

MOTORJI Z NOTRANJIM ZGOREVANJEM IN ELEKTROMOBILNOST

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Motorji z notranjim zgorevanjem in elektromobilnost
Course title:	INTERNAL COMBUSTION ENGINES AND ELECTROMOBILITY
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semest ri	Izbir nost
Strojništvo - projektno aplikativni program, prva stopnja, visokošolski strokovni	Energetsko strojništvo (smer)	3. letnik	1. seme ster	obveze n

**Univerzitetna koda predmeta/University
course code:**

0562726

**Koda učne enote na članici/UL Member
course code:**

3027-V

Predavanj a /Lectures	Seminar /Seminar	Vaje /Tutorials	Klinične vaje /Clinical tutorials	Druge oblike študija /Other forms of study	Samostoj no delo /Individua l student work	ECT S
30		30			40	4

**Nosilec
predmeta/Lecturer:**

Tomaž Katrašnik

**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:

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

Prerequisites:

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

Vsebina:

1. Predavanje:
 - Primeri pogonov v prometu in 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 motorjev z notranjim zgorevanjem in elektrificiranih hibridnih ter električnih pogonskih sistemov vozil;
 - Energijski tokovi v pogonih in osnovni pregled izkoristkov komponent pogonov vozil;
 - Ragonov diagram.
- Motorji z notranjim zgorevanjem (MNZ):
3. Predavanje:
 - Energijske pretvorbe v MNZ;
 - Teoretični procesi v MNZ (določitev izkoristka, delovne sposobnosti) in njihova primerjava s procesi v realnih MNZ;
 - Metode za izboljšanje izkoristka motorjev.
 4. Predavanje:
 - Zasnovne batnih MNZ in njihove značilnosti;
 - Kinematika bata in uravnoteženje prostih sil in navorov.
 5. Predavanje: Motorji s prisilnim vžigom (Ottovi motorji):
 - Zasnova in komponente;
 - Priprava gorljive zmesi;
 - Vžig zmesi in zgorevanje.
 6. Predavanje: Motorji s samovžigom (dizelski motorji):
 - Zasnova in komponente;
 - Priprava gorljive zmesi;
 - Vžig zmesi in zgorevanje.
 7. Predavanje: Motorji z naprednimi

Content (Syllabus outline):

1. Lecture:
 - Examples of powertrains in transport 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 vehicle's powertrains.
 2. Lecture:
 - Technology guidelines and R&D requirements of internal combustion engines and electric hybrid and fully electric powertrains,
 - Energy flows in powertrains and efficiencies of powertrain components,
 - Ragon plot.
- Internal combustion engines (ICE):
3. Lecture:
 - Energy conversion paths in ICEs,
 - Theoretical processes in ICEs (evaluation of efficiency and indicated mean effective pressure) and their interrelation to processes in real ICEs,
 - Methods for increasing efficiency of ICEs.
 4. Lecture:
 - Types and designs of piston ICEs and their characteristics and performances,
 - Kinematics of the piston motion in piston engines and balancing free forces and moments.
 5. Lecture: Spark ignition (SI) engines (Otto engines)
 - Design and components,
 - Mixture preparation,
 - Ignition and combustion.
 6. Lecture: Compression ignition (CI) engines (Diesel engines)
 - Design and components,
 - Mixture preparation,
 - Ignition and combustion.

procesi zgorevanja (LTC, CAI...):

- Zasnova in komponente;
- Priprava gorljive zmesi;
- Vžig in zgorevanje.

8. Predavanje: Mehanizmi tvorbe izpušnih onesnažil MNZ (dušikovi oksidi, ogljikov monoksid, nezgoreli ogljikovodiki, delci).

9. Predavanje: Sistemi in naprave za naknadno obdelavo plinskih onesnažil in delcev (TWC, DOC, SCR, LNT, DPF, GPF).

10. Predavanje:

- Izmenjava delovnega medija;
- Mehanske izgube v MNZ;
- Termoregulacija MNZ.

11. Predavanje:

- Prisilno polnjenje MNZ (valovna dinamika, mehansko prisilno polnjenje, prisilno polnjenje s turbopolnilnikom, kombinacije metod za prisilno polnjenje);
- Zmogljivosti MNZ.

Elektromobilnost:

12. Predavanje: Električni stroji:

- Osnove delovanja električnih strojev;
- Izvedbe električnih strojev in njihove značilnosti ter zmogljivosti.

13. 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;
- Dejavniki staranja baterij in gorivnih celic.

14. Predavanje:

- Topologije pogonov vozil (MNZ, električni pogoni, hidravlični pogoni, hibridni pogoni, priključni hibridni pogoni, kombinirani pogoni);
- Izbira ustreznih pogonov z ozirom na predviden način uporabe vozila.

Refleksija in sinteza:

15. Predavanje:

- Refleksija in povezovanje vsebin;
- Učinkovitost energijskih pretvorb v različnih pogonih vozil z ozirom na tip vozila in način uporabe – analiza

7. Lecture: Engines with advanced combustion concepts (LTC, CAI...)

- Design and components,
- Mixture preparation,
- Ignition and combustion.

