

# POGONI

## UČNI NAČRT PREDMETA/COURSE SYLLABUS

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

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

<b>Univerzitetna koda predmeta/University course code:</b>	0577605
<b>Koda učne enote na članici/UL Member course code:</b>	2031-U

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

<b>Nosilec predmeta/Lecturer:</b>	Mitjan Kalin, Tomaž Katrašnik
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<b>Izvajalci predavanj:</b>	
<b>Izvajalci seminarjev:</b>	
<b>Izvajalci vaj:</b>	
<b>Izvajalci kliničnih vaj:</b>	
<b>Izvajalci drugih oblik:</b>	
<b>Izvajalci praktičnega usposabljanja:</b>	

<b>Vrsta predmeta/Course</b>	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:**

Izpolnjevanje pogojev za vpis v Univerzitetni študijski program I. stopnje Strojništvo - Razvojno raziskovalni program.

**Prerequisites:**

Meeting the enrollment conditions for the Academic study programme of Mechanical Engineering - Research and Development program.

**Vsebina:**

1. Predavanje:
  - 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.
2. Predavanje:
  - Tehnološke smernice in zahteve razvoja pogonov in komponent pogonov,
  - Energijski tokovi v pogonih in izkoristki komponent pogonov,
  - Ragonov diagram.
3. Predavanje: Električni stroji:
  - Osnove delovanja električnih strojev,
  - Izvedbe električnih strojev in njihove značilnosti ter zmogljivosti.
4. Predavanje: Baterije in gorivne celice:
  - 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.
5. Predavanje: Toplotni motorji:
  - Izvedbe in zasnove toplotnih motorjev,
  - Značilnosti in zmogljivosti toplotnih motorjev.

**Content (Syllabus outline):**

1. Lecture:
  - 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.
2. Lecture:
  - Technology guidelines and R&D requirements of drives and powertrains and their components,
  - Energy flows in powertrains and efficiencies of components,
  - Ragone plot.
3. Lecture: Electrical machines:
  - Basics principles of electrical machines,
  - Classification of electrical machines and their characteristics and performances.
4. Lecture: Batteries and fuel cells:
  - 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.
5. Lecture: Heat engines:
  - Types and designs of heat engines,

<p>6. Predavanje:</p> <ul style="list-style-type: none"> <li>- Topologije pogonov vozil (električni pogoni, toplotni motorji, hidravlični pogoni, hibridni pogoni, kombinirani pogoni),</li> <li>- Izbira ustreznih pogonov z ozirom na predviden način uporabe vozila.</li> </ul> <p>7. Predavanje:</p> <ul style="list-style-type: none"> <li>- Topologije pogonov v industriji (električni pogoni, toplotni motorji, hidravlični in pnevmatski pogoni),</li> <li>- Izbira ustreznih pogonov z ozirom na predviden način uporabe pogona.</li> </ul> <p>8. Predavanje:</p> <ul style="list-style-type: none"> <li>- Vrste in izbira mehanskih pogonskih sklopov (Pogonski stroj, delovni stroj, sklopka, gonilo. Kriteriji za izbiro, izkoristki, prilagoditev komponent sklopa - funkcijska, geometrijska).</li> </ul> <p>9. Predavanje: Predležna in planetna gonila:</p> <ul style="list-style-type: none"> <li>- Predležna: Vrste - zobniško, torni, jermensko, verižno, prednsoti, slabosti. Prestave, hitrosti, pretok moči, izkoristki.</li> <li>- Planetna: Enostavna, sestavljena. Prestave (notranje, zunanje), hitrosti, pretok moči, izkoristki, prednosti, slabosti.</li> </ul> <p>10. Predavanje:</p> <ul style="list-style-type: none"> <li>- Zobniška gonila iz polimernih materialov (Prednosti in slabosti glede na kovinske, aplikacije, izvedbe, izbor, modeliranje in preizkušanje).</li> </ul> <p>11. Predavanje:</p> <ul style="list-style-type: none"> <li>- Poškodbe zobniških gonil (Vrste poškodb, vzroki, posledice, mazanje, termična obdelava in površine).</li> </ul> <p>12. Predavanje:</p> <ul style="list-style-type: none"> <li>- Ročni avtomobilski menjalniki (Določitev prestav, sestavni deli, struktura gonila, delovanje, sinhroni, sklopka).</li> </ul> <p>13. Predavanje:</p> <ul style="list-style-type: none"> <li>- Avtomatski avtomobilski menjalniki (Vrste avtomatskih menjalnikov, sestavni deli in struktura gonila, delovanje, hidrodinamična sklopka, posebnosti).</li> </ul> <p>14. Predavanje:</p> <ul style="list-style-type: none"> <li>- Industrijska gonila in diagnostika (Vrste industrijskih gonil, posebnosti,</li> </ul>	<ul style="list-style-type: none"> <li>- Characteristics and performances of heat engines.</li> </ul> <p>6. Lecture:</p> <ul style="list-style-type: none"> <li>- Topologies of vehicle propulsion systems (battery electric powertrains, internal combustion powertrains, hydraulic drives, hybrid powertrains, combined powertrains),</li> <li>- Selection of appropriate powertrains with respect to the intended use of the vehicle.</li> </ul> <p>7. Lecture:</p> <ul style="list-style-type: none"> <li>- Topologies of industrial drives (electric drives, heat engines, hydraulic and pneumatic drives),</li> <li>- Selection of suitable drives according to the intended use of drives.</li> </ul> <p>8. Lecture:</p> <ul style="list-style-type: none"> <li>- Types and selection of mechanical drive assemblies (drive machine, work machine, clutch, gearbox. Criteria for selection, efficiency, adjustment of the assembly components - functional, geometric).</li> </ul> <p>9. Lecture: Gearboxes and planetary gears:</p> <ul style="list-style-type: none"> <li>- Gearboxes: Types - gear, friction, belt, chain, strengths, weaknesses. Gear ratios, speeds, power flow, efficiency.</li> <li>- Planetary: Simple, complex. Gear ratios (internal, external), speeds, power flow, efficiency, advantages, disadvantages.</li> </ul> <p>10. Lecture:</p> <ul style="list-style-type: none"> <li>- Gear transmissions made of polymer materials (Advantages and disadvantages with respect to metal, applications, types, selection, modelling and testing).</li> </ul> <p>11. Lecture:</p> <ul style="list-style-type: none"> <li>- Gear transmission damage (Types of damage, causes, consequences, lubrication, heat treatment and surfaces).</li> </ul> <p>12. Lecture:</p> <ul style="list-style-type: none"> <li>- Manual vehicle gearboxes (Gear ratio definition, components, gearbox structure, operation, synchons, clutch).</li> </ul> <p>13. Lecture:</p> <ul style="list-style-type: none"> <li>- Automatic vehicle transmissions (Types, components and transmission</li> </ul>
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<p>napake, nadzor stanja, odkrivanje napak, ukrepi).</p> <p>15. Predavanje: Pogoni prihodnosti:</p> <ul style="list-style-type: none"> <li>- Refleksija in povezovanje vsebin,</li> <li>- Analiza najustrežnejših izvedenk pogonov,</li> <li>- Viharjenje na temo učinkovitejših pogonov prihodnosti.</li> </ul>	<p>structure, operation, hydrodynamic clutch, special features).</p> <p>14. Lecture:</p> <ul style="list-style-type: none"> <li>- Industrial drives and diagnostics (Types of industrial drives, specialties, faults, condition monitoring, fault detection, measures).</li> </ul> <p>15. Lecture: Drives in the future:</p> <ul style="list-style-type: none"> <li>- Reflection and integration of content,</li> <li>- Analysis of the most suitable drive versions,</li> <li>- Brainstorming on the subject of more efficient drives of the future.</li> </ul>
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### Temeljna literatura in viri/Readings:

