D CFD-based workflow for analyses of a wide range of flow and heat transfer conditions in air gaps of electric machines. *Fluids*. 2022, vol. 7, iss. 8, str. 1-28, ilustr. ISSN 2311-5521. [COBISS.SI-ID [118272003](#)]
4. KRAVOS, Andraž, RITZBERGER, Daniel, TAVČAR, Gregor, HAMETNER, Christoph, JAKUBEK, Stefan, **KATRAŠNIK, Tomaž**. Thermodynamically consistent reduced dimensionality electrochemical model for proton exchange membrane fuel cell performance modelling and control. *Journal of power sources*. Apr. 2020, vol. 454, str. 1-16, ilustr. ISSN 0378-7753. [COBISS.SI-ID [17079835](#)]
5. MELE, Igor, PAČNIK, Ivo, ZELIČ, Klemen, MOŠKON, Jože, **KATRAŠNIK, Tomaž**. Advanced porous electrode modelling framework based on more consistent virtual representation of the electrode topology. *Journal of the Electrochemical Society*. [Online ed.]. 2020, vol. 167, no. 6, str. [1-18], ilustr. ISSN 1945-7111. [COBISS.SI-ID [17157915](#)]