8. Lecture: Mechanisms of pollutant emission formation in ICEs (nitrogen oxides, carbon monoxide, unburned hydrocarbons, particles).

9. Lecture: Exhaust after-treatment devices for gaseous pollutants and particles (TWC, DOC, SCR, LNT, DPF, GPF).

10. Lecture:

- Exchange of the working media,
- Mechanical losses in piston ICEs,
- Thermoregulation of piston ICEs.

11. Lecture:

- Supercharging of piston ICEs (wave dynamics, mechanical supercharging, turbocharging, combined charging),
- Performance characteristics of piston ICEs.

Electromobility:

12. Lecture: Electrical machines

- Basics principles of electrical machines,
- Classification and design of electrical machines and their characteristics and performances.

13. Lecture: Batteries and fuel cells

- Basic 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.

14. Lecture:

- Topologies of vehicle propulsion systems (internal combustion powertrains, battery electric powertrains, hydraulic drives, hybrid powertrains, combined powertrains),
- Selection of appropriate powertrains with respect to the intended use of the vehicle.

Reflection and synthesis:

15. Lecture:

- Reflection and integration of content,

primerov dobrih praks in analize potencialov za nadaljnja izboljšanja pogonov prihodnosti.	- Energy conversion efficiency of vehicle's powertrains with respect to the vehicle type and intended use of the vehicle – analysis of good practices and analysis of potential further improvements of future powertrains.
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Temeljna literatura in viri/Readings:

1. Taylor, C.F.: The Internal combustion engine in theory and praxis, Vol.1 – thermodynamics, fluid flow, performance, The MIT Pres, Massachusetts, 1986, ISBN 0-262-20051-1
2. Heywood, J.B.: Internal combustion engine fundamentals, McGraw-Hill, N.York, 1988, ISBN 0-07-028637-X
3. Guzzella L, Sciarretta A.: Vehicle Propulsion Systems - Introduction to Modeling and Optimization, 2nd ed., Springer, 2007, ISBN 978-3-540-74691-1

Cilji in kompetence:

Cilji:
1. Razumeti teoretične osnove in metode vrednotenja procesov v motorjih z notranjim zgorevanjem
2. Spoznati različne zasnove motorjev z notranjim zgorevanjem in razumeti njihove značilnosti in prednosti
3. Spoznati in razumeti delovanje različnih metod za prisilno batnih motorjev z notranjim zgorevanjem
4. Spoznati pristope za zmanjševanje izpustov onesnažil in sisteme in naprave za naknadno obdelavo izpušnih plinov
5. Razumeti teoretične osnove in način delovanja komponent elektrificiranih pogonskih sistemov vozil (baterije, gorivne celice, električni stroji)
6. Spoznati interakcije in soodvisnosti različnih gradnikov sodobnih pogonskih sistemov vozil
7. Spoznati in razumeti delovanje elektrificiranih in električnih pogonskih sistemov vozil
8. Spoznati različne zasnove elektrificiranih pogonskih sistemov vozil in razumeti njihove značilnosti in prednosti
9. Znati določiti najustreznejšo topologijo pogona in značilnosti komponent pogona z ozirom na

Objectives and competences:

Objectives:
1. Understand the theoretical foundations and characterisation methods of processes in internal combustion engines
2. To know different designs of internal combustion engines and to understand their characteristics and advantages
3. To know and to understand working principles of different supercharging methods of internal combustion engines
4. Understand approaches for reduction of pollutant emissions and exhaust gas after-treatment devices
5. To understand theoretical basis and working principles of components of electrified powertrains (batteries, fuel cells, electric machines)
6. To know and to understand interactions in interdependencies of components in advanced vehicle powertrains
7. To know and to understand working principles of electrified and fully electric powertrains
8. To know different topologies of electrified powertrains and to understand their characteristics and advantages

<p>namen uporabe</p> <p>10. Razumeti pristope za razvoj naprednih-okolju prijaznejših in učinkovitejših pogonskih sistemov vozil</p> <p>Kompetence:</p> <ol style="list-style-type: none"> 1. Usposobljenost za vodenje tehnološke enote ali projekta na področju pogonskih sistemih vozil (S7-PAP). 2. Razumevanje fizikalnih pojavov in procesov v pogonskih sistemih vozil (P1-PAP) 3. Obvlada temeljna strokovna znanja na področju komponent in sistemov pogonskih sistemih vozil (P3-PAP) 4. Obvlada specifična znanja na področju komponent in sistemov pogonskih sistemih vozil, ki omogočajo aplikativna, inženirska in strokovno organizacijska dela (P8-PAP, P9-PAP). 	<p>9. To know how to define most adequate topology of powertrain with respect of the intended use of the vehicle</p> <p>10. Understand approaches for development of advanced-environmentally friendly and efficient vehicle propulsion systems</p> <p>Competencies:</p> <ol style="list-style-type: none"> 1. The ability to manage a technological unit or project in the field of vehicle propulsion systems (S7-PAP) 2. Understanding the laws of physics and the phenomena and processes in vehicle propulsion systems (P1-PAP) 3. Mastering the fundamental specialised knowledge in the field of components and systems related to vehicle propulsion systems (P3-PAP) 4. Mastering specific knowledge in the field of components and systems vehicle propulsion systems, which enable executing applied, engineering and organisational tasks (P8-PAP, P9-PAP)
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Predvideni študijski rezultati:

<p>Znanja:</p> <p>Poglobljeno strokovno teoretično in praktično znanje na področju motorjev z notranjim zgorevanje in elektrificiranih pogonskih sistemov vozil, podprto s širšo teoretično in metodološko osnovo</p> <p>Spretnosti:</p> <p>S1.1: Sposobnost vrednotenja različnih topologij pogonskih sistemov vozil in njihovih komponent z oziroma na zasnovo, izkoristek in trajnost komponent</p> <p>S1.2: Samostojna uporaba pridobljenega znanja pri analizi in snovanju različnih topologij pogonskih sistemov vozil in njihovih komponent.</p> <p>S1.3: Sposobnost snovanja okolju prijaznejših različnih topologij pogonskih sistemov vozil.</p> <p>S1.4: Sposobnost nadaljnjega, samostojnega študija.</p>	<p>Knowledge:</p> <p>Z1: In depth professional theoretical and applied knowledge in the area of internal combustion and electrified vehicle propulsion systems, supported by comprehensive theoretical and methodological basis.</p> <p>Skills:</p> <ol style="list-style-type: none"> 1. S1.1 Ability to evaluate different topologies of vehicle propulsion systems and their components with respect to their design, efficiency and durability of components. 2. S1.2 Independent use of knowledge for analysis and design of different topologies of vehicle propulsion systems and their components. 3. S1.3 Ability to design environmentally friendly topologies of vehicle propulsion systems
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	4. S1.4 Capability of further independent self-learning in the area of piston aircraft engines.
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Metode poučevanja in učenja:

P1: Avditorna predavanja z reševanjem izbranih - za področje značilnih - teoretičnih in praktično uporabnih primerov.

P2: Obravnava snovi po urejeni in vnaprej razloženi sistematiki.

P3: Avditorne vaje, kjer se teoretično znanje s predavanj podkrepi z računskimi primeri.

P4: Laboratorijske vaje.

P5: Uporaba študijskega gradiva v obliki (e-verzija predstavitve predavanj).

P8: Izdelava in predstavitev aplikativnih seminarskih nalog

P10: Uporaba anket v realnem času

P14: Virtualni eksperimenti

P15: Uporaba video vsebin kot priprava na predavanja in vaje

Learning and teaching methods:

P1: Classroom lectures with inclusion of solving selected typical and practical examples.

P2: Presenting of the learning content in an orderly and pre-interpreted systematics

P3: Tutorials where theoretical knowledge of lectures is supported by computational examples.

P4: Laboratory work.

P5: Use of study materials in format (e-version of lecture presentation).

P8: Design and presentation of applied seminar work

P10: Use of real-time surveys

P14: Virtual Experiments

P15: Using video content to prepare for lectures and exercises

Načini ocenjevanja:

Delež/ Weight

Assessment:

- Teoretične vsebine (predavanja)	50,00 %	- Theory (lectures)
- Samostojno delo na vajah:	50,00 %	- Practical coursework

Reference nosilca/Lecturer's references:

Tomaž Katrašnik:

1. **KATRAŠNIK, Tomaž**. Impact of vehicle propulsion electrification on Well-to-Wheel CO [sub] 2 emissions of a medium duty truck. Applied energy. Aug. 2013, vol. 108, str. 236-247, ilustr. ISSN 0306-2619. DOI: 10.1016/j.apenergy.2013.03.029. [COBISS.SI-ID 12782363]
2. BANJAC, Titina, TRENC, Ferdinand, **KATRAŠNIK, Tomaž**. Energy conversion efficiency of hybrid electric heavyduty vehicles operating according to diverse drive cycles. Energy conversion and management. [Print ed.]. 2009, vol. 50, iss. 12, str. 2865-2878. ISSN 0196-8904. [COBISS.SI-ID 11100699]
3. PRAH, Ivo, TRENC, Ferdinand, **KATRAŠNIK, Tomaž**. Innovative calibration method for system level simulation models of internal combustion engines. Energies. Sep. 2016, vol. 9, iss. 9, f. 1-36, ilustr. ISSN 1996-1073. <http://www.mdpi.com/1996-1073/9/9/708>, DOI: 10.3390/en9090708.

[COBISS.SI-ID 14830363]

4. **KATRAŠNIK, Tomaž**. Transient momentum balance - a method for improving the performance of mean - value engine plant models. *Energies*. Jun. 2013, vol. 6, iss. 6, str. 2892-2926, ilustr. ISSN 1996-1073. DOI: 10.3390/en6062892. [COBISS.SI-ID 12946459]
5. RODMAN OPREŠNIK, Samuel, **KATRAŠNIK, Tomaž**, SELJAK, Tine. Test report of exhaust emissions and fuel consumption of a triple-fuel spark-ignition VW Touran 2.0 Ecofuel in August 2010. Ljubljana: Fakulteta za strojništvo, 2010. 1 zv., ilustr. [COBISS.SI-ID 12100123]