<ol style="list-style-type: none"> <li>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 <a href="#">11212571</a>]</li> <li>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 <a href="#">6798110</a>]</li> <li>3. J. Vižintin: Gonila in pogonski sklopi, Slovensko društvo za tribologijo, 2012 [COBISS.SI-ID <a href="#">260126976</a>]</li> <li>4. G. Niemann, H. Winter, B.R. Hohn: Maschinenelemente, Band 1, Springer Verlag, 2005 [COBISS.SI-ID <a href="#">8511003</a>]</li> </ol>	
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### Cilji in kompetence:

<p>Cilji:</p> <ol style="list-style-type: none"> <li>1. Spoznati in razumeti delovanje komponent pogonov</li> <li>2. Spoznati in razumeti značilnosti in zmogljivosti komponent pogonov</li> <li>3. Razumeti dejavnike staranja komponent pogonov</li> <li>4. Znati določiti najustrežnejšo topologijo pogona in značilnosti komponent pogona z ozirom na namen uporabe</li> </ol> <p>Kompetence:</p> <ol style="list-style-type: none"> <li>1. P1-RRP: Obvladovanje temeljnih teoretičnih znanj na področju pogonov in njihovih component.</li> <li>2. S6-RRP in P3-RRP: Sinteza ustreznih komponent v pogone za različne namene uporabe.</li> <li>3. P1-RRP: Sposobnost razumevanja interakcije različnih komponent</li> </ol>	<p>Objectives:</p> <ol style="list-style-type: none"> <li>1. To know and understand the operation of drive components</li> <li>2. To know and understand the characteristics and capabilities of the drive components</li> <li>3. To understand the aging factors of drive components</li> <li>4. Be able to determine the most appropriate drive topology and characteristics of the drive components with respect to their intended use</li> </ol> <p>Competencies:</p> <ol style="list-style-type: none"> <li>1. P1-RRP: Mastering the fundamental theoretical knowledge of drives and their components.</li> <li>2. S6-RRP and P3-RRP: Synthesis of suitable components into drives for various applications.</li> </ol>
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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><b>Znanja:</b></p> <p>Poglobljeno strokovno teoretično in praktično znanje na področju pogonov in komponent pogonov, podprto s širšo teoretično in metodološko osnovo.</p> <p><b>Spretnosti:</b></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 nadaljnega, samostojnega študija.</p>
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### **Intended learning outcomes:**

<p><b>Knowledge:</b></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><b>Skills:</b></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>
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### **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>
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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](#)]